COOPERATIVE USE OF MOBILE COMPUTING DEVICES FOR ANSWERING MCPATH QUESTIONS IN CLASS TO IMPROVE INFORMATION LITERACY OF UNDERGRADUATES

BRIAN J. PHILLIPS

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (SCIENCE AND TECHNOLOGY EDUCATION)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2017

Copyright by Mahidol University

COPYRIGHT OF MAHIDOL UNIVERSITY

Thesis
entitled

COOPERATIVE USE OF MOBILE COMPUTING DEVICES FOR ANSWERING MCPATH QUESTIONS IN CLASS TO IMPROVE INFORMATION LITERACY OF UNDERGRADUATES

.....

Mr. Brian J. Phillips
Candidate

.....

Lect. Parames Laosinchai,
Ph.D. (Science and Technology Education)
Major advisor

.....

Assoc. Prof. Khajornsak Buaraphan,
Ph.D. (Science Education)
Co-advisor

.....

Lect. Wararat Wongkia,
Ph.D. (Science and Technology Education)
Co-advisor

.....

Asst. Prof. Patcharin Panjaburee,
Ph.D. (Science and Technology Education)
Co-advisor

.....

Prof. Patcharee Lertrit,
M.D., Ph.D. (Biochemistry)
Dean
Faculty of Graduate Studies
Mahidol University

.....

Lect. Parames Laosinchai,
Ph.D. (Science and TechnologyEducation)
Program Director
Doctor of Philosophy Program in Science and Technology Education
Institute for Innovative Learning,
Mahidol University

Copyright by Mahidol University

Thesis
entitled

COOPERATIVE USE OF MOBILE COMPUTING DEVICES FOR ANSWERING MCPATH QUESTIONS IN CLASS TO IMPROVE INFORMATION LITERACY OF UNDERGRADUATES

was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Doctor of Philosophy (Science and Technology Education)
on
June 7, 2017

.....
Mr. Brian J. Phillips
Candidate

.....
Lect. Watsatree Diteeyont,
Ph.D. (Educational Technology)
Chair

.....
Assoc. Prof. Khajornsak Buaraphan,
Ph.D. (Science Education)
Member

.....
Lect. Parames Laosinchai,
Ph.D. (Science and Technology Education)
Member

.....
Lect. Wararat Wongkia,
Ph.D. (Science and Technology Education)
Member

.....
Asst. Prof. Patcharin Panjaburee,
Ph.D. (Science and Technology Education)
Member

.....
Prof. Patcharee Lertrit,
M.D., Ph.D. (Biochemistry)
Dean
Faculty of Graduate Studies
Mahidol University

.....
Prof. Banchong Mahaisaviriya,
M.D., Dip Thai Board of Orthopedics
Acting Director
Institute for Innovative Learning,
Mahidol University

Copyright by Mahidol University

ACKNOWLEDGEMENTS

I want to extend my appreciation to Prof. Maleeya Kruatrachue. After working at Mahidol University International College for so many years, you allowed me the time to study by letting me step away from my administrated duties yet still allowing me to stay as a lecturer. These years spend pursuing my Ph.D. and raising my children have been some of my enjoyable of my life. Having MUIC extend a scholarship was unexpected, and I am quit obliged to you for this largesse.

Thank you as well, Prof. Rassmidara Hoonsawat. You were a pleasure to work for, and I value serving under you while you were the MUIC Dean. I had been interested in studying at the Institute for Innovative Learning its beginning. Your encouragement was the crucial element in having me apply, and I have really treasured studying there.

Prof. Chariya Brockelman, all of us at MUIC were proud to have served under you while you were our Dean. You demanded the best out of us in all situations, a high level of professionalism that has been carried on as a tradition of the college. You shaped me as an administrator and as a lecturer. You also allowed me to step aside for a couple of years to spend time with my family in Colorado and then allowed me to rejoin our MUIC family. Thank you much for your many years of support and encouragement.

Thanks to the Mahidol University staff, many friends and of course the participating students that helped me with this project

Finally, Elizabeth Phillips passed away about seven months before I started my Ph.D. It is too late to thank her, but hey, Mom, I made it.

Brian J. Phillips

Copyright by Mahidol University

COOPERATIVE USE OF MOBILE COMPUTING DEVICES FOR ANSWERING MCPATH QUESTIONS IN CLASS TO IMPROVE INFORMATION LITERACY OF UNDERGRADUATES

BRIAN J. PHILLIPS 5438745 ILSE/D

Ph.D. (SCIENCE AND TECHNOLOGY EDUCATION)

THESIS ADVISORY COMMITTEE : PARAMES LAOSINCHAI, Ph.D., PATCHARIN PANJABUREE, Ph.D., KHAJORNSAK BUARAPHAN, Ph.D., WARARAT WONGKIA, Ph.D.

ABSTRACT

The mCpath or Mobile Computing Learning is an original collaborative m-learning instruction. The classroom method was based on the mobile devices and mobile services undergraduates use often. Using their mobile devices during class, team members search for answers to path questions. It requires no specialized hardware or software. The research used a quasi-experimental design and developed three survey instruments to measure the effect m-learning instruction had on undergraduates' knowledge of digital literacy and mobile usage. The year-long experiment involved 318 participants taking an introductory computer course, and three sections each term for three terms were assigned as either control, experimental treatment, or hybrid experimental treatment. The Digital Search Literacy Assessment showed that knowledge about critically evaluating internet information did significantly improve for the experimental participants. There was no significant difference between the treatment groups with computer concepts or frequency of use of the mobile media. All showed significant improvement in digital literacy.

KEY WORDS: CLASSROOM INSTRUCTIONAL DESIGN / COOPERATIVE LEARNING / M-LEARNING / DIGITAL LITERACY / INFORMATION LITERACY

Copyright by Mahidol University

293 pages

CONTENTS

	Page
ACKNOWLEDGEMENTS	**iii**
ABSTRACT	**iv**
LIST OF TABLES	**viii**
LIST OF FIGURES	**ix**
LIST OF ABBREVIATIONS	**x**
CHAPTER I INTRODUCTION	**1**
1.1 Background	1
1.2 Significance of the study	8
1.3 Research question and research objectives	13
1.4 Explanation of Definitions	21
CHAPTER II LITERATURE REVIEW	**22**
2.1 Introduction to the literature review	22
2.2 Digital literacy, computer literacy and information literacy	24
2.3 Educational theory and models	32
2.4 Mobile learning	42
2.5 Cooperative learning	46
CHAPTER III METHODOLOGY	**51**
3.1 Research methodology	51
3.2 Research design	54
3.2.1 Participants	56
3.2.2 Experimental design	60
3.3 mCpath instructional process	65
3.3.1 Path questions development	67
3.3.2 Digital resources used for mCpath	77
3.3.3 mCpath Roles	78

Copyright by Mahidol University

CONTENT (cont.)

	Page
3.3.4 Peer report	96
3.3.5 Role assessment	97
3.3.6 DSL measurement of information literacy	107
3.4 Instrument development and data collection	108
3.4.1 Digital information literacy assessment	108
3.4.2 Computer concept	113
3.4.3 Mobile Medial Learning Survey	117
3.4.4 Learning journals	119
3.5 Data analysis	121
3.6 Ethics	122
CHAPTER IV RESULTS	**124**
4.1 Mobile Media Learning Survey results	124
4.2 Computer concept results	131
4.3 Digital Search Literacy results	138
4.4 Learning journal results	148
4.4.1 Team learning	155
4.4.2 Self-efficacy	157
4.4.3 Learning process (mCpath vs. lecture)	162
CHAPTER V DISCUSSION	**166**
5.1 Mobile Media Learning Survey discussion	166
5.2 Computer concept pretest discussion	170
5.3 Computer concept midterm and final discussion	175
5.4 Digital Search Literacy and mCpath	180
5.5 Undergraduates' attitude toward learning with mCpath	182

Copyright by Mahidol University

CONTENT (cont.)

	Page
CHAPTER VI SUMMARY	**188**
6.1 Summary	188
6.2 Implications	191
6.3 Limitations to the study	196
6.4 Points for further research	198
REFERENCES	**201**
APPENDICES	**228**
Appendix A Digital Search Assessment-Master Standards Mapping	229
Appendix B Participants grouped by term and treatment	240
Appendix C Pretest Results Mobile Media Learning Survey	242
Appendix D Posttest Results Mobile Media Learning Survey	244
Appendix E Digital Search Literacy Assessment given in term 3	246
Appendix F Mapping of ILCSHE outcomes to Digital Search Literacy Assessment	256
Appendix G Mobile Media Learning Survey	268
Appendix H Coding of learning journal about learning from mCpath	274
Appendix I Guide to implementing mCpath	276
BIOGRAPHY	**292**

Copyright by Mahidol University

LIST OF TABLES

Table		Page
2.1	Information Literacy Competency Standard for Higher Education 2000	30
3.1	Gender proportion of female participants in experimental groups per term	58
3.2	Frequency table of participants per major	59
3.3	Number of path questions throughout the mCpath experiment	76
3.4	ILCSHE substandards used to develop DSL	110
3.5	Frequency table of DSL question relating to disciplines	113
3.6	Computer concepts measured in computer concept exam	115
3.7	Computer concept versions and item analysis	116
4.1	Posttest Mobile Media Learning Survey for all terms, top 10 media	125
4.2	Posttest Mobile Media Learning Survey for all terms, bottom 10 media	126
4.3	Grouping of 48 media into 5 categories for Mobile Media Learning Survey	128
4.4	Table Descriptive statistics of pretest and posttest results from Mobile Media Learning Survey	129
5.1	Ranking of Mobile Media Learning for pilot, pretest and posttest	167

Copyright by Mahidol University

LIST OF FIGURES

Figures		Page
2.1	Illeris's 2007 Three Learning Dimensions applied to mCpath	38
2.2	Illeris's 2007 Three Learning Dimensions combined with Davis et al. Technological Acceptance Model (1989)	41
3.1	Original mCpath path question in pilot session 1	70
3.2	mCpath4 path question, experimental session 1	73
3.3	mCpath3 path question, experimental session 3	74

Copyright by Mahidol University

LIST OF ABBREVIATIONS

AASL	America Association of School Librarians
ACRL	Association of College and Research Libraries
ACT	American College Testing
ALA	American Library Association
ANZIL	Australian and New Zealand Information Literacy Framework: Information Literacy standard for Australia and New Zealand
BDA	Blu-ray Disc Association
CAUL	Council of Australian University Librarians
CSCL	Computer-Supported Collaborative Learning
CMCL	Computer-Mediated Collaborative Learning
DIGCOMP	Digital Competence
DSL	Digital Search Literacy Assessment
ECDL	European Computer Driving License
ERIC	Educational Resources Information Center
GeST	Generic, situated and transformative
ICT	Information and computer technology
IEEE	Institute of Electrical and Electronics Engineers
ILCSHE	Information Literacy Competency Standard for Higher Education
ILT	Information Literacy Test
ISS	Information Skills Survey
ISTE Standards	International Society for Technology in Education Standards for Students
LCD	Liquid-crystal displays
mAh	Milliamp hours
mCpath	Mobile Computing Path Learning

Copyright by Mahidol University

LIST OF ABBREVIATIONS (cont.)

MOOC	Massive open online course
NCCA	National Council for Curriculum and Assessment
NECTEC	National Electronics and Computer Technology Center
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer equipment
OLED	Organic light-emitting diode
PBS	Public Broadcasting Service
PISA	Programme for International Student Assessment: Assessment from OECD on math, reading and science skills of students in many different countries
PPI	Pixels per inch: Measurement of screen resolution for smartphones
SAIL	Project Standardized Assessment of Information Literacy Skills
SCONUL	Society of College, National and University Libraries
SMD	Student Mobile Device and Media Use Assessment
SMS	Short message service: a text message sent usually sent through a cell phone service
SRS	Student Response System
STEM	Science, technology, engineering, and mathematics
UNESCO	United Nations Educational, Scientific and Cultural Organization
PDA	Personal Digital Assistant
RIM	Research In Motion Ltd.
SSD	Solid States Drive
r_{pb}	Point biserial correlation
TAM	Technology Acceptance Model
Tbps	Terabits per second
TRAILS	Tools for Real-time Assessment of Information Literacy Skills
IMLS	US Institute of Museum and Library Services

Copyright by Mahidol University

CHAPTER I
INTRODUCTION

1.1 Background

This research projected on m-learning came about because it makes so much sense to use smartphones in class for learning.

The obsessive use of mobile computing devices by university students can be observed in almost every conceivable situation: before, after and sometimes during classes, on the bus to and from school, during meals, and certainly in the restroom during private time. In 2012, Pew Internet's research put 18-year to 29-year olds and their US usage of cell phones to mostly browse the internet at 45 percent (A. Smith, 2012), a conservative estimate now in 2016, particularly in Asia. There has been a long list of technologies that were due to revolutionize the classroom that has peaked, fizzled before failing into obscure educational niche, but the smartphone has the most potential to make it. This author remembers the interest in the television experiments at his elementary school in the 1970s watching science programming and then going home to watch Sesame Street and the Electric Company. Twenty years later, he was a staff member of the public television station that was still receiving a diminishing revenue stream from provided university distant learning courses after midnight. M-learning had the same enthusiastic and optimistic true believers that distance learning had about television technology. It has become a viable alternative to sitting in classroom lecturers, but mobile learning has not lived up to its early promise of revolutionizing education. Most research show that it can keep even with traditional instruction, but the current focus on using blended methods versus a totally mobile approach appears to mean that the technology has taken a distant seat from the classic class lecture. M-learning has started to settle into this support position as well because there are few revolutionary ways of using the new technology other than to provide lecturer notes and content video and audio.

Copyright by Mahidol University

Without some preset instructional plan for using smartphones and tablet computers in a college classroom, teachers fall between two extremes; either they enforce draconian grade school edicts forbidding all digital devices, or they slide into benevolent chaos. A good-natured instructor drones on to a room of students oblivious to the teacher teaching. Instead, there is a flurry of swiping and clicking on devices. Students are chatting online, update status, snap selfies and occasionally, taking notes. The first method is too unreasonably strict and in the second, the technology distracts from the education process, not supporting it.

Research from Canada showed students bring laptops with the intention of using it for note taking, but that the users tend to go off-task, and 50 percent never use it for anything relating to classroom learning (Ragan, Jennings, Massey, & Doolittle, 2014). If the distraction caused by attempting to multitask is included (Sana, Weston, & Cepeda, 2013), the modern technology-enable classroom becomes an imperfect place for a lecture-based instruction, defeating the whole purpose of grouping students into a classroom. New methods are needed to make the most out of the educational potential of the personal electronics because they are only become more accepted and impossible to keep out of the class. With wearable computing starting to come into its own, are we to ban all jewelry, watches, sunglasses, as well as the phone? Although it is still controversial in Thailand, already the US school systems have come to peace with allowing calculators into the classroom. Modern ones are essentially mobile computers that can be programmed and store information, and there are hacks to permit them to wirelessly connect to other devices. How is a computer that is a calculator different from using a virtual calculator installed on an iPod or iPhone or a smartwatch? Should a laptop be allowed but not a smartphone? Because mobile technology has become increasingly more crucial for completing homework and reports, how can students bring their tech to school but then make sure it is secure if it is not allowed to be in their immediate possession during a class?

Thus, we are at the point where teachers either need to go through an airport-type security protocol, using metal detectors and pat downs to eliminate all possible technological contaminates. Or we allow technology in the classroom.

Copyright by Mahidol University

If mobile devices are allowed, the issue then becomes how best to use it to help the educational process. An example of this has been the Thailand Ministry of

Education's One Tablet One Child policy started in 2012, with the main countrywide launch of 1.6 million units. Viriyapong and Harfield's pilot (2013) showed the complexity of the issues in deciding on the appropriate software and digital media and learning platform in a way that challenges first grade students with a wide variety of backgrounds. Thai students' poor performance on the 2012 Program for International Student Assessment (PISA) (OECD, 2013) shows there needs to be a radically different method of education because a liberal sprinkling of technology and money will not automatically make the PISA statistics grow sweeter. One of the blatant deficiencies of the current m-learning research has been that there is too much focus on developing new proprietary education platforms but a lack of a truly innovative instructional design that can work on all computer platforms. A new m-pedagogy should encourage a different learning dynamic that best fits students' learning needs and with the tools they have in hand. Much of the m-learning research focus on proprietary software and hardware that forces limited adoption, increases expense, and restricts the use of such leaning platforms (Cochrane, 2013). Research on students' mobile services usage conducted in this thesis and in other research projects by this author showed overwhelmingly that students despise learning platform. They know they have been restricted to enclosed learning cage that is closely controlled and monitored by the instructor. The majority only use these packages because they are forced to as part of the process. This author's contention is that it is extremely challenging to have students accept the usage of learning platforms that they are coerced into using. At best, they are mildly indifferent.

In contrast, the instructional design in this research is not restricted to a mobile computing platform or operating system. The author has focused on developing a method that can be used in the classroom, is cooperative in nature and uses publicly available services that are accessible through the web and quite familiar to students.

The researcher in this project has developed an original mobile learning instructional design called mCpath, the condensed version of the term Mobile Computing Path Learning. In its pure experimental form, there are no lectures from an instructor. During class, students work in teams and use their mobile computing devices to search for information and answer questions. Each student in a learning

Copyright by Mahidol University

team also has a role that has learning tasks, and that the person is solely responsible for completing a report and will be graded individually on the quality of the work. The team grade for each mCpath session comes from the mean of the individual role scores from the outcome reports.

As to introductory science class at the undergraduate level, one of the issues with students learning that they must master the basics before they can reach a level where they can start developing new knowledge. For most, they see it as having to memorize a long list of technical terms or of having to try to collect huge chunks of theory in their memory without relating it to how it can be used in real situations. To get more students more involved with understanding rather than just focusing on recall, science educators in the last several years have experimented with using virtual labs (Laronde & MacLeod, 2012), physical interactions (Anastopoulou, Sharples, & Baber, 2011), mobile learning apps (O'Rourke, MacDonald, & Goldschmidt, 2010), and of course game-based learning (Koutromanos & Avraamidou, 2014; Meluso, Zheng, Spires, & Lester, 2012).

At first, this author expected that with an introductory computer class, there would be fewer problems with students having to struggle to familiarize themselves with the terminology than there would be in introductory chemistry, biology or physics subjects. This is because almost all students would have been familiar with using computers, have taken a computer class during high school and interact with laptops and smartphones daily. So, the expectation was that students would be more familiar with simple terminologies, such as hard drive, RAM, and ROM. Through the data collected from the pretest learning journal, what was clear was most students still perceived studying a computer subject as like studying other science topics. To most of them, these are difficult to understand, dry items that had to be mastered by rote memorization.

One of the purposes of the mCpath method developed in this work is to encourage students to better learn the essentials through their exploration. They find the answers on their own or with the help of other teammates. It is the difference of learning the directions through either memorizing the route from a map or driving through the roads with the help of GPS and friends. Because there is more involvement and interaction with finding the right answer to a question through this

Copyright by Mahidol University

m-learning method, the original expectations were that it was more likely that students can remember the information better without having to go consciously through the ritual of memorizing. This would be because they actively engage with finding the information.

The reporting process requires reflection of what was learned to better cement the new knowledge into an individual's schema structure. Resting on Vygotsky's constructivist, the social interaction between the teams encourages power users to teach the computer neophytes, helping them quickly up to the next level of the educational ladder. If the newbies score higher, the whole team will score higher, so there is an incentive for the ones that know more to help.

The mCpath method was developed from a constructivist concept of first considering the prior knowledge and skills of the undergraduate students and then developing the instruction based on this. This was started by first looking closely at mobile computer and the mobile services that most undergraduates use. The author of this project was the co-researcher working on an extensive survey of media usage of Thai undergraduate students. The author developed a mobile media version of the study to better understand how undergraduates use mobile devices. The core of the method came from the results of the pre-research surveys. One of the big discussion topics in technology is how to get users to better accept a new technology. The basis of the mCpath instructional design was to create an educational method based on the computer platforms that students owned and on the services they are most familiar with. Because the testbed for the process would be a computer class, the method was designed to increase the level of digital literacy. Improve digital literacy has been a priority for educational institutions and governments throughout the world, as well as for individual universities. Around this, a cooperative group method was developed. Students would need to work together but at the same time to reduce the free rider effect, students would be responsible for their portion of their work. Because the results of the educational media survey conducted in Thailand and the more focused mobile media results showed that undergraduates dislike learning platforms, the method was developed around services that can be accessed on any computer platform.

Copyright by Mahidol University

The peer instruction method (Mazur, 2007) was one of the original inspirations for developing the mCpath method of learning in cooperative groups. It was the introduction in Mazur's book where he explains his issue about using PowerPoint in class. Students asked for a copy of the slides before the class, but Mazur said when he did this, students would complain that because they already had the slides. They already knew what he was teaching so why did not he teach something new.

Although undergraduate classes in Thailand certainly has a different dynamic than does an introductory physics class at Harvard, yet the fixation that the presentation has everything needed to learn was similar. In the last 10 years, there has popped up a new type of students that comes to class with no pen, no pencil and no paper. They expect the teacher to give them a copy of the PowerPoint presentation. There is little to no effort made to master the materials during the class. Most of these students practice just-in-time studying and take only a day or two before to cram for the exam. Of course, in this short of period, these students cannot read the book and the supplemental handouts, so they go for the bullet points of a presentation. The newer sneak and shoot method, where students take digital snapshots has the added problem of readability of the materials.

Yet these same smartphones taking photos of slides can be used to find class material. For an introductory computer course, there are more than enough resources to answer any elemental question. Yet there tends to be a gap in understanding or ability or motivation with these types of students that they can use their mobile devices in this way. It is the educational equivalent of dying of thirst in the middle of a river.

Going back to the inspiration of peer learning for mCpath, the over reliance of class presentations was the same issue for both methods.

The original peer learning process allowed for interaction between students when they took class assessments, so that those students that knew more about physics helped reduce the misconceptions of those that knew less. The short presentations and then follow up with concept tests in physics that became the tool for peer interaction and reflection. The other issue was his problems with students' focus on memorizing facts but not being able to understand the basic concepts. The Peer

Copyright by Mahidol University

Instruction shortens a lecture down to 10 minutes, relies on short multiple-choice questions to measure understanding, followed by peer discussion and then another quick test to gauge the understanding at that point (Green, 2003).

What is different between peer learning and mCpath was the source of class material. In the peer method, the instructor was still providing lecturers but just more to the point. Although scanned answer forms or clickers could be used to quickly collect feedback, technology was not at the core of the process, and any web search was an add-on, not native to the process. For the mCpath, the ultimate source of information would be the internet.

The other element adopted from peer learning was the testing of understanding through concept tests. The author needed some way to guide exploration on the internet through a series of questions. Although there are many differences between the mCpath learning method and peer instruction, its method of using test banks as concept tests to be used in the class did help inspire the types of questions asked in the path of mCpath. The Thailand institutional bias against using multiple choice encouraged this author to use short essay questions.

Instead of using test items that were too narrowly focused on a particularly area, a wide range of prompt were developed to help stimulate question development. The initial stems came from prompts to write questions that fit Blooms Taxonomy. Question stems from other educational models were also used. These include Felder and Soloman's Index of Learning Styles (Laronde & MacLeod, 2012), ways to inspire student creativity (Glassman, 2011), and several other papers on educational tasks (Doyle, 1979; Ornstein, 1995). Because Bloom's Taxonomy is the main educational model used in this research, most of the questions were developed to prompt at the understanding and recall levels. An open-source software package called Compendium was used to diagram out the question prompts. The same package was used to make the original path diagrams for the pilot phase and the first experimental term of the project. This lead to then next stimulus for mCpath development.

The inspiration for path in the mobile path learning method comes from Bucher's 344 Questions (Bucher, 2012), a whimsical self-exploration guide that has colorful flow charts that range from a simple series of why to the more soul searching what are you doing with your life. The beautifully drawn branches encourage the

Copyright by Mahidol University

concept of following a trail or a path. The author soon realized that creating something like this for every lesson would be too time-consuming. Because of this, the initial path questions took on the form of a mind map, with several branches coming from one hub. In its current stage of development, the paths have been trimmed to two. Visually, they work better as a list because of the limits of following the graphic element on a small 4 inch iPhone 5 display, but the original terminology of being a path was kept.

One major issue with allowing students to use their mobile devices in class is to encourage them to focus on using them for learning. Otherwise, an instructor has a class of students focused on updating their Facebook status or playing Angry Bird. Those doing research in computer-mediated collaborative learning have been wrestling with this for some time. M-learning enquiry in this area has just started (Sha, Looi, Chen, & Zhang, 2011; Sung & Hwang, 2013). Although students need to work in teams, the mCpath solution is to hold each accountable, or the students will see that the assessment process is unfair, affecting the amount of effort put into learning (Q. Wang, 2009). The 2010 Morris et al. paper in group study led to the idea of including roles with simple names and evaluating students individual performance based on an assessment of the performance of these tasks. In the mCpath process, a student may decide to chat with friends online or go for a smoke outside during class, but the same amount of work will still be there, so the student will have to take out of class or receive a low evaluation for poor effort.

1.2 Significance of the study

Because most undergraduates own a laptop and have wi-fi access on campus, at home and in many public areas, m-learning is already well along in replacing e-learning in importance (Nedungadi & Raman, 2012; Tseng, Tang, & Morris, 2016; A. L. Wang, 2015). The issue is how m-learning is used to teach. In most education platforms like Blackboard and Moodle, just as in the lecture format the class is built around delivering content from the teacher.

Copyright by Mahidol University

In contrast, the new method developed and tested in the project is radically different from the classic lecture format. Through searching for answers to path

questions, students search and find their information. The instructor sets the direction of learning through designing the path questions and evaluating the reports, but it is the students in discussion with other group members that decides on the most appropriate content to use for learning. Although the teacher sets the general path and has a concept of what students should find during the exploration, there is space for finding a fresh take on what was expected to be a well-worn topic. Instead of opening pre-packaged tidbits, the process allows for the synthesis of new knowledge. Because of this, the process can challenge the lecture as much as it does the students. Each cycle of mCpath creates unique answers.

The mobile computing path learning method devised and tested in this research is original and unique. Up to this point, this researcher has been unable to find any other instructional design that uses searching on mobile devices in class to cooperative learn to improve both digital information literacy and digital literacy of undergraduates. Only recently in 2016 has the author finally found any method that was anywhere comparable to mCpath, this being team-based learning as designed by Michaelsen (Parmelee, Michaelsen, Cook, & Hudes, 2012). This method was discovered way too late to have any influence on the structure of mCpath. Through the experimental process, the current author decided that the optimal group size for mCpath is five members. For team-based learning, Michaelsen and Sweet recommend five to seven members per team, and the learning process happens during class time (Michaelsen & Sweet, 2008). Team-based learning also has a significant amount of ice-breaking activities; something added and refined in mCpath process after the author's first experimental cycle with the method. Its focus on accountability is similar, but the way it is measured is different. Team-based learning uses an individual readiness test before taking the team readiness exam, while the mCpath individual assessment is based on that person's report.

Team-based learning is more like peer-based learning in that it heavily relies on multiple-choice items to allow quicker feedback. This means that an instructor has already restricted the material to what that instructor or a test-bank maker thinks is the right answer. There are many other differences as well.

Copyright by Mahidol University

The big difference in mCpath learning is that each team member has individually-defined roles, and they are graded on their work in these positions. The four roles are as follows:

- Auditor
- Presenter
- Reporter
- Researcher

These roles are interlocked in a way to encourage collaboration. For example, the Presenter receives the initial feedback from the lecturer, allowing the other members to adjust they type of information found, as well as the quality of the source material. Researchers and Auditors can help find sources and information that they can give to their Reporters to use. Because the roles are rotated each time, students can learn from each other. Former Auditors can share instructor feedback with the current Auditor. If teams work closely together, they should improve the score for both individuals and the whole group.

MCpath is also completely original in the way that it includes the two components of digital literacy, computer literacy, and information literacy, into a group learning method. Through answering the path questions, students are given authentic learning problems. Students are not practicing searching for fictional information. They are not being tested using case study questions, where the information has no relevance to them. In contrast, students are learning more about computer system through searching for their information. They are searching for information to prepare for their midterm, and in the process, they are also developing their search skills. Assessment is based on the quality and quantity of information and the quality of the internet sources, not on a multiple-choice selection. This is the difference in learning the theory of playing badminton versus playing in a competitive match and then receiving detailed feedback from the coach in an event. The method related directly to the types of technological skills required in the 21st century (Thoman & Jolis, 2005).

Copyright by Mahidol University

In designing mCpath, several limitations were set. The purpose of these were to ensure equal access and encourage technological acceptance by the students.

First, the new mobile instruction design used in this research needed to be platform independent and not require students to use or own any hardware, operating system or software. The only requirement would be access to a mobile computer and internet connection. The definition of a mobile computer device was broadened enough to include laptops, as well as smartphones and computer tablets. This was to ensure all students in the class had equal ability to participate in the class work. At the beginning of the project in 2012, almost all students used a cell phone, but it was not noticeable yet that these all were smartphones or were able to connect to the internet. There were also several other mobile operating systems other than Android and IOS, with Microsoft pushing its new mobile operating system. Although in declining numbers, a few students still were using Blackberry phones. At the time, applications were not as platform neutral as they are in 2016.

Pre-experimental survey information confirmed the practicality of using mobile computing devices that can connect to wi-fi or cellular 3g/edge data services with all students. The experiment requires only that the students access to search services through their web browser or an application, not requiring any specialized learning platform. Students can use any brand name smartphone, any computer tablet with internet access, or any laptop. This completely avoids any issues with compatibility plaguing other m-learning situations.

M-learning methods also tend to be platform-dependent. One great example is the promotion of using iPad and associated learning apps, locking in an instructor and students into an education solution, a solution that costs a premium. The Thai government's One Tablet per Child program certainly cannot afford the top-tier price, so has outsourced the PC tablet (Hardy & Nanni, 2015; Laohajaratsang, 2013, October; Sakawee, 2014, February 3). Having an institute locked into a platform is ideal for a commercial company but not practical for schools and universities on limited budgets. Some of the most recognized universities in the world, such as MIT, Stanford, and Berkley, have been part of the massive open online course movement, offering course content for free. One of the issues with MOOCs is it is just an online lecture, so back to the classic teacher talks, students listen model. It is a newer version of the distance learning model used by PBS since the '70s.

Copyright by Mahidol University

Most m-learning methods heavily rely on learning platforms. In the last couple of years, these have become more platform independent and more mobile phone friendly, but most of those were developed with e-learning mind and not focused on taking advantage of the unique capabilities of smartphones and other mobile devices. These instructional designs are based on mature learning models that make incremental changes to the classic method of classroom instruction.

The second limitation placed on mCpath was that websites or service used had to be accessible to any computer or person. To do this, the instruction would be designed around the mobile media that undergraduates used the most, helping ensure the acceptance of the method. The mobile media results clearly pointed to using search engines like Google and Bing. One of the major issues in digital literacy of the 21st century is improving information literacy side of the equation. By having the mCpath process focus on searching services, digital search literacy should improve through practice, through having students reflect on their ability to evaluate the quality of website content critically.

Most of the new m-learning methods are also one-shot research projects, used for completion of Ph.D., published once and then left on the library stacks to quickly fade into obscurity. This research on the mCpath instruction is part of a proof of concept; those undergraduates can learn on their own using their mobile devices and cooperative teamwork during class time. This research project is the initial stage that will help refine the method before it is implemented permanently into the classroom for that introduction to computer class from where it was researched. The next phase of implementation will be to test mCpath in a variety of disciplines in different configurations and then from this work, provide workshops on how to incorporate the methodology at other universities and institutes.

One the byproducts of the current project is the development of a protocol for students on how to properly use cell phones for learning. As undergraduates become more adept at using smartphones for note taking and for assisting in looking up terms used in class, they always have the strong temptation of using these devices as a major learning distraction. One of the challenges in a modern classroom is to develop a system where it is to the students' best interest to stay focused on a topic during class. Because of this, the classic lecture format should change, where a teacher

Copyright by Mahidol University

would drone on for an hour or more, with only a slight pause to ask for non-existent questions and then back to the really, long explanation. The mobile learning protocol applies as much to the lecturer as to the students in what and what not to do in a classroom.

The individual roles of the teams in mCpath have been mapped to the most used educational requirements in both the USA and Thailand, so a class that includes this teaching method can document the skills and knowledge outcome that is required for quality assurance and accreditation. Because of the team element and the process of searching for information, evaluating it, and using it, it embeds the 21st century skills, information literacy skills, self-regulated learning and use of mobile technology for learning into the teaching process in an intense way that would be demanding to match with any other method.

Unlike most of the m-learning research, this year-long experiment was designed with a large enough participant size to have the statistical power of 70 percent to measure a medium effect in differences.

1.3 Research question and research objectives

The purpose of the new instructional design was to increase digital literacy through contextual learning. The method uses social interaction and mobile technology as scaffolding to improve students' understanding and knowledge.

The overall research question is if using this technological instructional design in a controlled classroom will influence undergraduates' information literacy and knowledge and understanding large enough to be significantly different from that from regular classroom lecture pedagogy?

This central question divides into the main research questions:

1. To what extent will using online searches through mobile devices in the classroom change the digital information literacy of undergraduate students?

2. To what extent will using online searches through mobile devices in the classroom change the level of knowledge and understanding of undergraduate students about computer concepts?

Copyright by Mahidol University

3. What will be undergraduates' attitude in using mCpath instruction in cooperative teams in the classroom?

4. How will the use of online searches through mobile devices in the classroom change the usage of media by undergraduates?

To answer these questions, the author developed and pilot tested three instruments. The Digital Search Literacy Assessment was used to measure digital information literacy knowledge. The computer concept assessment measures participants' knowledge about basic computer systems. Finally, the Mobile Media Learning Survey collects information on the types of mobile devices students use, as well as asks about the frequency of use for a wide variety of mobile services. Each instrument collects different quantitative information to assist in answering the research questions.

For the questions backed by qualitative results, the main independent variable will be experimental treatment. This includes the control group, the experimental group and the hybrid experimental group.

Other factors that may influence the dependent variable are gender, age, year of study, major and class term. The computer concept test helps answer the question about knowledge of these concepts. Participants took this instrument three times during each term.

The dependent variable for research question one measuring information literacy would be the score from the Digital Search Literacy Assessment. The dependent variable for question two on would knowledge about computer improve would be the score from both the computer concept midterm and final posttests. For question three about students' attitude about the new m-learning method, the mean average of total usage would be used as the dependent variable.

The experiment was designed to measure the effect of m-learning on digital information literacy and the knowledge of computer concepts, using participants from three sections of an introduction to computer class for three terms. One sections received the experimental treatment once a week, four weeks in a role. Instead of receiving a class lecture, students learned on their own in groups using the mCpath method. The control class section was not allowed us their cell phone or mobile devices during class. During the experiment, the students in the control group

Copyright by Mahidol University

received a normal class lecture. Another section designated hybrid received treatment every other week. For one week, they would learn using the mCpath method, and then the next week after, they would receive a class lecture, not being allowed to use their mobile computing devices during class.

The basic naive assumption made going into this research was that there will be a positive effect, that students through using the cooperative m-learn method will have higher scores than students in the control group. The experimental groups are more likely to have a higher score on their midterm exams than would the control group. They would score higher on digital literacy than would the control group. The experimental group would be using their own mobile computing equipment with the internet search services they said they use the most frequently. Because they have become more comfortable using their mobile devices and were more likely to accept the use of the technology, naive expectations where they would be more likely to use more mobile media than would the control sections. The expectation is that having the participants use their own computer equipment, using the website they use most frequently and working together with others will help participant better accept this method, putting more effort into the learning process.

A second potential outcome would be that there would be no significant difference between any of the experimental treatment sections and control sections, in both information literacy and mastery of computer concepts. Numerous current and past e-learning and m-learning research projects showed no significant difference between the control and the experimental group. This is a large enough phenomena that the website www.nosignificantdifference.org has dedicated to it, continuing to collect more to the initial 355 cases (T. L. Russell, 1999). Most of the original e-learning and m-learning platforms are just an extension of the classroom instruction pedagogy. For providing instruction, this could be through video or audio recording, PowerPoint presentations or lecture, an example of this being the open source Moodle platform (Martin-Blas & Serrano-Fernandez, 2009). So, it is not surprising in these cases that there is no significant difference between learning through digital instruction and lectures.

Copyright by Mahidol University

Cochrane (2012), a millennial pioneer in m-learning, acknowledged publicly that this revolutionary method of learning is not so revolutionary. Even in

cases where he said a researcher had declared a method a success, the evidence of a statistically significant difference was iffy. From a review of success and failures, he developed his listed of six critical success factors. These are as follows:

- Integrate technology into course and assessment
- Teacher modeling of the use of tools
- Create a supportive learning environment
- Appropriate choice of mobile devices and social software
- Match mobile web with social constructivist paradigms
- Create sustained interaction with scaffolding

Cochrane's recommended integrating technology into the classroom. In the current research, the author has incorporated the use of mobile devices into a computer class for undergraduates to improve the computer knowledge and to improve their searching skills. In this case, the device and the applications that are the focus of the class are being used by the students to help them have better knowledge about both. As to measuring information literacy, the author has mapped the mCpath digital search literacy outcomes to the recognized US ILCSHE information literacy standard and two other information literacy standards. The US standard was included as a major component of the learning outcome in the total quality framework 3 form, a required document at all Thai universities. The information literacy outcomes were also included as part of the orientation, the midterm review session and the mCpath instruction sessions.

Cochrane (2012) also recommended that the teacher model the use of the system by walking through an example and vocally explaining the internal thought process. This was also incorporated into mCpath. There were two computer lab sessions before the midterm and one after where the author used one of the path questions and showed students how to use search filters, search terms and how to evaluate the quality of the search results.

As to selecting the appropriate mobile device and web 2.0 social software, again the author used a pre-experimental mobile learning media survey to collect detailed information on what mobile computer platforms students and what mobile media was most used.

Copyright by Mahidol University

The mCpath design was solidly based on social constructivist theory. The whole process starting by measuring students' prior knowledge and skill and then through peer interaction and use of mobile searching apps, consciously providing helpful ladders. This transitions to Cochrane's last point that scaffolding should not be presumed just to happen.

To quickly explain, the mCpath method includes four roles:

- Auditor
- Presenter
- Reporter
- Researcher

Although each report generated from each student individually assessed, these roles were designed to interconnect, so that each supports the key role, the Reporter.

Going back to how challenging it is to create an effective new learning technology, Hattie's comprehensive meta-analysis (2008) shows the effect size of computer-assisted learning was about the same as the mean effect size of all teaching methods and about half the effect size for web-based learning. It is against the odds in finding a sizable difference between regular class learning and one supplemented by computer technology. In summary, the vast amount of literature in this area would tend to predict there may be no significant difference regarding learning using m-learning versus learning in a class lecture. One expectation would be that there would be no significant difference between the control and experimental group.

Of course, the last possible results would be that participants that use cooperative m-learning and that by learning on their own and in teams, will have lower midterm scores than do participants in the control sections. The general expectation in this case is that undergraduates learn less effectively when learning on their own or in a group, compared to being provided content through a lecture that includes many differences sources into a condensed, structured form that is outlined through a PowerPoint-type presentation. This is more likely for the experimental sections that only use m-learning and less likely for the hybrid learning sections that still listen to a class lecture every other week. In this situation, the expectation would be that even with the help of peers, individual students may have problems sorting

Copyright by Mahidol University

through content on their own and be able to pinpoint the subject matter that was relevant to answering questions. The other issue could be the sharing of information, that an individual Reporters did not provide reports to their whole group or that an individual Reporter did not find information that was useful for preparing for the midterm.

Because the experimental sections use searching more often, it is highly unlikely that their digital literacy levels would be lower than for the control group. For both the experimental and hybrid sections, it would be expected that these participants would have higher digital literacy skills. This would mean that these students could find more information more directly to the question asked and they can do it quicker. They would also be more critical and more aware of what makes for better quality information. They would also be able to understand the legality of using copyrighted and creative common licensed material.

Because it is possible to have either a positive or negative significant difference, a two-tailed test will be used for the quantitative analysis.

Most the research is quantitative. The one issue with this is that an effect can be seen and measured, but a statistic by itself does not necessarily explain what is happening or why something happening. Qualitative analysis can better clarify the reason, especially when there are unexpected results. The mCpath process does generate huge amounts of student-generated content, and the learning journals give a practical insight into students' thinking process, how they evaluate websites. The learning journals also help answer question three, what are their attitudes toward using mCpath for learning.

The following hypotheses will be tested using a range of statistical methods that best fit the type of data collected:

- Hypothesis 1: There is no significant difference in computer concept scores between the control group, the hybrid group and the experimental group for either the posttest or retention test.
- Hypothesis 2: There is no significant difference in Digital Search Literacy Assessment scores between the control group, the hybrid group and the experimental group for the posttest.

Copyright by Mahidol University

- Hypothesis 3: The change in how participants use mobile media is not significantly different for the control group, hybrid group or the experimental group.

The 21st-century learning guidelines emphasize using technology, self-learning, and teamwork as ways to shift toward actual learner-centered instruction in classrooms (AASL, 2007; Binkley et al., 2012; National Institute of Education-Singapore, 2009; Thoman & Jolis, 2005). These usually go hand in hand with world popular outcome-based learning. Again, this author has selected m-learning using internet searching as the most relevant technology and the one most likely to be accepted by undergraduates. Through the original development of Mobile Computing Path Learning, the three 21st century skills have been synthesized into the process that has clearly defined information literacy outcomes mapped to information literacy standards.

In this proof of concept project, undergraduates will be using mobile computers and searching the internet during class in the process of finding information on computer concepts. They will be developing their digital literacy skills in working in groups and learning more about digital literacy. The instruction design is not platform dependent. Students can use any mobile computing device that has internet access. Because the instruction was fashioned around the most-used service used by undergraduate, this author theorizes that this method is more likely to be better accepted than would the use of a proprietary m-learning platform.

The author of this project expected to have three phases of development:

- Phase 1: pre-experimental phase
- Phase 2: experimental phase
- Phase 3: post-experimental phase

The pre-experimental stage was when the original data from the Mobile Media Learning Survey was collected. The survey was pilot tested and then eventually given to a total of 439 participants taking an introductory computer class, the same that was used for the experiment. The mCpath instruction design came from the analysis. The design also twice pilot tested the term before the experimental phase.

Copyright by Mahidol University

The current research project outlined in this thesis covers experimental phase two. The period was for a whole academic school year. For the institution where

the experiment was conducted, this was three 12-week terms. Participants were undergraduates taking one of the three sections of an introductory computer class.

The research objective in this segment relates to preparing for phase three. In the post-experimental phase, the most effective version of mCpath would be used in all sections of the introductory computer class.

Because both the experiment about the effectiveness of mCpath and the development and refinement of mCpath take place at the same time, the results from the round in one term can be used help improve the process for the next. The author made minor revisions from one mCpath cycle to the next. More major revisions were held till the start of the next term.

The main objective of the research at the end of phase two was as follows:

- Analyze the effectiveness of mCpath regarding students being able to learn basic concepts and improve their information literacy compared to the control group
- Through comparison of the results from the experimental and hybrid section and taking into consideration participants' attitude toward the method, implement the most effective version of mCpath

As was discussed before, ideally, the experimental method where students learn individually and in groups each week would show that students score the highest. Because they would be using their mobile equipment and using web services they already use often, optimistically, they would also have a strong positive attitude toward this collaborate m-learning.

Because there are so many parameters, such as group size, class time used, the number of path questions, sharing of information, it is unlikely to get the perfect blend in the first year. Again, most of the literature in e-learning and m-learning point at there being no significant difference between these and a class lecture. Because of the development of self-learning, working together and using technology to learn are skills valued in themselves. As happens in many cases with experiments, insights into how self-learning and cooperative learning works may lead in an unexpected direction.

Copyright by Mahidol University

1.4 Explanation of Definitions

In this thesis, “digital literacy” will be used to mean any literacy skills or knowledge that relate to computers or computer technology in the broadest of senses.

The term “information literacy” is used most often when talking about internet search skills, and it evolved from library literacy under library sciences. This research project will redefine information literacy as digital information literacy. As will be discussed at length in the literature review, there has been issues with a cacophony of terms that mix technology and literacy together. Digital literacy best fits these under one umbrella category, and the term digital information literacy more precisely defines what type of digital literacy is being measured in quite an understandable way with minimal explanation involved. In keeping with the naming scheme, computer literacy will be renamed digital computer literacy. Operationalize measurement of digital computers literacy will focus on basic knowledge about computers, termed computer concepts.

The term “mCpath” is abbreviated form of Mobile Computing Path Learning, the unique m-learning method that was created, developed and tested in this project through a quasi-experiment. Working in groups during class time, students use their mobile devices to find information for path questions. There are four roles that each of the mCpath team members can select.

- Auditor
- Presenter
- Reporter
- Researcher

To avoid possible confusion regarding the role names, in this paper they will be capitalized. For an example, the word “Researcher” because it is capitalized will refer to the mCpath role of researcher. In contrast, the term “researcher” all spelled in lowercase letters may refer to different individuals doing research, or writing research papers. This will be the same for “Presenter” and “presenter”, “Auditor” and “auditor”, and “Reporter” and “reporter.”

Copyright by Mahidol University

The class experiment was conduct thought a whole school year for three trimesters. To help clarify, the terms “experimental term 1”, “experiment term 2”, and “experimental term 3” will be used to identify the time discussed.

CHAPTER II
LITERATURE REVIEW

2.1 Introduction to the literature review

The Mobile Computing Path Learning method cuts across many specialty areas, so the literature search includes digital literacy, technology acceptance, m-learning and computer-supported collaborative learning (CSCL).

Again, the mCpath instruction is unique and unlike any other m-learning methodology used or being researched. It was designed initially from the ground up, based on on what mobile computing devices and the websites Thai undergraduates use the most. To ensure there were no issues with accessibility for all students in class, the definition of mobile computing devices was broadened to include laptops and tablet computers. The teaching technique that may come the closest to this unique instruction design is Peer Instruction (Mazure, 1997). This is because both relate to team learning and uses advance technology as part of its process. An essential element for Peer Instruction is class clickers, where students can vote during class on the right answer, and the results can be quickly shared with everyone (Miller, Lasry, Lukoff, Schell, & Mazur, 2014). Although there are conference papers on the topic, there are few journal articles on it, despite this being a pre-2000 phenomena.

This instructional design differs from mCpath in many respects, the main one being that with mCpath, the assessment needs to be in the context of what is being learned, so the teacher goes through the mCpath reports and assesses each student individually. A rubric can speed up the process, but there is more mental effort required than just quickly tallying up multiple choice results. This also means that in mCpath there is delay in giving back students their results. This is not an issue with Peer Instruction and the almost instant feedback is one of its key features. Mobile Computing Path Instruction could be adapted to use multiple-choice assessments, but this would be arduous being that the content found on the web can be completely different for each team, and even the same team will find different answers, given

Copyright by Mahidol University

when they search and the search terms and search services they use. Interesting enough, with multiple-choice items, Miller et al. (2014)have shown that students took more time when they chose an incorrect answer than they do if they get the correct answer.

Another difference is that although both have students work collaboratively during class, in the mCpath method, each student has a role that will receive both an individual grade and a team grade, minimizing the issue of free riders. There is an introduction phase used to help start developing a sense of team and then there is another major team-building activity. With Peer Instruction, there is a group discussion to come to consensus. There is no one particular method of collaborating, and the teacher has to develop a supportive atmosphere (Green, 2003).

Although there can be a range of methods of collecting the results from students in the Peer Instruction, the method has been used with the use of clicker technology(Miller et al., 2014), requiring budget requests, purchase of specific electrical systems, and maintenance of the equipment, with either the staff, teacher or students being held accountable for lost or broken equipment. In contrast with mCpath instruction, students use their own equipment and use search services that are ubiquitous. The main issue is the connectivity speed of the wi-fi, but this is supplemented by having some of the students collect through their 3G cellphone services.

The newer trend has been to replace the clicker with that functionality using a mobile phone (Stowell, 2015). This can be a simple SMS or microblogging (Tremblay, 2010), setting up a complete website (Lam, Wong, Mohan, Xu, & Lam, 2011, December), developing a mobile app (Cheong, Bruno, & Cheong, 2012) or using a learning platform (Benkraouda, Madi, Abada, & Qamhieh, 2013). The Student Response Systems can also use smartphones, cell phones, iPods, iPads, as well as computer notebooks (Arnesen, Korpas, Hennissen, & Stav, 2013).

Because the originator of Peer Instruction used it to teach physics, the method has been used most regularly in the sciences (Gok, 2012; Macarthur, Jones, & Suits, 2011; Miller et al., 2014; Tremblay, 2010). It is also used more often in introductory undergraduate classes (Benkraouda et al., 2013; Mazure, 1997), and in large classes (Macarthur et al., 2011; Ragan et al., 2014).

Copyright by Mahidol University

2.2 Digital literacy, computer literacy and information literacy

The world focus on computer literacy mainly came from the US National Commission on Excellence 1983 report famously named *A Nation at Risk*, documenting US students falling behind in the critical sciences (Lankshear & Knobel, 2011; Vinovskis, 2009). One of the five recommendations was to have high school students take a half of year of computer science (Gardner et al., 1983), thus blending computer competency into the essential competitive mix of math and English that was needed for an educated workplace. The Committee on Information Technology Literacy's 1999 report marked a conspicuous point where computer literacy ranked up there with reading and writing (Snyder et al., 1999). This connection between technology advancement in education to continue to stimulate a nation's economic grown has spread from the United States to the rest of the world. The best examples of this was the Prague Declaration by UNESCO and member countries that made information literacy a priority for all countries (Thompson & Cody, 2003). Another example is the early 2010 world-wide fascination and focus on what skills students need for the 21st century (AASL, 2007; Binkley et al., 2012; National Institute of Education-Singapore, 2009; Voogt, Erstad, Dede, & Mishra, 2013). With its PISA's educational assessments, OECD closely connects literacy to economic development (OECD, 2013). There has been a positive relationship between US industry and education in driving research into innovative technology that then drives the international economy (National Academy of Sciences, 2012). Smaller Asian countries fear that without a highly technologically literate workforce, their economies will lag. The EU also directly links digital literacy to economics, as well as to health and vigorous society (Ala-Mutka, 2011).

The introductory computer class used in this research still has at its heart contains the basis of computer literacy that developed in the 1980s during the personal computer era. The term initially included a hodgepodge of mainframe concepts, such as learning BASIC and developing databases. This then expanded into having users use the devices, so computer literacy evolved to include knowing about basic computer concepts and acquiring practical skills in using commonly used software packages (Cartelli, 2005; Childers, 2003; Culp, Honey, & Mandinach, 2003; Hess, 1994). Because of the overwhelming dominance of the PC from that time to current

Copyright by Mahidol University

day, this meant that students would be introduced to using the Wintel platform and the Microsoft Office package. Despite the growing popularity of Apple products, Microsoft still holds a 90 percent market share in desktops and laptops (NetMarketShare, 2014). The current introduction to computers class also focuses on computer lab practice of using Windows and Microsoft Office. UNESCO documents still mainly define computer literacy as skills in using a computer but further subdivides it into hardware, software, and application literacy, some of which does include knowledge (Forest Woody Horton, 2007).

Near the year 2000 with the rising importance of the internet, computer literacy split into a multitude of related literacy terms: ICT literacy, IT literacy, multimedia literacy, media literacy and information literacy (Bawden, 2008; Lankshear & Knobel, 2008, 2011). Indeed, Eshet-Alkalai and Chajut (2010) alone added four more to the list: photo-visual literacy, reproductive literacy, branching literacy, and socio-emotional literacy. These have become associated with any technological ability or knowledge that is broad enough to fit all the current literacy and potential ones arising from more technological innovations is the term "digital literacy."

Because of the rise of social networking sites and rising use of the smartphone platform, media literacy has the potential of replacing it because *media* also includes the concept of content as well as technological means of distribution (Belshaw, 2012). Gitelman's partial definition of media as "socially realized structures of communication, where structures include both technological forms and their associated protocols…" (2006, p. 7) fits well the mobile platforms and social apps generation. For the author, the term still connects too closely to the dated multimedia era that brings back images of a pack of CD-ROM references and bulky, external speakers, much as MIS still raises images of mainframes, dumb terminals and dot matrix printers. Media accessed using mobile computing devices is part of the research conducted in this project as both parts of the pre-experimental stage and as an ongoing measurement to see if the experimental method used increases the use of mobile devices.

Copyright by Mahidol University

Although there are a few researchers still using the term “computer literacy” (Baikady & Mudhol, 2013; Lee & Huang, 2014), most have already switched to using the more inclusive digital literacy.

Recognizing the confusing caused by the multitude of literacies, in 2011 Mackey and Jacobson (2011) argue that “information literacy” should be termed “metaliteracy”. In this way, the term would include the many different forms of media and emerging technology. From this researcher’s perspective, this would cause more confusion because digital literacy already includes all variations of communication and computer technology. Using “metaliteracy” for a segment of digital literacy would cause more confusion rather than coherence in the system because it has the same comprehensive meaning of digital literacy but would apply to a smaller subset contained within it.

Again, as briefly discussed in the Research Objective section of this thesis, the term will be “digital information literacy” will be used to operationalize “information literacy” because this new term clearly fits under digital literacy, the root node of all technological siblings in the taxonomy thicket. Because most of the materials refer to searching skills as information literacy, it is better to use that term in the literature review portion.

Another factor for using digital information literacy is that information literacy also includes non-digital information and technology or digital technology that has not shed its attachment to its analog counterparts. An decent example of a recent information literacy textbook that still includes chapters on library catalogs, complete with an explanation of the Dewey numbering system (Lanning, 2012). Another chapter example would be Librarians and Library Services. Although Lanning does an admirable job of incorporating some of the most current and useful digital services, there still is the wisp of the librarian’s bias for paper, not bits. Wilder’s (2005) challenging Chronicle of Higher Education article on having library systems better fit to how students find information rather than the other way around has hit a nerve. The current research in this paper refers directly to only conduction web searches through mobile devices.

Copyright by Mahidol University

Information literacy is one facet of digital literacy that has begun to receive more attention and institutional priority, with a range of methods used to

improve students' skills. One of the original approaches was to have students attend a session organized by the university library or to have a lecturer invite in a guest speaker from the library or other technical support functions. The Auburn University Library provides an example of this type of literacy instruction. An instructor can book a 50-minute session, and a good portion of this goes to introducing library resources, as well as coving the basics of information literacy (Oravet, 2014).

Another example of a more comprehensive attempt to improve information literacy includes University of Albany UNL205 Information Literacy and UNL206 Information Literacy in the Sciences classes. Starting in 2000, the library section offers a 1-credit information literacy course (Jacobson, 2002). Although the Auburn library can include a computer lab, there were other sessions that were conducted only in a classroom. In contrast, the UNL205 and UNL206 classes had web tutorials and searching of digital databases closely integrated into the sessions. The University of Wyoming has developed 3-credit upper division information literacy classes that focus on preparing students for continued graduate studies (J. Mayer & Bowles-Terry, 2013). The one shortcoming of the Albany information literacy class was that content from students' other classes was not coupled together. The University of Wyoming's LBRY 3020 does include current movies and does set content themes, but it still is an interdisciplinary subject.

Personal epistemology research first raised the issue that learning can be different between different academic disciplines (Hofer, 2006; Momsen et al., 2013; Muis, Bendixen, & Haerle, 2006), Grafstein (2002) first identified that a teacher would be better at subject-specific searches. Since then, most research literature that considers this issue recognize that is better to teach information literacy within a specific subject area, especially in STEM subjects at the university level (Brown & Krumholz, 2002; Leckie & Fullerton, 1999; Momsen et al., 2013; Scaramozzino, 2010; Tuominen, Savolainen, & Talja, 2005; Winterman, 2009; Woolwine, 2010). The University of Strathclyde had modified the 1-credit information literacy class specifically for business majors in second or third year (Webber & Johnston, 2000). These students select a business topic to research on an individual and group basis. Other universities embed information literacy into particular subject classes, such as the business programs in Butler University and University of Auckland and a first-year

Copyright by Mahidol University

seminar in science class at Penn State University (Lindstrom & Shonrock, 2006). Librarians with specialization focus on gender studies and biology at Indiana University-Bloomington work with lecturers to integrate information literacy skills into classes (Winterman, Donovan, & Slough, 2011). Through cooperation between faculty and librarians, the California State University system has become a useful model (Dunn, 2002; Lampert, 2005).

At the other extreme, instead of having the luxury of a complete class, for quite a long time now the information literacy training has been shuffled to the web as either a voluntary or mandatory education module (Lindsay, Cummings, Johnson, & Scales, 2006). Social networking has helped add extra dimensions, including tools for librarians to assess information literacy online (Luo, 2010; Magnuson, 2013).

Bruce, Edwards and Lupton (2006) have merged, "Six frames for information literacy education" framework with their literacy model that it includes behavioral, social cultural and critical elements to create their GeST Window of information literacy (Lupton & Bruce, 2010). GeST stands for generic, situated and transformative. Transformative defined as causing social change does not work well within the purpose of the current research project, but defining information literacy as situated or relating to social situations that includes learning in context and in collaboration with peers does. Lupton and Bruce define the generic component as being the skills individuals can learn, one of the main goals of the mCpath learning method. Thus, this research can use the GeS part of the GeST framework.

The most recognized informational literacy standard is the Information Literacy Competency Standard for Higher Education (ACRL, 2000). The popular SAILS assessment is based on it (Hill, Macheak, & Siegel, 2013; Lym, Grossman, Yannotta, & Talih, 2010), as is the Information Literacy Test (Madison Assessment, 2014), the South Dakota Information Literacy Exam (Leibiger & Schweinle, 2007, March/April), and the iSkills^{TM} Assessment (I. R. Katz, 2007). Because of its uses in so many of the popular information literacy instruments and because it is easier to break is objectives into smaller nuggets that serve for the concept measured in tests, the DSL used to assess information literacy in the current research was based on the ILCSHE. Consciously or unconsciously, it has become the major factor influencing the definition of information literacy throughout the world. Because the US standards-

Copyright by Mahidol University

based education has also influenced the definition of literacy in English and technology, especially to prepare students for university-level ILCSHE and the US Common Core adopted by most state school systems. The ability to understand the meaning of a word and the variations that have a similar meaning is important in selecting search terms, as it is in writing an essay. Understanding a writer's view through language used is important in reading skills and in evaluating the bias of a website. Although language literacy and information literacy are quite often defined and seen as separate competencies, in practice they intertwine so closely as to be inseparable. The notable gap in the literature about information literacy is the standards and assessments in languages other than English. If an information literacy instrument was translated from English to another language, would the instrument still be valid? Philosophers have debated if words can have the same meaning in different languages (Chomsky, 2008; Davison, 2005; Quine, 1959; B. Russell, 2009; Wittgenstein, 2001). The UNESCO has the most comprehensive list of information literacy for 89 different languages only list the resources available for each language (Forest Woody Horton, 2014). The report is impressing, with web resources and research references for 14 versions of French, eight versions of Portuguese and English, and three versions of both Chinese and German. Despite being quite comprehensive, Horton does not discuss potential differences between searching in English and in another language in uses of search terms, search results, evaluation of credibility of sites.

The ILCSHE's 22 performance indicators (ACRL, 2000) and its detailed information literacy objectives (ACRL Task Force, 2001) makes it popular with test designers because the outcomes are defined precise enough to operationalize, increasing testing validity. The five standards are similar in nature to the UK's SCONUL Seven Pillars standards, the Six Standards of the Australian and New Zealand Information Literacy Framework (ANZILF), and the 11 stages of the UNESCO's Informational Literacy Life Cycle. Each one groups elements into similar categories. SCONUL's standard wins on brevity because each is only a word long: identify, scope, plan, gather, evaluate, manage, present. Its "able to" sentences serve as outcomes, but it is still difficult to test for knowledge on "know what you don't know to identify any gaps" or "scope their search question clearly and in appropriate

Copyright by Mahidol University

language" (SCONUL, 2011) into example questions. This because of the vagueness of the definitions. An early article from this organization presented how six different UK universities implemented the standards, and the outcomes come across more as check-off lists, without much detail, and ICT computer skills were mixed into some of the outcomes as well (SCONUL, 2004). As this author has spent endless hours grading and writing recommendation to hundreds of students on how to improve searching, he can say this method of accessing information literacy for schools lack rigor. The accomplishments came across as laudable but not that quantifiable.

Table 2.1 Information Literacy Competency Standard for Higher Education 2000

Standard Number	Standard
1	The information literate student determines the nature and extent of the information needed.
2	The information literate student accesses needed information effectively and efficiently
3	The information literate student evaluates information and its sources critically and incorporates selected information into his or her knowledge base and value system
4	The information literate student, individually or as a member of a group, uses information effectively to accomplish a specific purpose
5	The information literate student understands many of the economic, legal, and social issues surrounding the use of information and accesses and uses information ethically and legally

Copyright by Mahidol University

Within the Australian and New Zealand information literacy standard, it is perceptible that it was inspired by the US ILCSHE (Bundy, 2004). Council of Australian University Librarians does offer two versions of the Information Skills

Survey (ISS) based on this standard: one for social science and one for law majors. The evaluation method was different from the Information Literacy Test and SAILs, as it uses a self-assessment with a Likert-like scale instead of a multiple-choice format. One of the advantages of this method is that the assessment is able to measure uses of information found, one assessment standard missing from the objectives of ILCSHE and its associated assessment surveys based on it (ACRL Task Force, 2001). Fifty-seven of the student's self-assessment of students was compared to librarian's assessments after interviewing the students for one hour (Catts, 2005). It is interesting that the ISS Technical Manual recommends that the law version of the assessment only be used for first-term students.

After extensively looking at standards throughout the world and especially in Europe (Ala-Mutka, 2011; Ferrari, 2012), the EU has come out with its own information literacy framework that defines five areas of competence areas: information, communication, content creation, safety (Ferrari, 2013). These are labeled first level dimensions, with a further 21 items defined more precisely in a subcategory called second level dimensions. The self-assessment grid of dimension three maps the five competencies to three levels of usage: A-foundation or basic, B-intermediate and C-advance. In total, there are five dimensions, with each giving more specificity. Dimension five does take a concept down to specific examples that then can be developed into precise outcomes. This model does take gigantic leaps toward a totally digital view of information literacy, especially with its unique focus on digital, hardware and personal security that is not there in other frameworks. Interesting enough, the committee developing DIGCOMP officially considered constructs from commercial assessments like the iSkills, ECDL and the IC^3 and standards from other European partners and UNESCO but ignored the well-recognized US ILCSHE, the Australian/New Zealand ANZILF or the UK SCONUL (Ferrari, 2012). The inclusion of remunerative instrument that focus more on digital literacy skills does explain the inclusion of information-seeking skills in the final DIGCOMP dimensions.

Unfortunately, the Digital Search Literacy Assessment developed for this research was developed in late 2012 and pilot tested on March 2013 and DIGCOMP standards were published in August 2013, so this newest EU information literacy model has influence at the analysis phase rather than in the initial development phase.

Copyright by Mahidol University

The fourth dimension would have been useful because it grouped examples under knowledge, skills and attitude. Results from the current project showed a division between information literacy knowledge and skills.

With the new ASEAN community coming online in 2015, ASEAN members have agreed to dramatically improve both ICT infrastructure and human resource training by 2014 (ASEAN, 2000, 2010). The education ministries in both Singapore and Malaysia have made students improve their digital skills a major priority of their long-term economic plans (Chee et al., 2010; Edzan, 2008; National Institute of Education-Singapore, 2009).

2.3 Educational theory and models

This research is based on the concept of social constructivism, the Vygotsky concept that teachers challenge students with age-appropriate activities that help mold their thinking and way of learning (Karpov, 2014).

The main issue with undergraduates is that most of the molding has already been completed, so a university lecturer can smooth off the rough edges. With the matter of digital literacy, an instructor is called upon to make up huge amounts of lost ground on the last tertiary leg of three-legged education relay. The Thai educational system mandates computer classes for all (Ministry of Education-Thailand, 2008) and the students certainly attend these class. The pretest results in this project showed a complete lack of knowledge of any of the basic computer terms or concepts.

As to their hands-on computer skills, Plan-It Consulting had 900 students from the Bangkok Metropolitan Area take the ECDL Foundation Assessment, used to certify the skills of students in using word process, spreadsheets and doing online searchers. Only 30 percent of those tested passed minimal proficiency. It is the same lack of skill that this researcher sees yearly in the computer labs at the beginning of each term for the last 15 years. This is despite students having earlier access to computers at home and in school each year. There is a huge gap between Thai undergraduate students' actual digital literacy and what they think they know.

Copyright by Mahidol University

Certainly, any science professor is well aware of the issues caused by science misconception (Allen, 2014; Badenhorst, Mamede, Hartman, & Schmidt, 2014; Committee on Undergraduate Science Education-National Research Council, 1997; Larkin, 2012).The issue with computer science differs to some extent because most of the theories and concepts are artificial (Blum, 2011). Instead of observations of nature, technologies are defined by humans and committees, and the definitions and specifics can continue to evolve quickly. An example comes from wi-fi. Because hardware manufacturers and software programmers need standards that are detailed enough that they can assemble and program routers, so the actual 802.11 standard is defined by IEEE task forces and input from industry. The next 802.11ac standard is an example of this, where in 2014 the group regularly met nine times per week and closely worked with mobile phone vendors, telecommunication companies, electric manufacturers, and several S. Korean universities to develop frameworks, test scenarios and evaluate the technology. There is still plenty of testing, debates, and hearings before the standard is approved by 2019 (Gong, Hart, & Mao, 2014; IEE P802.11, 2013). In fact, with the exclusive focus on wi-fi standards to the deficit of the older standards, there are some that are worried that several different alliances will develop competing Tbps standards for Ethernet without IEEE that could slow growth in bandwidth (Anthony, 2015, January). Even the secretive and massive Apple Inc. monolith must work closely with its thousands of software developers when it rolls out a new IOS or else risk breaking its iTunes infrastructure.

For undergraduates wrestling with developing a certain level of computer literacy, this means that just like with other science subjects, students can hold misconceptions that can be tough to correct. This can be difficult to alter because many students have a false sense of mastery because they equate knowledge with familiarity of using computers since being a toddler.

Just like the use of the English language, students can be perplexed with the exceptions. They also get caught up in the bewilderment caused by the varying conflict in view by different segments of the computer, the traditional one being software programmers versus hardware engineers (Blum, 2011). Instead of trying to understand the different elements in perspective, the students are likely to grab the first web page on a topic and give this information 100 percent credibility. For sources on

Copyright by Mahidol University

the internet that introduce computer concept, there are no extremely wrong answers. It is with the degree of incompleteness or the lack of precision and detail, rather than being incorrect.

This author believes that undergraduates' prior experience and education has a dramatic effect on their ability to better acquire digital literacy knowledge and skills and to be a more competent searcher. Because of this, a large part of the preparation for the experiment was developing the mobile media survey and then measuring students' use of mobile services, as well as to what mobile devices they used. Because overwhelmingly all students used Google search heavily, the new m-learning instruction was designed on this service.

This research project is also based on Vygotsky's zones of proximal development and of different methods of scaffolding that can be used to leverage up the level of learning for students' level of development.

Vygotsky was well aware of Piaget's theory of child development (Piaget & Inhelder, 2000; Vygotski, 2012), that the stage of intellectual development changes at different ages. The curriculum of most grade schools is optimally based on keeping children focused by challenging them, staying in the educational Goldilocks range of not too easy, not too difficult. If students fall out of this golden learning zone, they are either too bored to listen or too stressed and confused to learn. Vygotsky explained that this sweet spot of learning can be broadened into a zone of proximal development if these students get a boost from peers or mature adults. Cognitive theorists had been focusing on that short-term memory could hold only a few items at a time, so early instructional design for computer learn focused on designing for humans' memory limitation (R. E. Mayer, 2009; Paas & Sweller, 2014). More research keeps continually coming out giving techniques on how to push past the working memory limitation (Ackerman & Leiser, 2014; Autin & Croizet, 2012; Klingberg, 2010).

The issue is of course that both Piaget and Vygotsky were referring to grade-school children that had many leaps to go before becoming a mature, reasoning human. This research project deals with young adults that have different learning preferences. Almost all the participants have had a computer class during their high school studies, but for whatever reason, they did not learn the basics. The likely suspect would be rote learning. Most of the initial comments in the learning journals

Copyright by Mahidol University

from students were about not liking to memorize or being confused because they wanted the parts of the reading that would be on the test clearly marked, so they could memorize this. One favorite answering technique of these students would be to write back everything memorized about a topic, hoping that the real answer would somewhere in there. This author thinks most undergraduates perceive introductory science class content as a list of challenging vocabulary words that need to be memorized. At the beginning stage, he thought at a beginning computer class would be the exception to this because most of the students started using computers well before grade school, so they would tend to be more familiar with the terminology. Again, the students' comments in learning journals showed that this was not the case, and the students had the same perception of a computer class as they did for other science topics. Elementary concepts, such as the storage size of a kilobyte or meaning of 1 Hertz that students should have heard while using a computer were described as highly theoretical concepts that were onerous to memorize. Thus, the purpose of scaffolding as it related to this research project was mainly to speed up the amount of time needed to absorb the basic computer concepts.

Scaffolding was also used to shape students' personal epistemology, meaning how they learn to learn. The college at where the research is conducted is unique in that a portion graduated from a Thai high school, some from an international high school and then some studied outside of the country. Their different educational background does have an effect on if they understand that a knowledge domain is fixed or not or being able to relate concepts with another (Fujiwara, Laulathaphol, & Phillips, 2012, January). Most Thai undergraduates think that most of the class material is static, with 10 to 15-year-old computer tutorial website making an excellent source of information. On an exam, they will use the specs of a 2005 desktop as an answer for a current case study, justifying it by saying it is fast enough or good enough for a small business. To each question in life, most of the students prefer to remember one simple answer that keeps for a lifetime. Searching and finding more than one answer or negotiating with a team to settle on the best compromise better reflect learning after college.

Copyright by Mahidol University

There were several levels of scaffolding used during mCpath, the main one being able to look up the answers on the web using a mobile device. Most any search

of any term brings up much more than a million hits. The issue soon changed from how to find information to limiting the amount of content to a useable form. Learning how to search the internet more effectively is one of the lessons involved with the m-learning method. At the same time, it is being used as a supercharged textbook that has a vast amount of detail on almost any type of computer technology. Although the terminology from some sources can be daunting to a neophyte, there are various levels of explanation. Most of the issue with teaching students to more effectively search was weaning them from the simple dictionary definitions, the Wikipedia sources and the one paragraph high school tutorials. The lecturer found it laborious pushing them to browse more primary data.

The use of cooperative learning with peers was another scaffold rung used. The issue with the computer class being investigated was the variety of skill and knowledge levels, so group learning was one way bring the whole team up to speed (Ashman & Gillies, 2013). For example, an avid game-player would have prior experience building his own computer but then not understand at all the purpose of an operating system. A physics major could explain in minute detail how an LCD display worked but then not describe the elements of computer platform. The cooperative actives were designed so that if team members helped others, it would improve the team's overall grade, so there was an incentive for a member to help others.

The third scaffolding assist was the instructor (Gillies, 2007). During the mCpath sessions, the lecturer would have plenty of time to nudge students in the right direction. The two main contributions by the lecturer was directing focus and then modeling how to search for a particular answer as an example on how better to search for the right information (Pea, 2004).

As to educational models used during the research, Blooms Taxonomy was instrumental in developing the computer concept assessment. The purpose of an introductory computer class is to make sure students achieve a minimal level of digital literacy. Although there is criticism of Bloom's system (Marzano & Kendall, 2007; Pierce & Gray, 1981), it has been universally recognized and used to classify cognitive levels. Aiming at the first two levels, the computer concept questions all relate either remembering or understanding, under Bloom's revised taxonomy (Krathwohl, 2002). Because the process of searching requires higher level cognitive tasks, it is likely that

Copyright by Mahidol University

mCpath learning could be used for engaging learners at a higher educational level with more complex topics, but this would be a separate research project.

The development of the mCpath learning method was based on Illeris's 2007 Three Learning Dimensions. The model fits snugly within Vygotsky's constructivist educational philosophy because it includes the interactional dimension that socializing brings to learning. The three dimensions include content, incentive and the environment and each is placed at the corner of a letter t (figure 2.1). The top line of the t represents an individual learner, with the actual content to be learned on the left side (Illeris, 2009). Incentive to learn is placed on the right side. This interlocks with Bloom's Taxonomy in that for this project, the level of mastery of content is connected to Bloom's revised remembering and understanding for the cognitive dimension, fitting well with Illeris's content dimension. Bloom's more vaguely defined affective dimension belongs to Illeris's incentives. Although the educational research in affective and its influence on learning, in the last couple of years, it has caught up with many interested in the area. Although measuring emotions is tricky, there does indeed seem to be a connection between students' moods and their accomplishment in school (Cordova, Sinatra, Jones, Taasoobshirazi, & Lombardi, 2014; Gross, 2014; Sheppes et al., 2014; Webster & Hadwin, 2014; Zimmerman & Kitsantas, 2014). Indeed in a new article speaking about transformative learning, Illeris (2014) himself said there should be more focus on the emotional component of learning, with too much being directed on the cognitive. As to mCpath instruction, it may reach a transcendent level where it causes a complete change in how students view how they can learn with computers but the more most assumption is that its affects would be more assimilative for the majority (Illeris, 2009). This researcher predicts that the mobile learning process reduces the amount of mechanical learning where students remember facts as separate entities by using the motivation of group dynamics and the freedom of searching using a favorite phone instead of listening to a monotonous lecture. Yet because learning is self-directed, there is the possible risk that the method may be emphasized in students that are task focused, wanting to get the work done so they can go to some other work. To mitigate this possibility, individual self-reflection is built into the mCpath process, required by the peer reports, the learning journals and some other different role reports.

Copyright by Mahidol University

The Mobile Computing Path Learning provides several incentives to the learner, (see figure 2.1) the first being the use of mobile devices in class, something that is usually forbidden in most classrooms. Because each in the team has a role that will receive a grade, there is less need form the teacher to strictly monitor what programs students use. It would be wise for an instructor to walk to the room to keep students reminded to keep to the task on-hand. Yet if one individual decided to check e-mail or play a game during class time, either that person must spend more time after class or receive the appropriate points for minimal effort. With healthy team dynamics, there will be that extra peer pressure by others on that one straggler who takes one too many breaks.

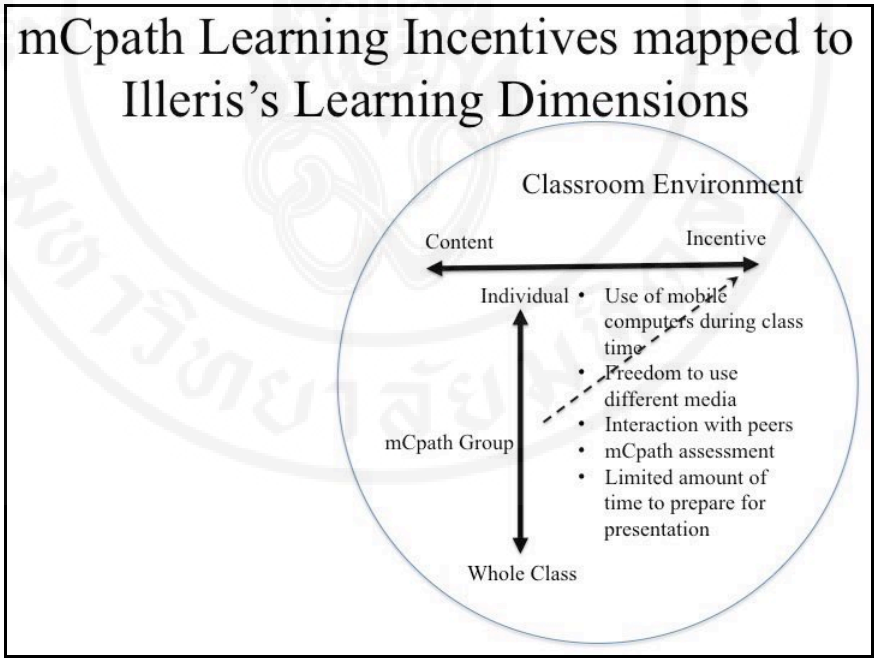

Figure 2.1 Illeris's 2007 Three Learning Dimensions applied to mCpath

Copyright by Mahidol University

Coupled with being able to use devices is the freedom during class to explore and use any website, database or app. The Researcher needs to explore YouTube videos or check out podcasts or iTunes University. Much like the adage about learning to read, does not matter if it is a comic book or romance novels, it all helps, this is the same with learning to search the web. At first, it does not matter which websites they first use. If they start learning to use search terms, scan through the results quickly and then refine the next search terms used, the students are learning to search, find and use digital media. With each next cycle of mCpath learning, students should learn how to better distinguish poorer sources from the higher quality information. This ability for students to self-direct their learning builds confidence in their own information literacy skills.

The third incentive to learn comes from the class interaction within and between groups. As this interaction belongs on the vertical dimension, it builds a convenient anchor point that props up the incentive.

Grading for the mCpath method has an individual component and a team one, coming from the mean average of the individual reports. The groups quickly realize that if they help encourage each other, share the work of looking up answers and share feedback on how to improve, they can better their grade by being a good team member. Assessing the reports and peer interaction relate to each other, much as does the use of mobile devices and the freedom to interact.

The last incentive is the limited amount of class time available for the Presenter to get ready to get up and speak, 1 hour or less.

Referring to the Three Learning Dimensions (figure 2.2), there is a range of interaction, from individual work to collaborating with one other student, on to interacting within the class. Although this mobile learning instruction is designed to be used in class, it could be used for distance learning in group, so the vertical axis may need to add a branch that recognized the difference between interacting face-to-face versus collaborating remotely (Abedin, Daneshgar, & D'Ambra, 2011; Gilson, Maynard, Young, Vartiainen, & Hakonen, 2014; Martins, Gilson, & Maynard, 2004). This would make for an interesting follow-up topic related to this m-learning method.

Copyright by Mahidol University

One of the major challenges with any new teaching methodology is getting the users to use the system. The most popular models used to explain why a

technology is accepted has been the well-researched Technology Acceptance Model (TAM). Davis first developed the model as part of his Ph.D. Thesis at MIT Sloan of Management, so it has been the darling for both information systems and business researchers. It was originally based on the Theory of Reasoned Action originating in psychology (Ajzen & Fishbein, 1977; Davis, Bagozzi, & Warshaw, 1989; Fishbein & Ajzen, 2005) has helped spread the popularity of the model to social sciences and education. TAM has become the go-to tool that can used to explain either why students would prefer to use Facebook when learning (Rauniar, Rawski, Yang, & Johnson, 2014) or why a lecturer should not use this service (Bright, Kleiser, & Grau, 2015).

The classic TAM says that perceived usefulness and perceived ease of use affects behavioral intent and this leads to usage (Davis et al., 1989). There are hundreds of variations to this model. A meta-analysis of 88 studies showed that perceived usefulness is the driving factor that leads to the behavior intent and then to the use of technology, with ease of use dropping out as not significant (King & He, 2006). The concept of ease of use has certainly driven software and hardware interface design, yet ironically if a computer game is too easy, it is not challenging enough to keep attention. It is also the one place where users expect to fail but still find the activity stimulating enough to play for hours at a time (Juul, 2013). Engagement is the key to creating an interesting game (Boyle, Connolly, Hainey, & Boyle, 2012). An instructional method more closely relates to this in that it must stay in the golden proximal zone of not too difficult, not too easy.

Mobile Computing Path Instruction has been designed using the Technology Acceptance Model and with the focus that perceived usefulness is more important than ease of use. The Mobile Media Learning Survey was based on TAM. The original was a comprehensive German-language survey, including questions on usage of 53 different media and also a question on satisfaction of usage of these same 53 services (Grosch, 2012). The English version that was developed to be used internationally had a total of 145 questions. In the mobile version, the satisfaction questions were removed, as were some of the other questions relating to educational background, self-efficacy concerning use of computer software, leisure usage of computers and educational behavior factors. Instead the focus was on usage, with high

Copyright by Mahidol University

acceptance related to high usage of the media or equipment and low acceptance relating to low usage.

As to the design of mCpath, Illeris's learning dimensions were combined with TAM's perceived usefulness relating to the incentive to learn dimension (Figure 2.2).

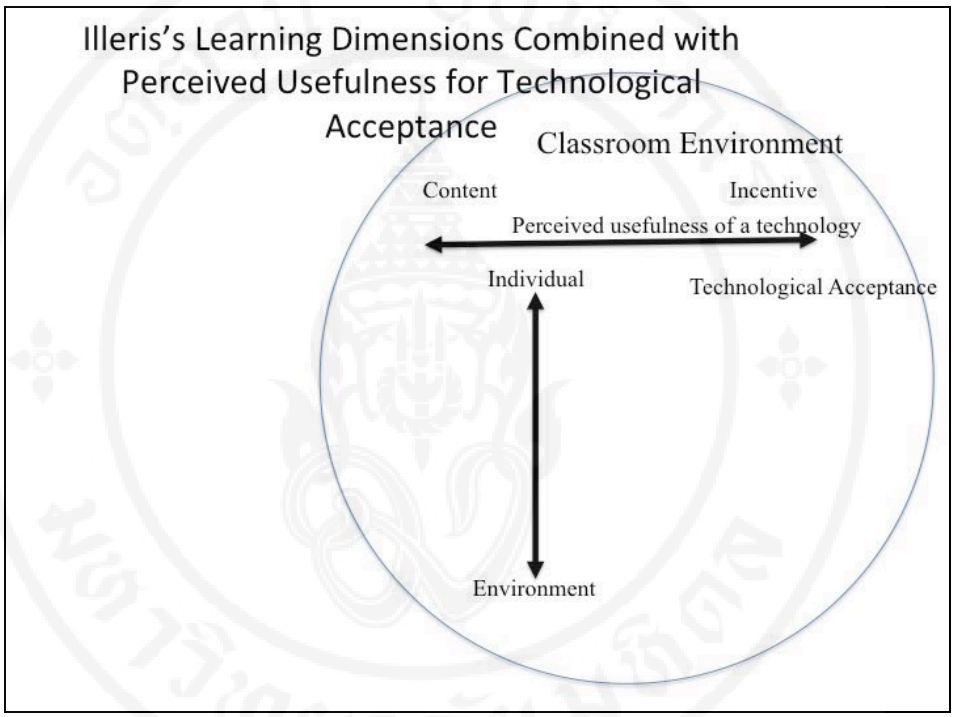

Figure 2.2 Illeris's 2007 Three Learning Dimensions combined with Davis et al. Technological Acceptance Model (1989)

The expectations are that an instructional design that allows students to use equipment and media that they already have accepted and perceive as useful, it also will be more quickly accepted than a teaching method that includes software or a learning platform that students have never used before.

Copyright by Mahidol University

2.4 Mobile learning

Although the author has been searching for articles since 2012 about a cooperative classroom m-learning method that has some similarities to his mCpath instruction, he has yet to find any.

The most current article that relates to m-learning is a test of a mobile app that encourages reflection of students at the kindergarten to 12 level (Leinonen, Keune, Veermans, & Toikkanen, 2016). The application went through several pilot tests until it was used in 1,324 European classrooms in 18 different countries. The app that measures individual reflection was called ReFlex. The students could record 60-second audio and video that summarized what they learned. Participants could listen to their recording and re-record it if they wanted to improve it. The question the students needed to answer was what was going on in school. The app that allowed group sharing was TeamUp. It again took 60-second clips, but then the group had to answer questions about what they did, who will they do and what problems did they have. The article was more about the development process and how the apps enhance interaction and reflection. Reflection was a large part of the mCpath process, and an audio, visual component like this would be of experimental interest but in the next phase of development where the instruction is further refined after being permanently implemented into a class. For an introductory undergraduate class, a focus on writing skills would still be preferred. The Presenters already allow participants a chance to practice public speaking skills. In this second stage after the experimental phase, the lecturer did require Presenters to have a team member record their presentation and the post the video up on YouTube as unlisted.

The closest system to being designed starting from the characteristics of the users was the ALEX© adult literacy application (Lumsden, Leung, D'Amours, & McDonald, 2010). This package does not focus on collaborative learning. It does not use an application or service that is available to everyone on any mobile device. The copyright in the name shows the author's intent to commercialize the package. The article was a good example of how to develop a new instructional design for a mobile device based on the users' ability. The researchers first recruited participants and consulted with them and organizations that worked with the disabled. From there, they selected the appropriate design and evaluation method and then adjusted it to fit the

Copyright by Mahidol University

participants' needs best. To gather information, the research used eight focus groups with 6 participants and then invited participants to give feedback in the design sessions. This paper was just the start of a longer longitudinal study, so somewhat like what the author in this thesis was planning.

The 2009 article from Vavoula and Sharples inspired the author look to develop a long-term research strategy for the development of the m-learning innovation developed in the author's research project. The researcher proposed three levels of development evaluation names micro, meso, and macro. Micro deals with the individual instruction, along with the method, data collection and assessment method. This phase continues throughout the initial develop stage, implementation and then deployment. Mesa evaluation deals with looking at the learning experience overall. This relates mostly to the implementation stage and then bleeds into the deployment. Data collected on the m-leaning method collected at the micro level is used to fine tune the development before the m-learning system is implemented into a class or group of classes. Finally, in the macro phase, they system has been deployed, so there should be a measurement of how well the m-learning method matches an institution's practices.

This three-level structure was repurposed to fit the need of this mCpath research. The current paper relates to the micro level, where the method has been developed and refined before being permanently implemented into all sections of the introductory computer class. The design step included a pre-experimental phase where initial characteristics of participants were measured and then the experimental phase where the innovation was developed, tested and then refined over the terms. At this point, mCpath development is at the implementation stage. The instructional method has been stabilized and implemented into the different sections of the same introductory class. In doing so, the expected outcomes from the method have been documented into the total quality control system used by all universities in Thailand. At the initial design phase, different information literacy and 21st century standards were mapped to the process, making it more efficient to map it to the Thai quality standards outcomes. The same forms and survey information used in the design phase have also been continued to be collected, so that the next research report at the meso level can be published. The expectation would be to deploy the mCpath instruction

Copyright by Mahidol University

throughout the university and to other programs at other universities. Before doing so, there needs to be pilot research conducted that adjusts the method. Currently it is designed to be used within an introductory computer class to improve digital literacy. It needs to be adapted to be used at different educational levels and in different disciplines. The macro level analysis would depend on if this instructional method were adopted on a larger scale by other academic division and institutions.

Despite there being many publicly-available services that run on multiple platforms, there are still projects that focus on developing specialized learning applications and learning platforms (Hsieh, Wu, & Marek, 2016; Jeno, Grytnes, & Vandvik, 217; Khemaja & Taamallah, 2016; N. Wang, Chen, Song, Lan, & Parsaei, 2017). Most of these are still small projects that are in pilot phase (Cochrane, 2013) that disappear after the initial publication. The development of a mobile education application is less complex than it was initially where there was a variety computer platforms. For smartphone apps, there are now only two dominate operating systems: Android and IOS. Although an application for each different system used to require twice the amount of development, the standardization of HTML 5, and more and more cross-platform programming tools make it more efficient for companies to develop both versions at the same time (Charkaoui, Adraoui, & Benlahmar, 2014, October 20-22). Smartphone application development still has many factors that make for a poor experience (Khan, Al-khanjari, & Sarrab, 2016, October 13-15). Although there are two major operating system flavors, there are many difference versions running on many different smartphone hardware. Part of Apple's success comes by keeping equipment and software standardized so that it all works together. Yet something as simple as the one resolution standard of the iPhone 4 has multiplied to 4 different ones (Lew, 2017). This is without considering the iPad and Apple Watch versions.

Most of the research and interests in m-learning started around 2000. "Computers & Education" published its first article on the topic in that year (Sharples, 2000). A handful of educational zines and innovative learning organizations started speculating about the uses of learning using a mobile device (Quinn, 2000; Soloway et al., 2001). This coincided when mobile broadband, which 3G started being tested and gradually coming online in the early to mid-2000. Now, most people associated a PDA with a Palm Pilot and RIM was just starting to add voice capabilities to its BlackBerry

Copyright by Mahidol University

pager. Nokia ruled with a market share of 35% and was just adding the ability to browse the web.

The iPhone in 2007 marked the beginning of the true m-learning era. Computer & Education went from publishing one article per year on the topic about one a year to a sharp elbow rise of six in 2007 that then more than doubled in 2008 to 18 articles. Using the search term “mobile learning”, this author sees the same doubling factor in the number of articles, from 2,820 in 2007 to 4,080 in 2008. The International Journal of Mobile Learning and Organisation and the International Journal of Interactive Mobile Technologies both first published in 2007. Ubiquitous Learning: An International Journal came out in 2008 and International Journal of Mobile and Blended Learning in 2009.

Up to 2007, computing on cell phones had been limited to small screens, short battery life and slow internet connection speeds. In 2017, these limitations are almost gone. The trend is toward supersize phone screens, 3,000 mAh batteries that last a day or more, 4G cell phone connections and beyond, and the ubiquitous access of wi-fi. Although the e-learning model is still alive and well, this author would argue that most online learning is currently m-learning. A desktop with a hard-wired ethernet connection is becoming a rare type of computer platform. More typical, university students studying for an exam have laptop and iPad out and using Line on a smartphone to chat with friends or message a lecturer through Facebook to ask questions.

Some of the first mobile learning experiments focused on the PDA platform. One of the earliest started in Europe as part of the MOBILearn project initiated in 2002 that had 24 institutes represent 7 European countries, Australia, USA, and Israel (Bo, 2002). This was an age where there was limited to display, battery life, processing and storage (Gafni, 2009). Post-2010, many of these had been overcome, but for many years, the initial research in PDA drove the direction of m-learning. One of the elements was allowing lessons outside of the classroom. One of the initial examples of this was the bird watching class that used PDAs and wi-fi (Chen, Kao, & Sheu, 2003). Again, the equipment was quite elaborate and required a special leaning platform. With it, students could see photos and videos about bird while in the field. It also allowed for a pretest and posttest to be taken outside. Grade-school students went

Copyright by Mahidol University

bird watching with a wildlife society. What the author took from this was that although interesting, the practicality of developing a learning platform customized for a detailed, narrow topic was quite cumbersome. Although the articles did not say what type of PDA, the learning platform likely required a specific hardware device. The ones shown in the photos were all the same and had the Compaq logo. The issues with this the of instruction method would be the amount of time required to develop the system and how quickly this would be obsolete, give the constant updates in mobile operating systems and the doubling of capacity in mobile devices since then till now.

An example of this was an at-sea course that taught about difference species of fish (Pfeiffer, Gemballa, Jarodzka, Scheiter, & Gerjets, 2009). Although the research had only 35 participants, it was an example of the hopeful advantage of situated learning in practice. In it, students used portable DVD players that used videos, photos and audio files. One group watched the videos, and the other looked at pictures. It had some interesting parallels to the current author's research project because there were two posttests. The students performed significantly better in the second posttest. There was also no major significant difference in either posttest. What interested the author was the complexity of having to purchase, maintain and use specialty external DVD players for a class of 35. This technology has already become obsolete.

One of the pushes toward using m-learning to learn in context was a study for EDUCAUSE Center for Applied Research that (R. N. Katz, 2009). It emphasizes that learning was no longer an activity that was at a fixed place and a fixed time. It was one of the first articles to also realize that e-learning would soon be replaced by m-learning. Just at about the beginning of 2010 decade, there were a flurry of articles on learning in context, but again many of these started out with a PDA perspective (Hwang, Tsai, & Yang, 2008).

2.5 Cooperative learning

Copyright by Mahidol University

One issue with this area of research is the name "collaborative learning". There are a variety of terms that similar meaning that has created disciplinary islands of knowledge. This includes "collaborative learning", "cooperative learning", and

"computer-mediated collaborative learning (CMCL)" or "computer-supported collaborative learning (CSCL)."

There are fine distinctions between collaborative and cooperative learning. One definition is that cooperative learning is when students work together but on assigned tasks, and for collaboration, students work together to accomplish a task (Roschelle & Teasley, 1995; Stahl, Koschmann, & Suthers, 2006). Although agreeing with the task focus versus working together definition, Davidson and Major (2014) added that the categories are much more complex than that in that there are different camps that started research in these areas and these areas have branched out in various directions. These researchers also include problem-based learning, but this author has left this area out of the discussion. In their argument, collaborative learning originated from the humanities and part of the social sciences. Cooperative learning came more from the sciences, engineering and the quantitative social science side. The mCpath instruction fits best on the cooperative side. There is an interdependence of tasks in each of the roles that encourages the students to work together. Because each student has an individual report that is graded, participants have an assigned task that will count both for an individual assessment and for the team assessment. The Peer Report, learning journal, and Researcher Report also encourage students to reflect on a whole as to what the group and each have learned throughout the process.

Johnson & Johnson (2014) listed five basic elements to cooperative learning: positive interdependence, individual accountability, promote interactivity, social skills, and group processing.

Each of these is a part of the mCpath process. Positive interdependence is building in an element where everyone should help succeed to reach a common goal. The Reporters are one of the key jobs where if they fail to find plenty of detail information or not share it with the rest of the team, then everyone in the group will not do well on questions relating to the path question on the midterm or final. The portion of the group score based on the mean of the individual score of reports is another built-in independence. If students help each other score higher on reports, then the students' each will receive a higher grade. If a member fails to put effort into the report, then that individual grade will pull down everyone's group score. The Peer Report is the mechanism where the team can punish the individual for freeloading by

Copyright by Mahidol University

giving a low peer score. During the experimental phase, this effect was buffered so that if one individual received a zero for not complying a report, those participants would receive a zero on their individual, team and peer score. The zero was left out of the team score so that it did not affect the whole team. The other disconnect was that during the experimental phase if students filled out the Peer Report, they automatically received a full score. During the next stage were mCpath was implemented full time into every section of the computer class was then the Peer Report used to calculate the peer grade for the group.

Individual accountability was implemented through the individual scores for each mCpath report. If students did not complete a report or put little effort into it, this was reflected in a low score. Those that showed good effort received higher individual report grades. The Peer Report was also an element. Again, during the experimental phase, if participants did not complete the report on time, they receive a zero score for the peer grade, with 5 percent of their total grade. In general, the students that showed lower effort would be the same students that would forget to fill out the Peer Report.

The mCpath improved social skills through having the Researcher compare between different teams. This helped three individuals reflect on how interaction within their group was different from interaction with other groups. This made groups aware of if they were more task focused or socialized more. During the first experimental term, the author did not advise students on how to interact. In the second and third experimental cycle, the author would give a short lecture during the computer lab on four different general organizations structures for teams: divisional, functional, centralized and decentralized (T. M Franz, 2012). The author would also present a model that showed how rewards, structure and the type of technology influences a team's effectiveness (D. S. DeRue & Hollenbeck, 2012).

The other model that helped students understand how the team processes tasks was one showing team workflow (W. Arthur, Edwards, Bell, Villado, & Bennett, 2005). Students that focus on their individual task with little assistance from others were following a pooled interdependent pattern. Those that would receive a task and then send it through other members to check were following a sequential interdepend

Copyright by Mahidol University

workflow. A healthy team with good communications would follow a reciprocal interdependence, where task and communications would flow both ways.

As to group processing, the lecturer left it to the team members to remind each other about deadlines and submitting the mCpath and Peer Reports on-time. The learning journal entries did show a strong team spirit, where members would call members to remind them to submit work. If some members were unsure of what a path question meant, they would consult other members that had better understanding about computer systems. Again, the scoring was set up to make individuals responsible for their work. The team score helped encourage cooperation in that if a member could help another score higher, that person would also receive a higher score. The presentations in class created the competitive element. The immediate consequence would be the lecturer praising a team for a superior presentation or having a presenter cut up for not being well prepared, for reading a script and coming across as boring. Students were given anywhere from 40 minutes to an hour to prepare for the presentations. Although it was left to the group to decide how to work, many put effort into helping the Presenter prepare to speak. This created an intense atmosphere that put pressure on all to learn quickly. A member or two that would wander off for a smoke or were ignoring the group to play video games or chat online were condemned for not helping. Some of the Presenter would serenely do nothing, letting their group gather the information to be presented. Usually, these types of Presenters would embarrass themselves because it would become quickly obvious they did not understand anything and did no work on their own. Although not intentional, this intense preparation created a game-like atmosphere, where there was incentive to compete against other teams.

The mCpath also included Johnson and Johnson's (2014) three social independence into its process.

CMCL comes the closest to being an m-learning method that also uses students working together in-class. This covers many technologies, including m-learning, learning platforms, social media, games, groupware and well as other older technologies like multimedia instruction (Zheng, Huang, & Yu, 2014). The research area originated from distance e-learning (Stahl et al., 2006).

Copyright by Mahidol University

Some of the more current journal articles in this are about using blogging for collaborative work in class (Kuo, Belland, & Kuo, 2016). The researchers chose this medium because there was no special technology required to learn to communicate. Sixty non-traditional minority undergraduate participants they were taking an online course participated. A survey and qualitative data were collected at the end of the experience. Because there was no experimental method and the sample size was quite small, it would be difficult to make generalization out the results. The researcher did say that participant felt more connected to others in their team and that learning in a group was a better learning experience. This project is a satisfactory example of these types of projects. Most are small, have non-random participants, and have a distance learning focus to them.

Copyright by Mahidol University

CHAPTER III
METHODOLOGY

3.1 Research methodology

The research methodology used in this project is mainly quantitative. To answer the three main research questions, three measurement instruments developed for this project are the computer concept test, the Mobile Media Learning Survey, and the Digital Search Literacy Assessment. The computer concepts and Mobile Media Learning Surveys were developed and tested either during the pilot phase, and the Digital Search Literacy was developed in the experimental term 1. All three were given the first week of class as a pretest. The Digital Search Literacy posttest was given two weeks before the end of the term. The computer concept posttest was embedded into the midterm class exam and part of the final class exam.

Because the m-instructional design needed to be applied to all students within one section, a quasi-experiment method was used. Students in one section of the class, designated the experimental group, received four treatments of the mCpath instructional method. The students in the section designated hybrid received two treatments or one every other week for a month. Undergraduates in the control treatment received a normal lecture for the same period. A more detailed explanation of the process is included in the research design section.

In the original research proposal, a statistical power table was used to estimate the appropriate sample size. The one used calculated the difference between two means using a two-tail test. In order to have the statistical power of 70 percent to measure an effect size difference of 0.30, there needed to be a minimal sample size of 277 (Ellis, 2010). Since then, the researcher in the project has found a program that can calculate this more precisely (Faul, Erdfelder, Lang, & Buchner, 2007, 2009). A one-way ANOVA with a medium effect size of .25 and statistical power of .95 would require 252 participants.

Copyright by Mahidol University

There has been bountiful criticism of the use of a small sample size in research not having enough statistical power to measure a difference, especially in educational (Ingre, 2013; Simonsohn, Nelson, & Simmons, 2014; Vadillo, Konstantinis, & Shanks, 2016). Because of this, it was of interest to the researcher in this project to set a targeted minimum number of participants of 300. Because the classroom size was limited to 40 students per section, the maximum possible was 360. Normally, the enrollment will vary within 15 percent, with the worst case being 25 percent loss or 270 participants, so slightly more than the 252 calculated by G*Power.

Because the researcher in this project was also the teacher, there could potentially bias in data collection (Fanelli, 2012; Grimes & Schulz, 2002; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003; Podsakoff, MacKenzie, & Podsakoff, 2012). Again, education research happens to appear to have the highest measurement error (Cote & Buckley, 1987). Although the research method was quasi-experimental, as much random selection and process was included to help reduce potential bias. An example was the assignment of group status. Each section was designated control experimental and hybrid randomly for the first two terms, and then for the last term, the section was assigned to the experimental status that they had yet to be designated. The midterms exam was assigned a random grading order, with all the exams from the three sections mixed, so that the teacher had no idea which exam came from which section. A rubric was also developed to help insure consistency with how the computer concept tests were evaluated. The questions that the mCpath presenters had to answer in class were selected randomly, as was the order of presentations.

The other method used to reduce potential systematic bias was to use item analysis in the develop of all three assessment tools, thus improving their reliability of all the instruments. This assisted with spotting items that had ambiguous wording or were too difficult to understand for a normal undergraduate where English was not necessarily their primary language.

The pretest version of the assessments was given in the first week of the class. The participants took the computer concept midterm posttest five weeks later and the other posttests in the 10th week. The pretest version of the computer concepts and the Mobile Media Learning Survey were given on the first day together, a total of 90 questions for the two. The Digital Search Literacy given in the next class have 50

Copyright by Mahidol University

questions. Because there were many questions given and then more than a month between pretests and posttests, so there should have been no issue with students being able to recall answers if the same version was used.

There was a possible issue with the retention with specific versions of the computer concept test. If the same version of this test was used three times, even with a gap of six weeks between posttest and retention, there would likely be more issues with test-retest reliability. Another similar potential problem was if the same version of the computer concepts was used two terms in a row. It would be likely that students that took the midterm the term before would talk to friends currently taking the same class and the same midterm version. To improve test-retest reliability in both these cases, four version of the computer concept exam was developed. Each version had 19 questions, and item analysis was used to create each version and to make comparable versions that had similar difficult and ability to discriminate. To reduce the potential problem with friends helping friends, version 1 and 2 were used the first experimental cycle, versions 3 and 4 were used in the second experimental cycle, and finally, version 1 and 2 were again used in the last round. Because there was a summer break after experimental cycle 2, this ensured that there was a 25-week gap between when the retention and the pretest for versions 1 and 2. As to avoiding using the same assessment three times in one term, one version was used for both the pretest and posttest. Another version was given as both the posttest and retention. This meant that the midterm included both versions, so it had a total of 38 questions. The order of the questions was randomized for the midterms and finals, so there was no division between versions. These students also took a computer lab that contained 20 midterms during the same week but on a different class day, so this adds to the confusion of remembering which questions would possibly be asked on the final class exam. With a five-week gap between the tests and these extra measures put in place, it should reduce the potential test-retest reliability.

The use of different versions of the computer concept in each term creates a different issue, the ability to compare results in different terms, this being instrumentation reliability. To adjust for this, either ANCOVA or multivariate linear regression needs to be used, including dummy variables that account for this effect.

Copyright by Mahidol University

3.2 Research design

There were two phases to the research: pilot phase and experimental phase. In the pilot phase, the mCpath method was developed, operationalized, tested and refined for experimental use in the next step. Characteristics on how students used mobile devices and what media services they most used were also measured by using the Mobile Media Learning Survey. The length of this phase was 12 weeks.

In the experimental phase, a school-year-long experiment was designed to measure the differences between using the m-learning instructional design called Mobile Path Learning and giving a classroom lecture. Three sections of an introduction to computers class that the researcher routinely teaches were selected because the focus of the class was to teach computer literacy. The next logical progression in class development would expand this to digital literacy through adding more focus on digital information literacy through the mCpath method. The instruction of the class was in English, so all the assessments were in English as well. The majority attending are Thai nationals, but it also included students from other parts of Asia, as well as the students from dual nationalities.

For this institute, the class schedule has three-trimester terms and a short summer term. The computer class used for the research meets twice a week for 12 weeks, on Mondays for the 2-hour class lecture and on Fridays for the 2-hour computer lab. The mCpath process was only conducted on Mondays up to the midterm. In general, the midterm was scheduled for the seventh week, but in the third term because of the number of holidays, it was changed to the eighth week.

For the experiment, one of the sections each term was designated control, experimental, and hybrid. For convenience and consistency, the terms for each experimental round will be labeled Experimental Term 1, Experimental Term 2 and Experimental Term 33. Some of the instruments were tested in the term before this and will be defined as pretest term.

In the control group, students listen to a lecture each Monday. The method used is an active learning through a Socratic-type instruction. Individual students would be called on to answer questions, and the materials would be presented through the discussion, so much more interactive than a regular classroom lecture.

Copyright by Mahidol University

For the experimental class, they would participate in four rounds of mCpath instruction before taking the midterm. They received an orientation lecture the first week and then a review session lecture just before the exam but mainly were expected to learn the materials covered on the class midterm through mCpath work and reading the assigned materials. In the first term, the stress of doing the mCpath reports and having to take midterms in other classes was too much, so the treatment was reduced to three times. For other two terms, the experimental students participated in four rounds as expected.

As to the hybrid class, they participated in mCpath every other week, so receive two treatments before the midterm and attended two regular lectures as described for the control group plus the orientation lecture and review session. The mCpath instruction went as planned for all for these classes all three terms.

The design of the research was quasi-experimental. Much like in an American university, students in this college select the classes to take based on major requirements, interest and schedule availability. This is unlike other international programs in Thailand, where a cohort of students will enter the university during the same term and take the same classes until they reach the upper level, then they have choices. Because student chose the time slots, it was not feasible to randomly assign students to a section. Randomization of results were used to try to reduce the potential biases caused by both the quasi-experimental design and because the researcher was also the teacher of these sections. MCpath teams were randomly assigned. The computer concept evaluations embedded in the class midterms and class finals were graded in random order with a rubric used to increase grading consistency. The order of class presentations was also randomized. Three assessment tools were developed to measure the effect of mCpath learning: a computer concept test, Digital Search Literacy Assessment, and the Student Mobile Device and Media Use Assessment. The reports from the Reporters, Auditors and Researchers and student feedback from learning journals was also included in a database so that they could provide a qualitative explanation of the phenomena discovered in the quantitate analysis.

For this introduction to computers class, usually the 12 pm section fills up quickly, then 2 pm then fills up and the 4 pm time slot is least preferred. The class is

Copyright by Mahidol University

required for hospitality and tourism majors, but other majors are free to choose it or take other natural science electives.

For the first two terms, the sections were allocated randomly to either control, experimental or hybrid, and in the last term, the section was rotated to the experimental role that it had not yet been assigned. There were three different experimental groups each term and that each section would also be assigned to three different experimental groups throughout the school year.

The class capacity for each section was 40 students. Usually, the first two sections fill up to capacity and then the third section varied from between three-fourths to two-third full. The original estimate was that there would likely be about 300 students in total participate in the experimental, about 100 per term. Most of the literature in e-learning and m-learning tend to show almost no difference between the experimental methods and classic lecturing. The author decided that a one-term sample would not have enough statistical power to measure the likely small difference between the experimental sections and the control section. With a sample of 277, there would be a statistical power of 70 percent, and the research would be able to measure an effect size difference of 0.30, considered medium effect by Cohen, using a two-tail test at α=.05 (Ellis, 2010). Although more power would be preferable, it was decided that one school year would be a reasonable period. Although it does not reach the idealized 90 percent power, it has much better than most education experiments (Brewer, 1972; Maxwell, 2004; Tomcho & Foels, 2009). Current m-learning research has a host of small classroom experiments (Cochrane, 2013), and quite a few reported cheery successes. When critically analyzed, these projects usually lack rigorously-developed assessments or have that one small clause that data was adjusted.

3.2.1 Participants

At the research location, the total international college student population during the project was 3,103. Computer science, computer engineering and information system students cannot take this introduction class for credit. This is because they have their version of an introduction to computer class that goes into more depth with either more of a programming or hardware perspective. Thus, the college student population net of the computer-oriented majors is 2,904. At this

Copyright by Mahidol University

undergraduate program, all the subjects are taught in the medium of English. To be admitted, applicants need an IBL TOEFL score of at least 79, an IELTS score of 6.0, a SAT score in critical reading and writing of 1100 or to pass the institutionally administered IBT TOEFL with additional writing and math sections. Because of the students' level of English language ability, all the assessments were in English as well. Because English is a secondary language for the majority, the reading level for the measurement instruments was intentionally placed at a high school level.

The total Thai undergraduate student body in 2012 for the whole country was 2,405,109 (UNESCO Institute for Statistics, 2014b).

The computer class used in this experiment is a general education subject in the natural sciences, designed for first and second-year students. Because there is limited capacity each term, usually the second-year students push out the first-year students because they can register first. Thus, the second-year students make up nearly 50 percent of the total number of participants in this study, with the first-year students trailing at 35 percent (table 3.1). The tourism and hospitality majors are required to take this class. Some put off taking all their general electives till later, so there are third year and four-year students taking this class as well.

As already covered in the initial research design chapter, because students make the decision on the section they will take, it was not possible to randomly assign students to experimental groups. Instead, assignments of which section would receive treatment was randomly made the first two terms, and then in the third term, a section was assigned to the role it had not received yet in the other terms. In this way, in each term, there was a control section, a hybrid section that received partial treatment and an experimental section that received four treatments. For a section offered at a time within three terms, it would also have been designated control, hybrid and experimental at least once.

The number of participants in each treatment group came out to a pleasingly and almost perfect 33 percent for each. There were 107 in the control group, 106 in the hybrid experimental group, and 105 in the experimental group.

Copyright by Mahidol University

The total number participants in this m-learning experiment for a total of three terms taking an introductory computer class was 318, 10.2 percent of the total student population or 11 percent with the population net of the computer majors not

allowed to register this class: 107 in term 1, 106 in term 2 and 105 in term 3. One student was excluded from this total because the student had medical issues before the midterm. The student retook the class the next term but was not included in any of the data. Three other students retook the class because of academic reasons, so their assessment and test results was included for their first time but not for their second retake.

Table 3.1 Gender proportion of female participants in experimental groups per term

Term	Control proportion	N	Hybrid proportion	N	Experiment proportion	N
Term1	0.66	25	0.40	14	0.43	12
Term2	0.37	11	0.56	22	0.60	22
Term3	0.54	21	0.34	11	0.75	30
Total	0.53	57	0.44	47	0.61	64

The percentage of female and male participants was 52.8 percent to 47.2 percent respectively, a ratio of 1.12. This was close to the 2012 world average of 1.08 but below the 2012 Thailand ration of female to male of 1.34 (UNESCO Institute for Statistics, 2014a). The college ratio of female to male was 1.27.

The percentage of females in the sections varied considerably, from 34.4 percent in the hybrid test group in Term 3 to 75 percent in the experimental section in the same term.

Copyright by Mahidol University

Table 3.2 Frequency table of participants per major

Major	Frequency	Proportion of N	Proportion of Pop.[1]
Business Majors	282	0.887	0.721
Business Economics	19	0.060	0.063
Finance	28	0.088	0.111
International Business	75	0.236	0.248
Marketing	40	0.126	0.133
Tourism/Hospitality	120	0.377	0.166
Fine and Applied Arts Division	7	0.022	0.095
Animation Production	0	0.000	0.018
Film Production	6	0.019	0.025
Television Production	0	0.000	0.015
Communication Design	1	0.003	0.037
Science Division	20	0.063	0.120
Applied Mathematics	1	0.003	0.005
Chemistry	1	0.003	0.010
Physics	1	0.003	0.004
Food Science and Technology	2	0.006	0.026
Biological Sciences	11	0.035	0.061
Environmental Science	4	0.013	0.015
Social Science Division	9	0.028	0.063
Total	**318**	**1.00**	**1.00**

[1] *Total college population is net of computer science, computer engineering and information system students*

Copyright by Mahidol University

Section 3, taught at 4 pm in the afternoons, tended to have less enrollment, so comprised 28 percent of the sample. Section 1 and section 2 made up

36.8 percent and 34.9 percent respectively. Because the mean of the number of participants in the control, hybrid an experimental group came to an equal 33 percent for each, so the smaller sample size in section 3 was balanced out by the sample selection method.

At this international college, there are four academic divisions offering a total of 20 undergraduate degree majors. One of them, the nursing major, currently has no students. The participants came from 14 subject majors. The largest majority were business majors (p=.887). This was a larger proportion of the total business students body (p=.721 net of computer majors), an expected result because travel and hospitality majors are required to take the class. The proportion of the other business majors is more comparable. Science majors made up 6.3 percent of the total sample, under-representing the total population by about half and the Social Science Division (p=.028) percent. The Fine and Applied Arts Division also are under-represented (table 3.4) because of the absence of animation and television production majors.

The majority of the participants were also of Thai nationality (M=.943, n=317). The 92.7 percent mean for the whole college student population for 2012/2013. A portion of these students have dual nationality or are Thai nationals that grew up and were educated abroad. This can be better seen by looking at the total percentage that primary speak Thai, 89.6 percent. The mean average age of the total participants was 19.8 (SD=4.7, n=311). Nationality and demographic data came from the completed versions of the Mobile Media Learning Survey, and information about major came from the official class lists.

Sixty-one percent of the participants were first year students, and 27.7 percent were second year students. Only 11.3 percent (36 total) were in their third and fourth year. The college where this research is conducted requires most of the general education electives be taken within the first two year of study.

3.2.2 Experimental design

3.2.2.1 Control treatment

Copyright by Mahidol University

The difference between the experimental groups and the control was that the control groups received instruction on Mondays for 12 weeks. The control groups were not allowed to use their mobile devices during class time. They

did not work together in groups, searching for their information that related to the topic taught. As far as the researcher knows, the control participants did not see the mCpath questions or reports before either the midterm or finals.

Using Illersis's Learning Dimensions (2007) it would be expected that these students have less incentive for learning the class materials than would the experimental sections that were able to use the mobile devices in classes, that could search any website for class information and that worked closely together with other students in teams. The participants in the control section did receive two lecturers during the computer lab sessions on using Google search, but they did not have to practice these skills through being required to search for information during and after class. They also did not receive detailed feedback based on the answers in context.

Going into the experiment, the expectation was that these participants would not do as well on the posttest of either the computer concept assessment or the Digital Search Literacy Assessment as would the participants in the experimental sections. As to the Mobile Medial Learning Survey, the author expected that the overall usage of mobile media for learning on the posttest would be similar or a little higher than for the pretest. The overall purpose of the class was to develop a better appreciation of the use of computers, regardless if the m-learning method was used or not. The author was expecting that either there would be no differences between the control and the experimental sections or that experimental section may show a higher usage of mobile media, given that these participants were required to use their computers more for school work.

In all other respects, the control groups were taught in the same manner, received the same handouts, and covered the same topics. All sections listened to lecturers in the computer lab on Fridays and then followed through computer demonstrations. Because the instructor for these classes was also the research of this project, there was certainly the potential for an unintentional bias treatment, either for the experimental group or because of potential over adjustment, a potential bias toward the control group. Although the information covered was the same for all sections, there could have been a difference in the method used for instruction, given the time of day. This would hold for the last section taught from 4

Copyright by Mahidol University

pm to 6 pm. To help dampen potential biases, randomization was used as much as possible. There were three sections, and the assignment of experimental was rotated each term so that each section in each time slot was designated control, hybrid and experimental section through the trimester school year. Section 1 was randomly assigned control in experimental cycle 1, again randomly assigned as section 3 in experimental cycle 2 and then rotated to section 1 in the last term. The grading order of the midterms and final papers were randomized. This randomized order number was written on the cover sheet, and the students wrote their name on a sheet just inside this cover sheet. When grading, the instructor would avoid looking at the sheet with the students' name. To ensure that students received the right score, the tests were then put back in alphabetic order on a section basis, and then there was a double check to make sure the students received the right score.

Although it is tempting to say that the control group received only the classical lecture treatment, Kirkwood and Price (2014) make a good point that classrooms already have a certain level of technology enhancement. There is rarely a case where the control group has no access to any computer technology. Since the topic of this whole class is the practical knowledge and use of computers, all students had a computer lab session on Fridays, using personal computers running Windows 7 and using Office 2010. In the current research projects, the control groups and the experimental sections communicated with the instructor through email. All were required to give the instructor their e-mail address, and a separate email account was used to assist in separating out conversations with students in the class. The total volume of email sent and received from students in the class for during all three experimental cycles was 5,685. There were 2,545 messages set out from the lecturer. Of these, 1,053 related or 41 percent related to mCpath work.

All students were asked to send an e-mail that explained their background and experiences. They also were required to email their learning journal. The lecturer also wrote comments back to all.

There was a class website. Homework assignments were announced in class, and then detailed instructions were posted on the website. They could download handouts, syllabus and check the class schedule on the class website. Google Analytics show a total of 4,779 page views of the handout page for the whole

Copyright by Mahidol University

time, with 3,906 unique views. The total for that site during the research period was 61,276 page views. According to the analytics, 97 percent of the sessions were in Thailand, making it likely that a good proportion of the students in the class used the web resources. During the computer labs, all sections had access to a desktop PC, running Windows 7.

To encourage note taking, all in all sections were told to take notes, but two weeks before the midterms, pdf versions of the lectures were all posted on the website for download. Videos of the class lectures were also posted. These had a voiceover paired with the PowerPoint presentation. Google Analytics shows there was a total of 2,111 page views of the video webpage. The average time on the page was 5:45 minutes, so it was likely that the students used this resource. Peaks in the page view statistics match closely to the midterm and final dates of exams for the class. There was a two-week peak of 113 in February, 110 in March, 150 in June, 144 in July, a whopping 386 in October, with another 124 in January 2014. As to the average time on a page within a two-week peak, it ranged from a high of 22:55 minutes from March 3 to March 9 and to the low of 6:08 minutes from July 7 to July 13.

The class lecture was more in an interactive Socratic-style, also known as systematic or direct questioning. Using the class list, the lecturer would select a student and then asked a basic question, such as how a hard drive encodes data on its platter. Students would either answer with what they knew or say they did not know. The lecturer would explain, supplementing the explanation with PowerPoint presentation, and then ask the question again of the same student. After speaking, that person's name would be marked with a different color and then would not be called until everyone had a chance to answer questions.

The control group received 7 class lectures before the midterm and then 4 class lectures after the midterm. All section participated in the 10 computer-lab session. They received two computer lab training session on using Google for search, as did all in the experimental groups.

Copyright by Mahidol University

During the first session of the term, students in the control group were informed about the experiment. They were also informed that they had been randomly designated the control section and that they would receive normal

lectures like student had the prior term. The only issue would be that they would be asked to fill out survey forms and questionnaires. Thy received this information again on the second class during the first week and asked to read and sign the MU-SSIRB 02 Participant Information Sheet. On the third class, the students were then asked to sign the MU_SSIRB 03.

3.2.2.2 Experimental treatment

With the sections that were assigned to the experimental group, the first week was an orientation session, then for the next four weeks, the students participated in the mCpath instruction method own Mondays instead of receiving a class lecture. Before the midterm, the experimental section would receive a test review where the lecturer would explain the testing format, and explain the material that would be covered on the exam and how many questions for each topic.

The participants had the same access to materials on the class website. This included the assigned reading, pdf versions of the PowerPoint presentation and videos recording of the presentations.

The Friday computer lab session was taught the same way as it was for the control section and the hybrid experimental session, with the same topics covered on the same day.

3.2.2.3 Hybrid experimental treatment

With the hybrid experimental section, these students received the same orientation session the first week as did the control and experimental section. The difference in treatment was that they hybrid group would receive the mCpath treatment once every two weeks for a total of two treatments before taking the midterm exam. In the alternative weeks, the participants would listen to a class lecture.

Just as with the experimental section, the participants in the hybrid treatment were randomly assigned to teams. The hybrid group received the same mCpath instructions, had two hours of class time to work on their reports, and then all reports we due at the end of the week, Saturday by 23:59. The received detailed feedback on their reports, just as did the experimental group. They also had a Friday lab class and were taught the same way during the class as was all treatment groups.

Copyright by Mahidol University

3.3 mCpath instructional process

The mobile computing path method was first designed to be used within the class time and the classroom space. One of the reasons was that the process is unique, with no information on other teams using mobile devices for searching so the researcher wanted to control the parameters as much as possible. After receiving student feedback from each mCpath cycle, small changes could be made to help simplify and clarify instruction or how students completed the work.

Team members for each mCpath group would be assigned randomly. This was done by using the decimal fraction generator at random.org to make a list of 400 numbers to ten decimal places. Extra numbers were included in case there had to be some adjustments due to add/drop period and withdraws after the midterms. Originally, four members were assigned to a group, but after the second term, some of the students suggested to have two reporters, one responsible per path, so the groups were changed to five members per group in the last experimental term.

Before an mCpath session, students were reminded on a Monday and Friday to remember to bring their mobile computing devices to class. There were no instructions as to which device would be preferable.

During the mCpath class, the first 15 minutes were used class announcements, reminders, and quick updates on mCpath instructions. Then students then would work together in their group for 55 minutes. A list of questions called Path Questions would be posted on the class website, and students were instructed to work in pairs answering as many of the questions as possible during the time limit given, giving priority to helping find information for the person that would be presenting during the class. During the first experimental session of the first mCpath, there were issues with connecting with wi-fi during class, so two groups of students could work elsewhere, but because one of those teams when directly a computer lab to use desktops, the directions changed to having to work together in a classroom.

In the last 40 minutes, the student designated as the presenter would present answers to three of the path questions and answer questions from the instructor. One of the issues with having 4 members per group was that each presenter had only 4 minutes. With the adjustment of five per group, the maximum number of

Copyright by Mahidol University

groups per class was eight, leaving more time for the lecturer to ask questions and to correct some misunderstandings of content.

Each mCpath session, the team members needed to pick one of the roles:

- Auditor
- Presenter
- Reporter
- Researcher

Except for the Presenter, each one required that a report was completed and sent in by Saturday before midnight. All students were encouraged to complete as much as possible during class but that most had extra time during the week. Each would receive a grade for the report or presentation, and all the averaged mCpath individual scores would count as 10 percent of the total grade for each student. These individual scores were average together to make the team score, and this also counted as 10 percent of the grade assessment for the term. If an individual failed to turn in a score, that person received a 0 for both the individual and group score for that session, and this was not included in the team score. The purpose of this was to encourage team collaboration but at the same time to hold each person accountable for completion of tasks. If students decided to chat on Facebook or mysteriously spend all session in the restroom, those individuals then had to take time out of class to finish their work or receive a grade reflecting the effort invested.

Although teams could complete tasks as each group decided, the lecturer emphasized at the beginning of a session that it would be beneficial for all group members to help each other, so that it improved the team score. Likewise, each member could work along on the assign tasks, but students would be reminded that they could accomplish much more by sharing the searching tasks and then help each other recheck the quality of the answers.

When feedback was sent back on the reports, students were encouraged to share all information, so that the next person would learn from mistakes and score higher next time, helping the whole group score as well.

Copyright by Mahidol University

3.3.1 Path questions development

The path questions are at the heart of the mCpath process. They are designed to have the students investigate the areas that would normally be covered through class lecture. The learning outcome of the computer class for the class work was defined using the first two rungs of Bloom's Taxonomy of Learning of Domains: understanding and remembering. Students need to remember basic terminology in terms of recognizing the parts of a computer system. They also needed to show understanding through being able to explain in simple terms how a part of the computer system functioned, such as how an optical mouse worked or how data is encoded on a magnetic storage device. Priority was given to mCpath questions that helped stimulate remembering and understanding of computer concepts.

Originally the path questions were presented as a node diagram. In the pretest pilot phase the term before the experiment started, the path method was tested after the midterm point in three different sections. There were three main branches, with some more branching within the other stems. The primary feedback from students was that they did not know which questions to answer or what path to follow, so they were quickly lost in the woods. The other issue was the number of questions they could answer. Path 1 had 43 questions, path 2 19 and path 3 contained 53, so the total came to 115 questions. Because there was no information as to how many questions students could answer, too many were included the first time. Of course, the grading of 28 Reporter Reports with these many questions would quickly become unmanageable if most did answer all.

Although any graphic program would work for creating the path image, the one first used was an open source hypermedia mapping program called Compendium. This was in line with the concept of using tools that were publicly assessable on the web. Later for ascetic reasons, the researcher experimented with various mind mapping software packages and settled on using path diagrams were created using a commercial package that runs on OS X called Curio. The advantage of this package was that it quickly converted a list of questions to a mind map diagram, but to get the numbering correct, the researcher had to usually remake a text version of the list. Although the path diagrams were kept as part of the original design them when

Copyright by Mahidol University

students had difficulties following the question on the images on the limited iPhone displays. Because of this, the path questions were first presented on the website as a numbered HTML list and then the path diagrams were included below. During the experiment, the path diagrams were included, but in the current class implementation, there is only the list of path questions with no graphic diagram.

The format and medium of how students turned in the reports were also left up to the students in the pilot. A few students sent photos of written notes, but the major it either answered in an attached Word document or the text of an e-mail. Some gave just a short answer with no supplemental information about web sources. Others sent complete answers with URL addresses.

In the mCpath1 of the first experimental term, the paths were trimmed to two main paths. Some paths would branch into a second branch that would then merge back to the main path. Student were randomly assigned to teams of four people and instructed to work in pairs answering questions. The students were still confused with the extra bunching, so in mCpath2, the process was simplified to having two paths with no extra branching. mCpath1 had a total of 30 questions: 14 path1 questions and 16 path2 questions.

The other major defect found in the initial pilot was that the size of the text used in the path questions was too small to be read from a mobile phone screen. The default size of 10 points was changed to at least 14 points in the initial mCpath1 experimental session, and this solved most of the problems. The students using an iPhone still had readability problems, so a list of the path questions was also included under the path diagram in mCpath2. For readability, the list of path questions was eventually shifted above the path diagrams.

The other major adjust was that in the first term of the experimental phases, there was only one reporter answering the two sets of path questions. Although the other team members could help this reporter answer questions, this one person would be responsible for answering all the questions and for references the web sources used for these answers. One of the recommendation that a student gave in the learning journal was to have two Reporters instead of one.

Copyright by Mahidol University

3.3.1.1 Path questions

The drivers of the whole mCpath process are the path questions. As to ILCSHE Standard 4, it provides the specific purpose for each team to search the web. The Reporters are responsible for answering all the questions. The Presenters answered three of these questions during class. The Auditor needs to look at the web source for one answer and evaluate the quality of this information. The Research helps answer some of the questions but needs to use a search engine different than Google Search and then has compare the differences between using these two services.

The questions provide the basis for the computer concept questions that are on the midterm and final exams. The ultimate purpose is to have the students find the information on their own and then master it. With the sections that were assigned as the experimental group, the first week was an orientation session, then for the next 4 weeks, the students participated in the mCpath instruction method instead of receiving a class lecture. Before the midterm, the experimental section would receive a test review where the lecturer would explain the testing format, and explain the material that would be covered on the exam and how many questions for each topic.

The participants had the same access to materials on the class website. This included the assigned reading, pdf versions of the PowerPoint presentation and videos recording of the presentations, enough to answer basic questions relating to the bottom two steps of Bloom's Taxonomy.

The questions are broad enough to cover the same materials that would have been given in the class lecture. Because of this, most of the questions start with either "what" or "why." In most cases, the questions at the top were less complex to answer, and they became more difficult lower down the path, with the more challenging questions at the end. One of the comments from the students in the first experimental cycle was that the paths were tedious to go through, so more variations to the types of questions were added. As would be expected, most were conceptual in nature, such as "what is the internet" or "how does an optical drive work?" Some were more specific to a technology, "where is L1 cache located on an

Copyright by Mahidol University

Intel I7 CPU?" A few questions had local geographic relationship, such as "Where in Bangkok can you printout a 3D image?"

The inspiration of path questions again came from the highly graphically and colorful images of questions in a concept map (Bucher, 2012). The original path questions in the first pilot looked like an upside tree with three main paths, and then nodes that branched to two to three more choices. Questions for each path were highlighted in a different color. What happened was that students became lost and quite unsure of which questions to answer.

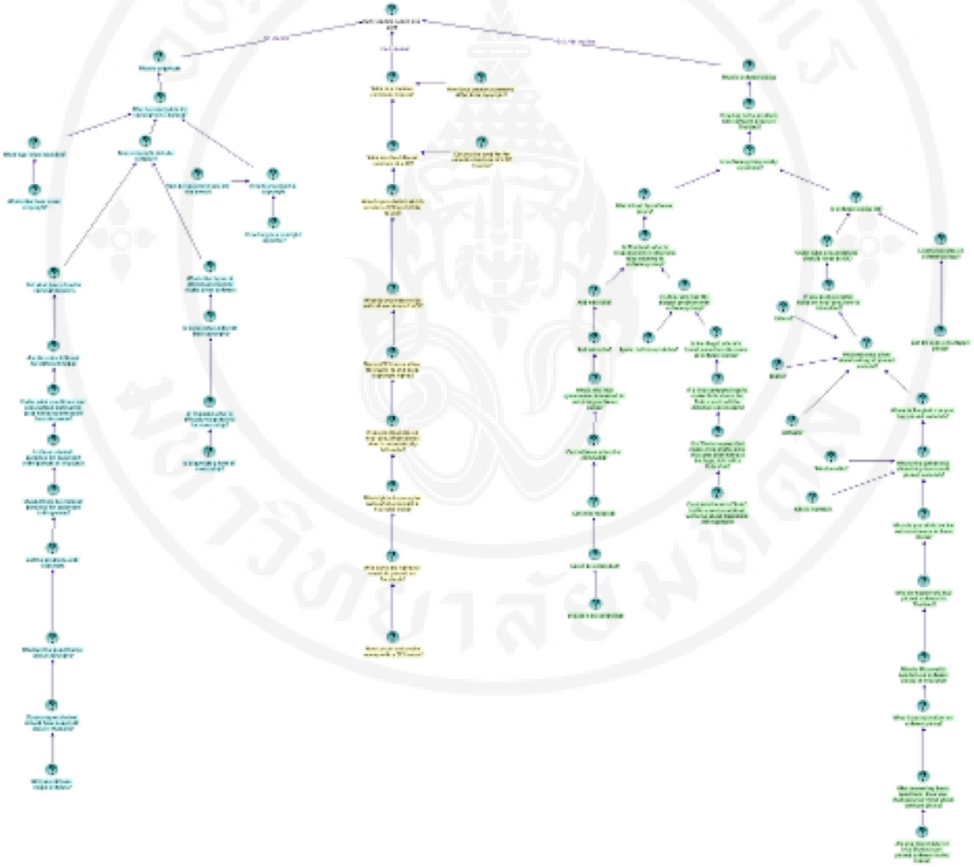

Figure 1.1 Original mCpath path question in pilot session 1

In the second pilot session, the paths were redesigned as two main branches coming off the main node, and then more questions branch further down. The reason was that it was expected that two students would work together on one path. Where there was a split in the path, one student each would then work on

Copyright by Mahidol University

answering those quetions, and as the paths merged, the students would also merge together to work on questions. This path question format worked reasonably well enough, that it was used for the mCpath1 and mCpath2 of the first experimental phase. In mCpath1 of experimental phase 1, path 1 would split into path 1.1. And then path 1.2 and then merge back after four questions, and path 2 had the same sort of split and merge. Feedback from the students showed that they were confused about if they had to answer all the questions on the split. In mCpath2, experimental phase 1, on path 2, there was an experiment to see if students could handle several questions that branched off from the main question. For example, there was a lead-in question about the types of monitors and then several branches out asking about the meaning of contrast, refresh rate, luminance, dot pitch and pixels. The other hub asked about four different type of flat-screen technology. This arrangement did not work as well, so the final pattern used throughout all other sessions was a node diagram that showed two sets of path questions.

Compendium, an open-source concept mapping software was used in experimental phase 1. This is in keeping of the original concept of the project in using software tools and services that are publicly available. The Compendium Institute describes their software tool that allows door sharing of ideas. It had the sponsorship and financial support of many well recognized organization, such as The Open University, Hewlett Foundation, and NASA (Compendium Institute, 2012). The software was design to use in teams and to be used to generate creative ideas. Its collaborative features are what drew the interest in using the package the first time, especially as this software can link different media together and during the plot phase, the mCpath roles were still evolving. Its full potential was never used in this project, and only its ability to represent nodes graphically was used.

Simply to experiment with using different concept mapping software, version 8 Curio for Mac, a proprietary mind mapping package from Zengobi, was used for experimental cycles 2 and 3. It was useful because each term could be organized into a folder. The path questions could also be quickly turned into a text list or a text list could be quickly turned back into a mind map. During preparation for an mCpath session, this made it easy to have a text list version that could be turned to path question diagram and then also converted into an HTML list to

Copyright by Mahidol University

post on the website. One of the issues with Compendium was that each node had to be rearranged to make in more readable. Curio allowed for automatic reorganization branches in either a horizontal or vertical perspective. Another issue with Curio was that by default, arrows all pointed up at the center node. They could be reversed to point downwards, but it took some time to do this for each session. When students saw the arrows, they were unsure if they were supposed to start answering questions from the top or from the bottom to the top. With Curio, the questions were nested as subquestions, so it showed a slightly larger connector to the parent node and then a smaller connector the child node. It appeared more natural to start at the top and answer the question in sequence. The Curio mind maps also had a sleek graphical appearance that made the whole instructional method look more in line with an m-learning package. The default template used gum-style chiclets used bright colors and a drop shadow. After experimenting with different designs, the template used was a simple white rectangle with no border, 24-point black Helvetica text, a 5-pixel bulge drop shadow and 1 point line connectors with straight lines at the elbows. This gave the nodes a slight 3d effect but made the graphic quite readable on a range of different size displays. Both Compendium and Curio had an overabundance of extra options that made generating a path image more complex than it should have been. Compendium was designed to be as a shared workspace, connected to databases. It had different symbols for different nodes, tags, bookmarks, templates, varied levels of security and many more features. Curio also had an overabundance of features, including drawing tools, image galleries, idea spaces, organizers and even an events scheduler. Currently, there is range of graphical tools that are better designed to fit an extensive array of computer displays.

Copyright by Mahidol University

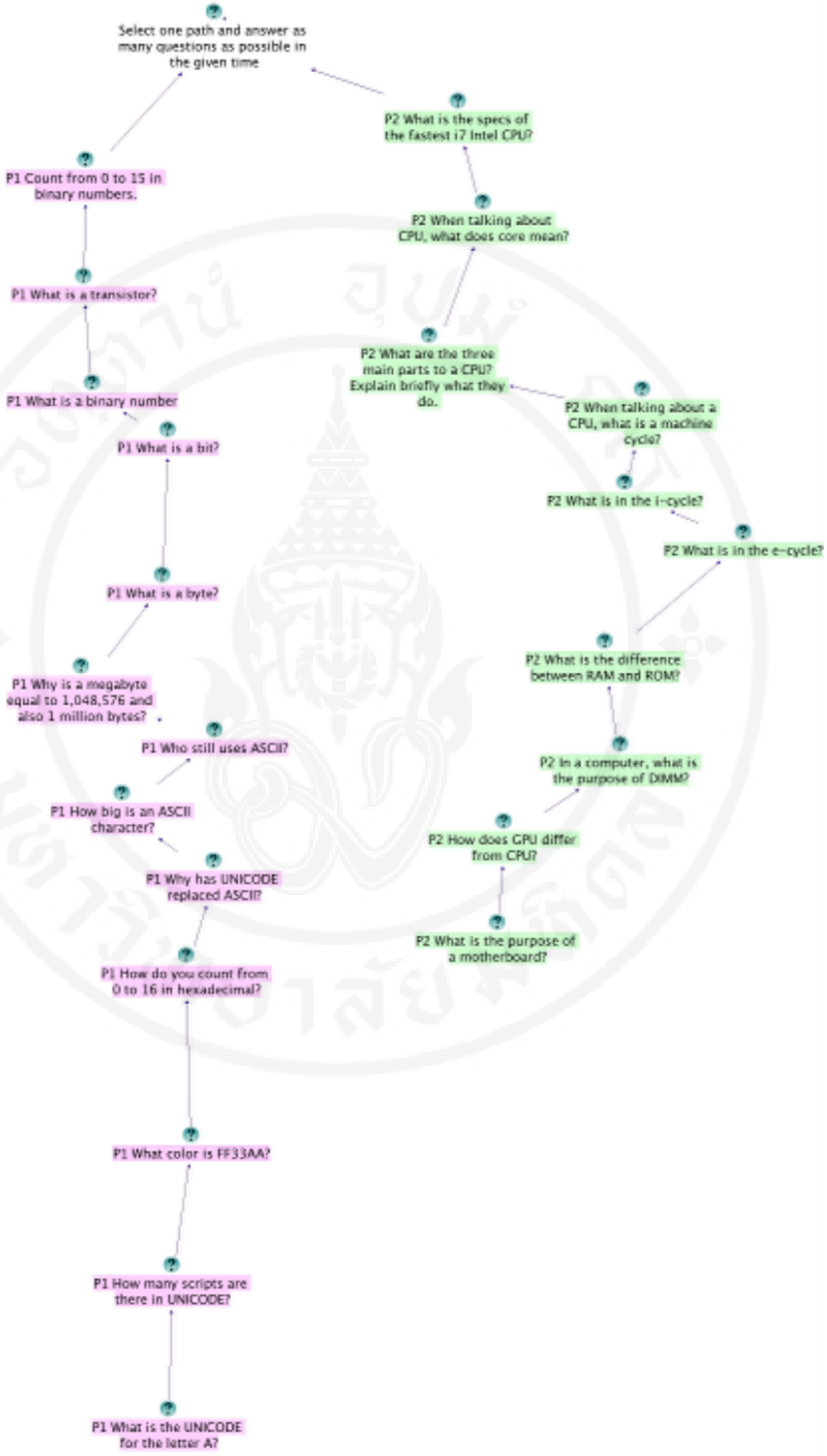

Figure 3.2 mCpath4 path question, experimental session 1

Copyright by Mahidol University

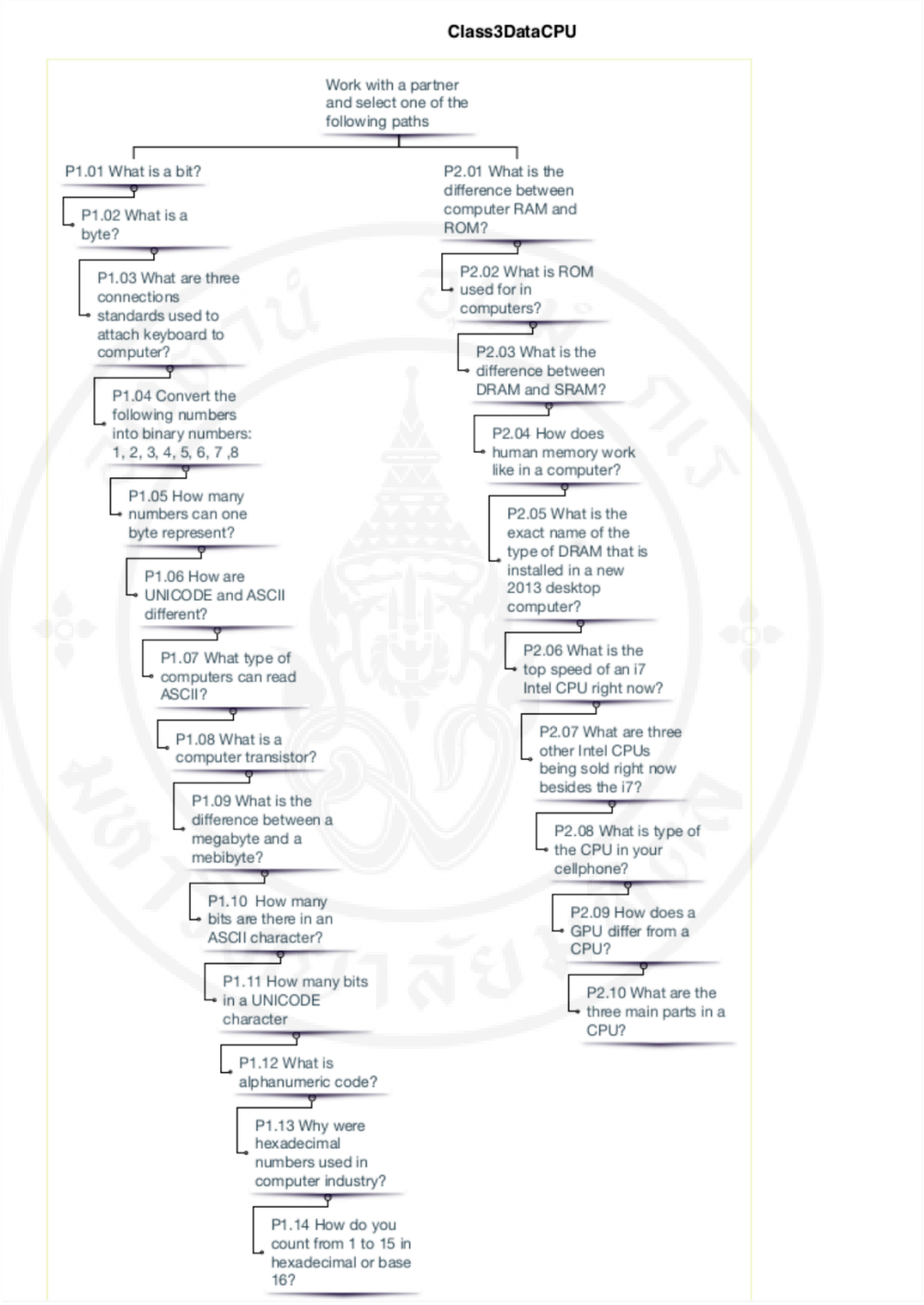

Figure 3.3 mCpath3 path question, experimental session 3

Copyright by Mahidol University

Although the graphic image of the path questions was readable on laptops, tablet computers, and large display phone, there was issues reading them clearly on an iPhone display. To supplement this at the start of the experimental phase 2, on the website an HTML list of questions was included underneath the image. By experimental phase 3, this was swapped to the top, and the graphic PNG path mapping was kept as a remnant of the mCpath development process. In the post-experimental phase, the graphic dropped the term “path questions” was kept as part of the process.

One of the other adjustments made for experimental cycle 2 and 3 was the elimination of any color in the diagrams. Graphically, the two sets of path questions were visible enough without using color to emphasize this.

Another adjustment starting in experimental cycle 2 was the use of path numbers to better identify the exact path questions. The original images had no reference numbering to a specific path or question, making it onerous to grade.

One of the issues was how many questions would cover the material usually taught in the lecture and that was of a practical number for both answering and grading. To test to find the appropriate number, the project researcher intentionally started out experimenting with using the extreme of too many questions. In pilot phase of mCpath1, there was a whopping 69 total questions to be answered. To say the least, most of the group were overwhelmed with this many. The number of path questions for the mCpath2 pilot was reduced to 46. There were so many questions, that students gave a short fill-in-the-blank response. Another shortcoming of having too many questions was that only a few students cited the web page source for the answers of each question. Grading and giving feedback on these many questions for 20 groups was also overwhelming.

In mCpath1 of experimental phase 1, the number of total path questions was reduced to 30: 14 path1 questions and 16 path2 questions. The number of question reduced each mCpath session until there were 14 total questions for mCpath6, experimental cycle 1: 7 path1 questions and another 7 path2 question. This was intentional because as students neared the midterm point, they had more projects and quizzes in other classes, as well as the time needed to study for midterms. Psychological, it was also easier to have students first expect to answer 14 to 15 but then find out that they need to answer less of them than to increase the number. This is

Copyright by Mahidol University

because the questions also become more difficult, and students were held to a stricter grading standard for each mCpath session. They had more time to spend more finding more information at the better websites.

The path questions in experimental cycle 1 were still being tweaked and refined because this was the first experience with using this process in the classroom. After refinements, cycle 2 and cycle 3 path questions were the same, with just some minor adjustments made.

Table 3.3 Number of path questions throughout the mCpath experiment

Experimental Cycle	MCpath Session	Path1	Path2	Total Questions
1	1	14	16	30
	2	12	16	28
	3	11	9	20
	4	13	10	23
2	1	14	15	29
	2	12	14	26
	3	14	10	24
	4	10	11	21
3	1	14	15	29
	2	13	14	27
	3	14	10	24
	4	10	11	21

Copyright by Mahidol University

The imbalance between path 1 and path 2 was on purpose. They were mini experiments to see the optimal number of questions per path. This did cause problems with Google Forms, especially when adding an extra question or two to the form template because the questions would sometimes be stored out of order in a spreadsheet and had to be adjusted. Some of the better students would also be wary because they were used to answering 14 to 15 questions and were unsure as to if they were missing some questions or making a mistake somehow.

Certainly, one of the main conclusion of this process was that the number of questions could be reduced. The importance of the learning experience was the attention put into the quality of the work in using search terms, filtering the results and then answering the questions. In the post-experimental phase, path questions were reduced to a consistent six each. To cover the same amount of content material that would have been collected in twice as many questions, they were broadened to include more comparison questions between technologies. For example, a question about "what is a computer platform" and "Give three examples of platforms" was merged into "What are 5 types of computer platforms," forcing to students to find more examples and understand the characteristics of a platform.

3.3.2 Digital resources used for mCpath

To ensure as equal of access as possible for each mCpath team, the minimal requirements were that each student brings a mobile computing device to class and have access to the internet. Mobile computing devices were defined broad enough to include smartphones of any make or model that had internet access, tablet computers of any make, and laptops and notebooks.

Students could use any search engine they wanted, but the majority used Google Search. In the second and third term, as part of their duties, the Researchers were assigned different search engines and then wrote their analysis on the difference found between using Google Search and Bing, YouTube, the university' EBSCO Discovery or other such search services. One of the purposes of this assignment was to encourage students to use other tools.

Copyright by Mahidol University

For the tools used by the lecturer in the mCpath process, the initial purpose was to use the simplest and most publicly available services and then to refine the

process each term as was needed to eliminate some of the work involved with grading hundreds of reports, as well as storing all the results in a database.

The initial services used the first term to receive mCpath reports and send back feedback was a class website and a class email address. A spreadsheet was used to keep track of assigned groups, attendance, and grades. An open source program called Compendium was first used to make the graphic path question images. These have a root, node design, so mind mapping software or a program that handles flowchart diagrams works well. In the second term, a commercial product was used in place of the free open source software for aesthetic reasons, but the free software worked fine.

Because of the tedium of having to copy/paste text from e-mail to a database field, Google Forms were used for the Auditor and Researcher Reports. The Reports still e-mailed in their answers to their questions from Term 1 to Term 3.

3.3.3 mCpath Roles

The mCpath design is unique, and to this date, there has been no other research or teaching method found in the literature, in conference proceedings or on the web. There may exist some similar instructional method like this, but at this point, this instructor has searched far and wide and has not seen such.

The mCpath roles are key to the building in the cooperative element into this instructional design. One of the shortcomings of group work is building in interdependence between team members so there is the interaction between members (Dennen & Hoardley, 2013; Kua, Tseng, & Akarasriworn, 2013). Teachers put students into groups and expect them to work closely together naturally. They also sometimes mistake active discussions as interaction and involved engagement. What typically happens is that one or two students will take on most the work, with the others following and then one or two looking for a free ride for an easy grade. This is possible if the tasks are not designed to internally rely on others in the team.

Students were randomly assigned to different teams, and during class instead of listening to a lecture, students worked together on answering path questions and then had one student present. The final reports were due by Saturday before midnight.

Copyright by Mahidol University

The Reporter was responsible for answering all the path questions by Saturday of the same week. During class time, the Presenter had to find the answers to three path questions and present them during class. The Auditor was responsible for finding the highest quality links for three of the answers and then need to analyze these in detail, with the report due at the end of the week. The Researcher was assigned different databases to use and then had to submit a report on the differences between using the assigned service and Google Search. Researchers also had to write about differences between their group and other groups, and the reports were again due by Saturday.

The mCpath roles were designed originally to be additive interdependent (Winfred Arthur, Edwards, Bell, & Villado, 2005). This means they were designed so that students can complete tasks on their own. Each role has a set task that needs to be completed within a definite time frame. Most of the roles did not necessarily require communications during or after class to accomplish their roles. The Reporters can answer all their path questions without referring to other members, but they had the most to gain by having others help them finish their work. If each member found the answers to three questions, then the Reporter's work could almost be completed during class time. If they all helped search for questions, there would have been a wider variety of sources as well. Even when there were more than one URL used, one Reporter tended to heavily rely on one type of information. Some of these were Wiki-style quick answers to technical questions. Some of the better students spent more time searching in tech journals. The better ones used Google Scholar and found primary source. A few students would heavily rely on Google Books, but most that did use dated materials pre-2000.

The Presenters have an hour to find information that answers three questions and prepare to present during class. The ones that did their own searching and preparation usually had good presentations because they could answer questions better. The main issue was that most relied too heavily on only one source, so had major issues with any question that did not fit was on their reference webpage. These types of Presenters did better remember the source of their materials. The ones that relied on other members to give them a script to read did quite poorly in both presenting and answering questions. Those that found some of their own answers and

Copyright by Mahidol University

had the assistance of their team members in finding more information tended to do better with presenting, as well as answering questions. Where they had problems were in explaining the source of their information because they had not necessarily found this on their own. To add to the collaborate dynamics, in the third experimental cycle one group member had to use a smartphone to record the presentation, and then the Presenter was required to post this up on YouTube by Saturday. This required some communications and cooperation because sometimes the owners of the phone would post up the video on their account and sometimes the Presenters downloaded the video to their own computers and then uploaded it.

The Auditors could find their web sources and evaluate them on their own, so in theory they could have finished their reports on their own. In the first mCpath session, they could take the Reporters' sources and then use this for analysis but then highly encourage to find their own source for the next reports, so that the researchers then had total control. They could select what question they wanted to answer, as well as being able to find their own source. The issue is that the Reporter and Auditor have two diverging purposes. The Reporters need to find more than one source and a variety of types helped strengthen their final product. In contrast, the Auditors needed to find only one source and this had to be of the best possible quality that they could find. In mCpath1, during the Friday lab class, the students had practical training on using Boolean search operators and "site:", "intitle:", and "inurl:" to dig past the weaker sites and find the better sources. They were also introduced to the search tool function in Google Search and how it can be used to limit search range to sites that have been posted or update within a certain time limit. Finally, they were shown how to look at the original source code for a web page and then quickly search for date information in the head tags. The next search lab session was usually on the Friday of the last mCpath session and focused on finding primary versus secondary sources, using an example path question from the Monday session. The searching instructions were taught intentionally after an mCpath class session, so that the students could better understand how these tools could be used to help them with their m-learning reports. It is part of focusing on teaching in context, where there is more meaning because students could then see a practical benefit in helping them solve a problem. During the first mCpath session, students are confused about exactly what they are

Copyright by Mahidol University

looking for, so they either type in the whole question as a search term, or they go for a short and simple one-word search. They are unfamiliar with the terminology and are unsure if this is the right information or not. Most go directly to the weaker tertiary sources because they provide simplified explanations that can be quickly scanned and understood. These tend to be the more commercial sites that provide quick answers to users to drive advertising traffic. Many of these scraped the better information from other sites. The better of them will link to the original information, but many do not. After students have had some experience on their own trying to sort through this, they then understand the usefulness of using "site:.com" to cut out these types of sources. They become quite excited when they find that "site:.edu" will get them quickly to a computer or engineering program of a famous program, but then their brand-name blindness makes them less aware that some of these sites are more than 20 years old or that content may be from another undergraduate or a computer center staff member. Having another team member look at the material helps these Auditors have a better chance of seeing these weaknesses.

The one role that does depend heavily on others is the Researcher. As part of their job, the were required to talk to other group members to compare differences between the two. By implication, this also meant they needed to talk to their team as well. At first, these Auditors tend to be shy because they do not know other class members that well. Some never talk to another person, so they write in quite general terms, have only one to two sentences of analysis or only write about the dynamics in their group. Another trick is to write about similarities, not differences, so that any interaction happening in the Auditors' group is extended out to the others. Because the groups are assigned randomly, most have a friend in another group that they can count on to help with this analysis. As the Researchers understand that when they have listed many differences, they receive a better grade, then they spend more time and energy talking to other students. The main purpose of having student see the differences is to encourage them to adopt the better practices in other groups.

The students were reminded several times during the term that if they cooperate and work together, they are likely to finish more quickly and produce a better-quality report. If they worked on their own, then it would take more effort for each. If one member misunderstood directions or did not put as much effort into a

Copyright by Mahidol University

report, this would lower the group score. An example would be if the Researchers helped Reporters find some of the answers for the path questions by using YouTube or Google Scholar, it would help speed up the Reporter's work and provide a wider variety of sources include, making the quality of answers better. For some of the Auditors, they did quickly understand that by using Google Books or Google Scholar, they made a huge leap in quality of source material, plus it made it so much easier answering the questions about timeliness and accuracy of information. Most realized this when they were working with their Researcher that had to use these services for that mCpath process. This means that many of the groups reached sequential interdependence. This was seen in the remarks that some of the Auditors were angry at some of the Reporters for finishing their reports on the last day, so that the Auditors had less time to spend on analysis. A few members of team reached reciprocal interdependence, where there were plenty of discussions and exchanges of information during and after class. Some of the Some of the Researchers realized that this intensive amount of discussion slowed down the overall workflow. A few noted that even though their progress was slower, they thought the overall product was of better quality than for other groups that used more a sequential method.

The weight given to the mCpath grades was specifically designed to foster a higher level of interdependence as well. Because of the work and effort involved, the m-learning made up 20 percent of the total score for the experimental and hybrid experimental sections. Students were given 10 percent for individual grades for role reports, and then the mean average individual score of each group made up another 10 percent. Students were reminded several times during class and in emails that as each member scored higher, this would increase the group's score as well. Developing healthy group dynamics takes time and trust (Adler, Heckscher, & Prusak, 2013; Lencioni, 2005). Through the Peer Reports, the lecturer could clearly see a stronger sense of team developing through each mCpath cycle. In some of the groups where a member failed to submit a report on-time later in the term, these students would often email and ask that they only receive the zero score and please do not let it affect the team's total score. Normally the lecturer would not receive this type of message on the first mCpath homework.

Copyright by Mahidol University

At the beginning of the experiment cycle, the roles and responsibilities of the Auditors, Presenters, and Reporters were already developed, but the actual process and the form of the reports still were in development. Post-research, these have continued to be refined. In the spirit of using services and tools that are open to anyone to use, Google Document Forms were used. In experimental cycle one, they were used for the Peer Report, as well as for Auditor and Researcher. During this period

In the pilot phase and for the first two mCpath in experimental term one, the Reporters used email to submit their reports. The reason was that the lecturer wanted to be open to receiving information from a variety of potential media. Students could send audio files, videos or images, as well as text. After trying to access the first few reports, the practicality of grading forced the instructor to limit to receiving answers as text. Having to listen to a complete podcast or watch a 15-minute YouTube video was just too time-consuming. Students emailed the Reporter reports throughout that first term, but there were many issues with doing this. First, there were difficulties in confirming if students emailed the report or not. There as a specific email account, icns141@gmail, that was used to communicate with students in the class. Some email the instructor but used hotmail.com, not gmail.com. Some students would be too quick with sending without checking carefully, and the autofill function would include the wrong address. The other issue was that with an email, there was no standard form used to submit answers. Some students would include the URL address after each answer. Some would include all URL addresses below in one huge mess, where it was difficult to sort out which belonged to which answer. Some of the students numbered the answers but some did not.

For all experimental cycle, students e-mailed their personal introductions and learning journals directly to the instructor.

Ideally, the mCpath group were randomly assigned the first week, and then the students stay in the same group the rest of the term. The lecturer wanted to design the system to be robust enough to handle changes with a school term.

In the first experimental term, the target size of a group was four members. With adjustment of having two Reporters, this target was changed to five members per group starting in the second experimental term. Having five members helped considerable with adjusting. At minimum for the mCpath instruction to work, there

Copyright by Mahidol University

should be at least two members because the two Reporters are looking up information that will make up the midterm exam. With a class with a maximum capacity of 30 and 4 members per team, this means there will always be two groups with 3 members. If one of these groups has a member missing for whatever reason, then that group comes quickly down to the minimal two needed for that session. If one of these three-member teams have two people come down sick, then there is not enough for the process, and then the one member left over must join another team. This was the difficulties the lecturer had in the first experimental term. For example, during mCpath1 on experimental term 1, section 2 had four groups with only three members, although section 3 only one such group. Almost each mCpath session had adjustments to team membership. To document which member was in which team, an extra column for the that assigned group was used for each session. With a target of five members, only one adjustment needed to be made in experimental term 2 and none in the last experimental term.

One of the issues was handling students adding and dropping the class within the first two weeks of school. Some students would sit in for the first couple of week but not yet register. There were always at least two or more students that would register but then not attend the first two weeks. Some of these students dropped the class and some eventually showed up, returning from holiday. Most of the students would prefer to register for section 1 and 2, but both sections filled up quickly, so some were forced to section 3. During add/drop, some students would change sections. Because section 1 and 2 usually was at maximum capacity, substitution was normally used for assigning the new students. This meant that new student that was adding the class was assigned to the group where a student withdrew. The problem here is group cohesion. Because the original members had a chance to participate in a couple of ice-breaking activities, they had already started developing a sense of their role within the group. The newer member usually had more difficulties integrating into their team. The turning point usually was when the group worked on the YouTube video project together.

Copyright by Mahidol University

As part of the learning process, student reflection was built into the initial mCpath method, the main ones being the comment section and the question about what students would like to more about in the Peer Reports and then there was the

more formal Learning Journal, where student need to seriously consider what they have learned during the term. Researchers were also forced to compare their group to another group as well, forcing them to mull over if their group was using the best method for finding information. The amount of student reflection was further enhanced through refinement of the process by adding questions in the Presenters and Auditors' Reports on what they plan on doing differently next time. The popular Kolb's Experiential Learning Model (1981) ingrained the importance of reflection into the learning process in modern education, but this education concept is as old as Dewey's 1910 book on How We Think (Dimova & Kamarska, 2015). It has been one of the factors built into computer research, especially in regards to using video, blogs and online portfolios (Kori, Pedaste, Leijen, & Maeots, 2014).The purpose of reflection as used in this research is to connect concepts and knowledge to reality (Procee, 2006).

3.3.3.1 Presenter

The Presenter role maps directly to ILCSHE Information Literacy Standard 4, using information to accomplish a specific purpose. In this case, it is to take raw information from the web and reformat it to present aurally during class.

During the first session, Presenters selected questions to answer, but because most groups answered the first three questions of either path 1 or path 2, so in all subsequent sessions, the Presenters were assigned to answer different path answers.

Presenters can refer to notes, but if they read directly from a script, their score will be lower. They also receive a higher score if they can show they have some knowledge of what they are talking about. When asked, they should clarify an explanation or answer questions related to their answers. This is part of ILCSHE 4.3 Performance Indicator, which is to communicate the product or performance effectively to other. In the first mCpath sessions, some Presenters will try to read directly from the text from the website but quickly find that this does not work well. The audience has problems understanding what is being read, and the Presenter is unable to answer questions at, resulting in a lower individual presentation score.

Copyright by Mahidol University

Although Presenters are more than welcome to use presentations aids, the time limitation usually means that they usually focus on mastering the content and have little time to fiddle with PowerPoint or Keynote files. In a potential follow-up version of this project would be to experiment with having students experiment with presentation technology. One interesting variation would be to have students use Skype or FaceTime to present in the class from a remote location.

The Presenter has 40 minutes to find information for three of the path questions and then has a maximum 10 minutes for presenting and answering questions during class. This relates to ILCSHE Standard 2 in finding information efficiently. This time element helps keep each group focused on the academic task during class time. Each group handled this task differently. Most teams helped the Presenter find information in time. Some would have every member helping, and some would have one or two people assisting. Of course, some groups will have the Presenters find all their information.

One of the post-research refinements to the Presenters' role was to have each team record the presentation via smartphone and then post up the unlisted video to YouTube. As part of this process, the Presenters had to fill out a Google Form that asked for the link address. The Presenters were also asked to reflect on their performance by requiring them to answer the question on what they would have done differently if they presented again. The students had a chance to see what they looked like and sounded like when they presented and through the question, they were forced to think about it as well. The ability to watch the presentations one more time also helped the instructor give more detailed feedback on how to improve and to ensure the scoring was more consistent.

The other change to the post-research process was that the Presenters needed to only answer two questions instead of three. This allowed them to focus more of their attention on understanding the material they were reading. It also allows the lecturer more time to ask questions.

3.3.3.2 Reporter

Copyright by Mahidol University

The Reporter is responsible for answering all the path questions, as well as including URL address of the information used as sources. This was one of the key roles that fulfilled the essential elements of ILCSHE Information

Literacy Standard 2 and 3, first determining the nature and extent of the information needed and then to finding the information effectively and efficiently. Reporters need decide on the search terms or phrases used to target the appropriate information. They need to know how to filter out the weaker sources that draw in beginners with click bait, digging down to the more primary source materials.

Because the Reporter's job is key for the mCpath method, the job was explained twice in the first week and then briefly before the first mCpath session. Instructions were also posted on the class website, and the lecturer highly encouraged Reporters to ask questions. The Reporter was responsible for answering all the path questions. Other students could assist the Reporter finding information, but if no one did, the Reporters will still responsible for answering all the questions. This person would also be responsible for listing the URL addresses used as sources of information. The Reporters did not have to rewrite or paraphrase the information. They could copy and paste information because their role was to find the raw material that would be used by everyone in the group to prepare for the midterm and final class exams. The other team members were the ones that needed to be able to synthesize, summarize and interpret. The Presenters took the found information and turned into an oral presentation that could be understood. The Auditors needed to look closely at the source of the material and evaluate the quality. The Researchers needed to understand enough to compare the differences between what was found between their group and other groups.

In the first mCpath treatment, Reporters were told not to use Wikipedia as a source. If they did so, their report score was lowered. In the second mCpath treatment, the standards were tightened more, and Reporters were told not to use any tertiary sources and then given a list of some of these, tertiary being any dictionary-type or encyclopedia-type definition of a technology. Those that included such sites were penalized with low scores. Of course, these tertiary sources are the ones that are most likely to be found in the first-page results of a quick one-term search.

Copyright by Mahidol University

After turning in their reports, the Researchers received detail evaluation of their reports. These would indicate where the answers were well done or weak or incorrect. The lecturer asked the Reporters to share their reports and feedback

so that each member of the team could use it for study purposes. It was left up to the Reporters to share this information, but they were reminded in the report feedback and during class to do so.

Some students in their learning journal did ask that the lecturer sends all Reporter Reports to all students. There were several reasons this was not done, the one big one being copyright issues. It is one thing for students to share information within small groups but entirely different affair if the lecturer emails copyrighted material to everyone in the class. Under UK copyright law, this could be considered issuing copies to the public and potentially could be a version of broadcasting to the public. Although most copyright statutes have a clause for fair use for educational purposes, this depends on how much is directly copied. There is still the issue of correctly identifying the author and giving credit where it is due as well. One of the issues with website quality is that some sites intentionally steal copyrighted materials from books, journals or other websites and then fail to cite the original authors. Having to vet several thousands of pages of text for appropriate copyright notices and accurate information and then format it for readability just before the midterm is not practically possible.

Another reason that the lecturer did not share all of the reports was the potential for the free rider effect (Kempler, Linnenbrink-Garcia, & Didonato, 2013). Already in a normal classroom, there is a segment of the students that write nothing down, expecting to receive a detailed transcript from a designated notetaker. These types of students would like to invest the minimal amount of effort possible and then receive the copy of the best version of the report.

The last issue is that the whole purpose of the collaborative learning design is to develop team interdependence, where the essential part to the learning puzzles is in the hands of fellow members. Instead of looking to the lecturer for the one authoritative correct answer, through the process, the team participants should understand there are ranged of acceptable answers, based on the context of the material and the differing roles. At the beginning of the search process, neither instructor or students necessarily know the scope of potential answers (Sharan, Sharan, & Tan, 2013). Over the process, the students need to learn to support their learning through team participation and interaction. Although this research project first focused

Copyright by Mahidol University

on the more minimal learning objectives of understanding and remember, richer and more healthy team interaction sets the seeds for the development of a deeper level of learning for the next phase of research in this area.

In the first mCpath, many the Reporters would clip short, one sentence answers, scrapped from the from the first search results. Some Reporters would include an URL address for their references and some would not. Almost all of them would use only one source. As they received feedback, they learned that to find more different sources. More of them would error on copying/pasting too much information, some that were not related to the question asked.

Although the pre-experimental phase of mCpath helps develop the teaching process, there were many processes in the first experimental cycle that were better refined in cycle two and three. One was the method of how the Reporter Reports were submitted. The lecturer first allowed the students to submit work through e-mail. As part of wanting the students to experiment with different media and different note-taking technology,

The first experimental cycle, there was only one Reporter per group. In their learning journal, one of the students suggested having two Reporters to help with answering so many questions. This made sense because his means it was more likely that each person in the group would have two chances to work in this role. The increasing number of reporters also allowed for a larger sized group. This gave each group more members to assist with tasks. It also reduced the number of groups presenting during class, so allowed for more time to ask questions.

3.3.3.3 Auditor

The Auditor's sole function is to accomplish what is listed in ILCSHE Information Literacy Standard 3, "evaluating information and its sources critically…" (ACRL, 2000). Most students have difficulties assessing the quality of internet sources and usually the analysis is superficial (Braasch et al., 2009; Faix, 2014; 2012; Kiili, Laurinen, & Marttunen, 2008). Being able to search the internet for almost any type of information is a new phenomenon. The arcane technology and cryptic commands for searching digital resources in the '80s used to require librarians' assistance. Google Search's interface launched in 1998 revolutionized both how everyone finds websites and information. Some of the most popular journal databases

Copyright by Mahidol University

have been forced to adopt a Google-like one-search service in order to survive (Asher, Duke, & Wilson, 2013; Rose-Wiles & Hofmann, 2013). Digital search technology has radically changed in the last 15 years.

Even the Google search routine has evolved. The founders of Google published their initial search algorithm (Brin & Page, 1998), so the more canny web developers thought they knew how to game the system. Because of this, there has been continuous tit for tat with gossip about updates and revisions and refinements to Google's original search code (MOZ, 2015; Schwartz, 2013, March 15). Although search engine optimization gurus make their living best guessing how to rank pages higher, the only true experts are the Google programmers that continue to trim and revise, and they have been as secretive as the US NSA. This means that the technology is still relatively new and continuously changing, so most teachers, as well as their students may need to improve their web evaluation skills as well. One of the byproducts of grading the Auditor Reports is the teacher's repeated practice in evaluating websites in a knowledge domain, so that person does truly become an expert in evaluating those types of websites.

Interesting enough, a new study on how librarian students through many different countries search found that Americans had the least amount of problem evaluating sources and students from Turkey, Portugal and Lithuania had the most difficulty (Saunders et al., 2015). These are self-reports, and students have a habit of overestimating their computer skills and knowledge (Ballantine, Larres, & Oyelere, 2007). Yet, the research may indicate that non-native English speakers may have more difficulties with evaluating websites, even the librarian experts that have more advance training in this area. As will be discussed further in the analysis sections, one of the findings from this project was the gap between knowing and the actual skills of being able to apply this knowledge effectively.

Most of the literature agrees that students need to improve their critical analysis of websites, but there is no agreement on the best factors used. Smith's Toolbox of Criteria (1997) provides a comprehensive list that includes scope, content, accuracy, authority, currency, uniqueness, links to other sources, writing quality, page design, site purpose, intended audience, and seven more items. ERIC, well-known for providing education research on the web, also came out with its pre-

Copyright by Mahidol University

2000 recommendations on how to evaluate web sources by using seven factors (Abdullah, 1998). These tools are certainly extensive but too broad to be practical for the mCpath Auditor Report.

The CARS Checklist (Harris, 2015), favored on the web and in writing centers, has a more manageable list of four items. The terms “credibility” and accuracy overlap with Smith’s list, but “reasonableness” is not precise enough to give students clear criterion. The “support” item also has a similar issue with not providing an understanding through its name and would need to be explained in detail, defeating the purpose of using it. Another problem with support is that it is used not only to mean references to the source material but also is supposed to include supporting evidence used within the content of the page. Because the factor “accuracy” also includes facts, statistics, specificity of explanation, there certainly is overlap between these two.

Helms-Park and Stapleton’s survey on factors that faculty considered important for web quality assessment (2006) provides the flip view on how most lecturers are likely evaluating the quality of internet sources. Out of nine factors culled from numerous web evaluation systems, they found the following four to be the most important: academic rigor, the reputation of a site, name listed for a writer of content and objectivity and reliability of the content. The 31 participants in this study were all from the humanities, with the majority coming from the writing side, so although this gives a useful insight into their thinking, it may be less applicable to science and engineering. The issue was that because they tend to older, the lecturers are likely to have a bias toward the older paper-based way of research, using index cards and going through stacks of journal articles. This is not good or bad but has the possibility of coloring perceptions on how students should evaluate sources.

The criteria for the mCpath Auditor criteria was that there should have only three to five factors. It should be designed for university-level student understanding, and the name of the criterion should be mostly self-explanatory and require minimal explanation to means. They should be designed to fit the purpose of a general education class for non-computer majors.

Copyright by Mahidol University

In the pre-experimental pilot 1, the Auditors were asked one open-ended question to evaluate the quality of the website for three of the questions.

They e-mailed their analysis to the lecturer. From these responses, it was unmistakable that the students needed prompts to help direct their analysis in the right direction. From the students' remarks, the researcher determined that the three most critical evaluation criteria were relevance of the data, accuracy and credibility of the information source. These factors were used was used in a Google Form 5-point scale for the pre-experimental pilot2, along with a request for the URL address. The students did not understand the question about relevance, but just simply answering yes, the data on this page was relevant. In version 2 used at the start of the experimental cycle 1, accuracy, objectivity and timelines of information were factors added.

To develop the new prompts for mCpath Auditors, the researcher reviewed a range of university and library web resources, as well as more formal journal articles and several information literacy books. From this, a comprehensive list of factors used to evaluate web sources was developed (Appendix 3). The researcher then used these criteria to evaluate websites used by Auditors. After coding 14 different sites in detail, a version 4 form was developed that included scope, as well as accuracy, objectivity and timelines of information. It also included room for students to write their analysis, as well as asked for the UR address of the site used. This was the version used for all other experimental cycles, as well as the post-experimental phase.

As to the meaning of each of criteria, scope is the one that usually needs to be explained to students several times. This relates to the amount on information on the webpage. If it contains a simple one to a two-sentence definition, the scope is low. If it contains a complete 100-page book chapter, then the scope would be comprehensive.

Accuracy did not necessarily relate to true or false information. Even some of the thinner recycled materials had enough information that was true enough assisted students with answering test questions. This issue as it relates to computer was if the description of the technology was overly generalized and non-technical, accuracy would be low. A site that oversimplified information to make it more understandable would also rank low on the accuracy scale. Out-of-date information certainly would affect accuracy as well. Examples of highly accurate

Copyright by Mahidol University

information would be design specifications from standards organizations or hardware manufacturers that designed and sold the equipment. Information that was more tertiary should be rated lower, and current detailed information that came from a primary source written by industry experts, such as programmers, IT professional or OEMs, should have a higher score. One of the interesting discoveries that came through discussion with faculty, as well as with students, from other disciplines was the varying definition of a primary digital source. For example, would a press release from Apple.com be considered a primary source if used to answer about technical specifications of wi-fi standard on an iPad?

Because they cover the topic in their English language classes, the participants had the least difficulty understanding objectivity, although they still demonstrated a gap between knowledge and actual skill in determining objectivity of a source. A commercial website that is trying to sell a product has a high bias. Information is written as an option piece or includes mainly personal opinions have a high bias. Language that uses loaded terms and is overly positive or overly negative obviously have a bias as well. One of the more difficult aspects of this criteria is to get students to dig a little deeper into seeing the background and intent of the whole website, as well as looking up the background on the author of the content. Although not always obvious, societies or organizations that promotes standards such as the Blu-ray Disc Association have a bias toward protecting and promoting its technology, even though most of its technical papers are written in an impartial, factual style.

The last criteria to be added was timeliness, listed as, “How timely was the information that was used?” Students chose from a list that included the following: Within a day, within a week, within a month, within a year, 2 to 5 years old or cannot tell how old. Although facts in any science discipline can go stale, for computer science finding current information is especially essential important in computer science. An example of the speed of change has been technologies connected to smartphones. An obvious one has been the development of the new phablet segment of the market that started with the Samsun Galaxy Note in 2011, where even Apple has been forced joined the race for bigger phones. Other factors that continuously change are camera resolution and software features, wi-fi and cellular

Copyright by Mahidol University

network standards, fingerprint id, display technology, voice services and certainly battery life (Apple Inc., 2015; OnePlus, 2015; Samsung, 2015).

Other web evaluation criteria list “timeliness” as “currency”, but there was too much potential for students to misinterpret this to mean money currency.

3.3.3.4 Researcher

In the pre-experimental development, the Researcher’s role was the least clearly defined at the beginning of the process. The original intent was to use these participants into helping document the group dynamics. This was done by asking an open-ended question about what were the differences between your group and another group. As part of the instructions, an example of differences could include the sources used for answers, the number of sources used and any variation from this. The lecturer encouraged students to write about any differences, anything from group dynamics to how the group communicated or how tasks were assigned and completed. The more specific differences listed, the better the score on the Researcher Report. In the two pilot reports, Researchers were asked to compare the differences between their group and two other groups. This form was used for experimental cycle one and two.

In experimental cycle three, a new task was added to the Researcher’s role. The Researchers were asked to experiment with search tools and databases other than the dominating Google Search. This would range from using other social services such as YouTube, Reddit and Facebook. It also included other search engines and databases like Bing and Yahoo. The final point was to encourage students to use the more academic tools so that they can see themselves the better quality of the information compared to a Google Search. Google Scholar and Google Books provided the most flexibility because at the time of the research, students needed to be on campus to access the research resources that the university subscribed to. Although they could be accessed by proxy service in theory, the system at that time was buggy, had slow access speed and prone to not work for a variety of reasons, especially when using a mobile phone or tablet computer. Post-experimental phase, the university library has considerably improved the proxy access.

Copyright by Mahidol University

To force the Researchers to be aware of the differences, their main task is to find sources for the mCpath questions using these new tools and then

write about the differences found between using the designated servers versus using Google Search. For example, in the version 3 of the mCpath1 Researcher Report, the Researchers were asked to use YouTube to find information for one of the path questions and then write about the difference between Reddit.com and Google Search. In the second questions, they were asked to do the same thing but use YouTube instead of Reddit. The third question still asked about differences between groups. Reddit and YouTube were used in the first two mCpath sessions. The Researchers used Google Scholar and either Facebook or Google+ in mCpath 3 and mCapth4. At the time, a Facebook search would show results from Bing, but this was discontinued in 2015 (Oreskovic, 2014). The quality of the answers was good, so the Researcher's was adjusted to include using different databases. This also aligned well with ILCSHE Outcome 2.2.e, "using different user interfaces and search engines, with different command languages, protocols and search parameters" (ACRL Task Force, 2001, p. 10).

In the post-experimental phase, the report was reduced to one question about differences between using the service assigned that week and Google Search and one about differences between groups. The instructor also told the students that they needed one example if using the designated search tool for one question but that the more they used the service, the more they would have to say about the differences.

The Researcher role was not as well defined at the beginning of the process and was refined throughout the experimental terms. The lecturer did not attempt to guide the reports in a certain direction until after the post-experimental phases. This was to see what differences students would see between groups. In the post-experimental implementation, in the lab class after the last mCpath sessions Researchers were introduced to model that explain team effectiveness regarding rewards, structure and technology (D. S. DeRue, & Hollenbeck, J. R., 2012). They were introduced to McGrath's Task Typology and four ways to classify organizational structures (Timothy M. Franz, 2012). Finally, they had practice during class in explaining their workflow method using a model from Arthur et al. (2005). The Researchers were also highly encouraged to talk to other Researchers. This adjustment worked extremely well and has become the method used in all subsequent terms.

Copyright by Mahidol University

3.3.4 Peer report

For each mCpath cycle, each student was asked to fill out the Peer Report. Its purpose was to have students reflect on what they learned and how well they helped their team. On a 5-point scale, students graded themselves and each group member on how much effort they put into the work. During the pre-experimental phase and the experimental cycles, it was emphasized that the score they gave would not be used as part of the grade for the class. They should feel free to be as honest as they wished to be with the evaluation in the Peer Report because what they included would not influence their class score. It also would be held in private, with none of their information read by another group member.

An important part of the feedback was the question that asked students what they would like to know more about. This was used to revise the content covered the next term, as well as the types of questions asked in the next term mCpath. Because of the students' input, extra Saturday sessions were included to cover topics that were not necessarily included on the exams but that students said would be interesting and helpful for them to learn.

An open-ended request for comments also was helpful in fine tuning the mCpath process week to week. The suggestion to number the path questions came from the mCpath2 Peer Report in experimental term 1. The complete confusion and frustration that came with having to work with a randomly-assigned group member in that term came out in the comments as well, so in the next term, several ice-breaking activities were included in the first and second week of the term, along with having to make a team YouTube video based on different theme each term. Several of the students used this to express how well they were working as a team. Some examples of the comments from mCpath2 Peer Report, experimental term 3, included "Great group to work with!" and "everyone helped each other and we did a good job." For most of the experimental phase, was a wi-fi signal in the classroom ran at an acceptable speed with minimal disruptions. When there was a bad wi-fi day, one of the students in experimental term 3 in mCpath2 made a comment that the connection speed was poor that day. The first indications that Line was challenging Facebook as the communication medium of choice for working in groups came in comments in this report during the last experimental term.

Copyright by Mahidol University

Students were also asked to affirm the role they had selected for that week. This was used as a double-check and helped with troubleshooting. If students turned in a different role than was listed on the Peer Report, the lecturer would email them to reconfirm and then ask if he needed to explain the roles or help clarify in any way. Some students also failed to turn in a report, so having the role information assisted the lecturer with rechecking in the right report summary to see if it was accidentally missed when first checked. If the Peer Report and the mCpath role report was not submitted, it was noticeable that the student did not intend to finish the work.

The Peer Reports were five percent of each student's total grade. A student received 100 percent for a completed report and a zero for failing to submit the report on time. During experimental term one and two, the lecturer would send out reminders after the deadline and allow late submission up to a couple of days. This was because the teaching method was still in the development process and the comments were helpful in providing data for qualitative analysis for the research project. In the last experimental terms, students needed to submit the reports on time to receive credit. In practice, the students in the experimental section could miss several reports, and it would not drastically affect their total grades. For the hybrid experimental group, they could miss one report without altering their score by much.

The Peer Report process continued into the post-research phase. The students that have more absences had the lower midterm grade also tend to be the ones that never submit a Peer Report. It is also still a useful system to receive regular student feedback about the class.

As the process was design, it was supposed to eventually be used to as a peer assessment element. This lecturer has plans to test using it in this manner in future classes.

3.3.5 Role assessment

For anyone considering using mCpath instruction, it is important that teachers put themselves in the same role as the students, to better understand how they are finding and evaluating information. In this way, a lecturer can provide better advice on how to improve. Although this was not originally intended, the mCpath instructional method is an excellent way to make sure instructors stay current within

Copyright by Mahidol University

their field of expertise. By critiquing the quality of information students find, their lecturer will be exposed to a wide range of sources than would be normal. Post-research, this lecturer is rotating the mCpath sessions each term, so that the materials students found one term can be implemented into lecturers the next term. An example of this currently happening is the new but quiet rise of Bluetooth Low Energy. It appears to be similar to the older Bluetooth standards, but its unique ability to last for up to a year on a button cell battery and communicate with a range of mobile devices (Bluetooth SIG Proprietary, 2014; Townsend, Cufi, Davidson, & Davidson, 2014). The technology has the potential to make it the next key technology. Several students included in their report this last 2014/2015 school term. The question for next year will certainly be how Bluetooth Smart is being used today? MCpath questions about differences, similarities, features and such with the new Windows 10 and OS X 10.11 El Capitan will also certainly help this lecturer track issues like acceptance and security. During the experimental terms, the smartphone race for the highest resolution screen and camera sensors, and the battle between LCD and OLED screens was just beginning. Through the mCpath reports, all of this was closely tracked.

The main basis of the mCpath process was to have students learn to improve their search skills in actual context, looking for information that would be relevant for them, that they had to learn for their midterm examinations. Each was asked to share reports and the feedback they received from the lecturer, so that when members rotated to a different role, they would have examples of what they should and should not do. The lecturer did not send the group reports to everyone in the team because of several reasons. One was to put the responsibility of sharing information on the team members, not on the teacher. This means each member had to actively communicate with other members. Another was so that if a student was not comfortable sharing the grade they received for a report, they could cut this information out. A third included the issues explained before regarding copyrighted material. It is one issue if students share information informally among themselves, but the lecturer mails out copyright material to everyone in a team, this again could be considered broadcasting without permission. Another point was that some students would certainly have believed any information emailed from the teacher would be correct and not questioned it. By receiving information from another peer, group

Copyright by Mahidol University

members had a healthy doubt that the information was totally correct. This apprehension was uncomfortable, but some realized that they should be critical of more types of information, including information from teachers.

As to grading the mCpath reports, again the lecturer wanted to avoid using proprietary learning platforms. The main tools used were email and a spreadsheet.

All the reports were graded on a 5-point scale, with 5 representing 100 percent and 0 representing 50 percent. Although the scoring method was explained on the first day of classes and students were reminded during the first mCpath session, students mainly remembered that a 5 was an excellent score and a 1 was fail. This misunderstanding was not corrected till after the midterm. The reason was that a good size segment of the student population was satisfied with just getting by. The reputation of the university is strong enough domestically that most of these students will be employed shortly after graduating. Those that want to study abroad will aggressively push to score as high as possible, and then there is that larger segment that certainly would love to score an A but are satisfied with a C+ and ok with a C grade if they do not have to exert too much effort. In this group, a little fear of failure helps to motivate. During the post-experimental cycle, part of the safety net has been taken down, with the 0 to 5 scale representing 45 percent to 95 percent on a 0 to 100 scale.

The mean of all the individual mCpath reports represented 10 percent of the total class score, and the group mean average represented another 10 percent. The grades were used to direct students' attention to several aspects emphasized in that mCpath session, much like an English teacher will focus on grading a grammar topic like punctuating compound sentences or subject, very agreement. In the first session, the focus was getting the students to understand how to turn in a report and to avoid using Wikipedia. The Auditor could use a weak source from their Reporter, but the Auditor needed to show some effort and thought in their analysis, not just write a sentence or two of generalized nonsense. The Researcher needed to have some distinct differences and would receive a higher score for definite examples. They would receive a lower score if they wrote about similarities and a 1 if it was all about how sources or other teams were all similar or if they only wrote about the dynamics of their group without comparing to another group. If the Presenters could speak without

Copyright by Mahidol University

reading everything from notes and could answer a few questions sensible, they would get a good grade. If they read everything, they would get less than a 2. For Reporters, they received a low grade if they had only one line or two per answer. For the Auditors and Researchers, they received an automatic 1 if they wrote only one to two sentences of analysis.

For mCpath2 and mCpath3, for Reporters, they were encouraged to use more than one source, to use search functions and filters in Google Search and to have a decent amount of information but not copy a whole webpage. They lost one point for each site that they used that was on the do-not-use list. For Auditors, they were penalized for repeating the criteria but without giving examples. They received a lower grade for sources that had no date or was more than 5 years old. They were also encouraged to find their best website, so were penalized if they had good analysis but it was on a poor site. They would receive an automatic 0.5 for using tertiary site that was on the do-not-use list that was sent out before the class. Researchers were expected to have as many differences as possible with specific details.

For mCpath4 and then on, each role was helped to a stricter standard. For Reporters and Auditors, they both needed to focus on finding more primary sources. Reporters needed to find a healthy range of different sources from different types of websites.

Peer reports represented 5 percent of the score. If students submitted the form on time, they received a full 100 percent, but if they failed to turn in the report, they received a zero. This factor helped mitigate bright students' fears that their mCpath group score would cause them to lose their A grade. It also buffered the effects of the mCpath role scores. This was on purpose because although the process was being tested, it also was still experimental and being revised and refined each term. As was discussed before, the report had information that was used for the research project, so students were reminded several times before each due date, and then this could slip by a couple of days, just so the lecturer had more input from the students. Post-experiment, the lecturer still uses Peer Reports but holds the students to a strict due date.

Copyright by Mahidol University

When grading reports, the lecturer would first check the Peer Reports. He would add the role of each student and the score for the report. For any students that

were missing a Peer Report, the lecturer would recheck to make sure report was not skipped or that he forgot to include the score. With the mCpath1, the lecturer would give positive feedback on comments made in the Peer Reports, to encourage students to write more and put more effort into them. In other mCpath sessions, the lecturer would run out of time to give comments to everyone but would still make comments and send out a thank you to students that had obviously spent more time writing. To help a more critical feedback, students that did provide criticism were thanked for the honest feedback that would help with further develop and improve the mCpath process.

Next, the lecturer would grade the Reporter Reports. In the first experimental term when there were up to 30 path questions with no numbering, it would take considerable time to grade each report. In experimental term three, because the number of path questions was limited to 12 per path, these were the quickest Reporter Reports to processes. It could take up over 10 hours to grade these. Post-experimental, a new Reporter's form was developed and the number of questions was restricted to 6 per path. The use of the form made sure the information is submitted in a consistent form, making it easier to compare answers and URL sources used among students. A rubric would speed up the grading of these reports. Because students make similar mistakes, a text expander can speed up the process of giving comments. In keeping with the theme of using commonly used tools, Microsoft Word does have auto text function. OS X has its own freely under Keyboard/Text in System Preferences.

Usually, the Reporters want to know if their answer for each question is correct or not. If the web information relates to the question, the issue is not if the answer is correct or not but how much technical detail is included and how superficial or deep does the answer go in explaining. For example, when asked which smartphone was the most popular in the world, there would be at least one student that would write only iPhone or Android with no attempt to explaining why. Some of the students would refer to a review in an online tech magazine and would take the writer's opinion as proof. Others would cite a blog that included market share data, but sometimes there was no reference to the original data or information about the date that the data was collected. The better students would ask the lecturer what he meant by popular and then would differentiate out market share of smartphone operating system from

Copyright by Mahidol University

the vendors that sold the most phones. They then would use tech reviews to explain why an OS or brand of smartphone was popular at that time. Each answer was correct, but the quality of the answer showed a different level of development.

When grading Reporters' reports, the other issue was to balance the quality of the answer with the number of sources used. Some students would have several pages of text, all copied from the same source. At the other extreme, a student that would use five different sources but then only have a one-sentence answer. The better projects would use four or more sources, and it would be obvious in the answer that parts of it were from different sources. Some would copy and paste too much information and have parts that were not relevant to the answer. In general, this was preferable to having a short one-sentence answer.

In the first experimental cycle, the lecturer gave feedback to Reporters in summary form. In the second experimental term, he gave brief feedback on all answers and then also wrote a summary. In the last term, the lecturer wrote specific feedback for each answer and then wrote a summary on how the Reporter could improve. This included look up every reference website, making a copy of it for future references, and then judging the quality of each web source, as well as referring to how well it related to the question.

The next reports graded were then the Auditors' reports. By grading the Reporters' reports first, it helped familiarize the lecturer with the types of sources typically used by most students. Again, for mCpath1, the Auditors could use weaker websites that their Reporter or another member found, but for the next round, they were expected to find the best source for their answer. They also received an email and told in class to avoid certain tertiary source websites that provide only short dictionary definitions or overly simplified explanation of how a technology worked.

When grading, the lecturer would first check the source website and give his opinion of its quality. Then he would check the Auditor's report and compare what the student wrote. The form asked to include the URL address of the source used for an answer the question. Students were asked to rate on a 1 to 5 scale the objectivity of the source, and the scope of coverage. For timeliness of information, students were asked if the sources were published within a day, a week, a month, a year, within 2 to 5 years, over 5 years or could not tell how old. These criteria were used as a prompt to

Copyright by Mahidol University

writing the analysis of the site. They were not limited to these factors, but they helped start students with some of the more critical factors. Closer to the last mCpath session, students would receive an hour lecture on the differences between primary, secondary and tertiary sources and on other criteria to consider when evaluating websites. This included the purpose of the website and how commercial it appears to be and how to look up the owner's name through a whois service if an author was listed and that person's background and tips to estimating the publication date of a website.

Reporters that included a Wikipedia source would automatically receive a low grade. This was because they were told not to use this source for mCpath reports on the first day, the main reason being that they are tertiary sources. The other was that of course, Wikipedia sources were always listed in the top search page, and the point of these reports was to force student to find different types of information, to learn how to dig deeper past those first few sites that come up on a quick one-term search.

In mCpath1, some of the researchers would write only a sentence or two of analysis, most stating that they thought every website they used was highly accurate, highly credible but with no explanation of why they thought this. This was despite not being able to determine the date of publication or in many cases, there would be no identified author of the page. A couple of good examples of this came from mCpath1 of experimental term three, "It's quite useful because it tells the definition of computer platform but not deep. It also has writer name, and it is technology website" and "This source is trust able (sic), because there are specific information and details." Another student referring to information about the top supercomputer from an official Chinese government website wrote that there was no bias in it even though that participant realized that the government closely controlled content on this site.

If using a review article from a technical magazine or blog, some students did realize this information was more opinion based, so had more potential for bias.

Some of the students did use some of the search tips to screen out .com site or used the site: filter to find .org and .edu sites. When they found such sites, they put a large amount of trust into these sources, especially sources from a university. It took some extra practice to get them to look at the quality of the information at educational websites as well.

Copyright by Mahidol University

Finally, the lecturer would grade the Researchers' reports. In the first two experimental term, the question asked was to compare differences between teams. Because all the other reports were read first, this one gave an overall perspective on how students worked together in teams. In the mCpath1, some of the students would only write a sentence or two and not give any specific details. A good example of this came from the first experimental term, "Every group use different sources to search for their own works, making the answers come up different in each group." There would be some other researchers that would put credible effort into the report, giving rundown of the different number of sources cited by team or would look and the amount of text used for the answers. Most focused on the differences between path answers.

As they became more comfortable with working with their team members and became more confident in talking to others, the researcher would go into differences in interaction, in communicating, in accomplishing tasks and in the different types of computers used by groups. The researchers used these reports to emphasize the team spirit that had developed within the group, an example being, "To begin with, I can say that I am lucky to be in this group because the group members work hard and help each other out very well." This researcher went on to explain that the team helped their presenter with finding answers in time, and that the work between members was shared evenly, that this allowed them to work faster. Some of these researchers emphasized team spirit too much and forgot to compare with another group.

The big adjustment made in the third experimental term was having the Researchers use two different search engines for two questions and then compare this to the results found if only Google Search was used. In mCpath1 when comparing YouTube to Google, the Researchers would often start off by saying the obvious, that one uses the video the other text. The following is a good example of a typical answer:

> "*Information from YouTube is easier to understand because the video is more perspicuous. However, information from Google is more reliable that YouTube because we cannot identify that who is producer of this video, so in this case,*

Copyright by Mahidol University

> *Google is better than YouTube. Moreover, Google has more information, so if you want to get more specified information, go to Google."*
>
> (research ID 2016)

It was difficult to get the students to quit focusing on the similarities. Another difficulty was that some students only briefly tried to use a search engine to answer one question, so did not really get to understand the strengths and weaknesses well. Because of this, the Researchers were highly encouraged to use the designated search service as much as possible to answer questions, so that they would have more to write about. This instruction helped improved variety because there were more Reporter Reports that included YouTube and Google Books sources. The Researchers were helping their Reporters more and after working as a Researcher, they were more likely to use other search engines when it was their turn to work as a Reporter.

The grading of the reports in sequence, from Peer reports to Reporters to Auditing and then the Researchers helped give the lecturer a good, overall view of the information found, types of websites used, the quality of them, and then finally the group dynamics at work within each team. When the same mCpath topics were covered the next term, the lecturer could quickly see which students grabbed their results from the first page of a quick and which ones put in some honest effort to find better quality information.

Having to grade 30 to 60 reports each week could be daunting. To speed up the process, the lecturer in this project would highly recommend using a rubric but has yet to do so himself. Again, part of the important in the process is having the teacher develop a better sense of what sources are available for a topic, which are excellent resources, which are usable, and which are poor enough that a teacher needs to warn students to stay away. Because the number of links and the type of information that is available is never static, always changing, searching expertise is somewhat like computer repair. It is a continuous process to stay current. Although there can be some overlap in websites found from term to term by students, there were also numerous new sites and some absolute jewels, fantastic discoveries. One such discovery was the YouTube links to the humanHardDrive (Stratter, 2012), an electric

Copyright by Mahidol University

engineer that is mostly self-taught and has an unbelievable mastery of computer hardware. Another is a succinct pdf overview of how digital resolution works from an Australian professional photographer and university lecturer that retired from RMIT (Walkling, 2011). Although it was ancient, the ultimate find was a website that used to answer the path question to what was Unicode, www.columbia.edu/kermit/unicode.html. This led to the beautifully crafted link to the history of computing at Columbia University, complete with some of the original images of the huge mainframe in the original IBM Watson Lab (da Cruz, 2015). It includes a complete story of the Kermit protocol, used to transfer files on the internet before the world-wide web. Heartbreakingly, the creator of the website was laid off in 2011 but has lovingly kept the history site current.

Using online forms to gather information in a systematic format helped a great deal in collecting data. In the beginning pilot, it was difficult to separate out the students that had technical difficulties with sending in the information to the right email address and those that did not do the work on time, so pleaded that they had sent their work in but that the lecturer did not receive it. Using online submissions helped separate out these two issues.

Because Google was developing its Google Form technology, there were some issues with the service being overloaded or abruptly going down without saving data. Part of the lesson became beware of trusting online technology too much. It was typical that as many of the students would try to turn in a report Saturday night, and five minutes before the due time, there would be a heavy rainstorm that would knock off the power. In this case, the Reporters that tried to fill out the information directly in the Google Form, with no document to refer to, they would lose all their information. The lecturer would encourage students to make several backups of the information, keep a copy of the report in text or PDF form and take screenshots of submissions to prove that they sent in reports on time. The service is now reasonably stable for a free service, and if students see the form response at the end, they can likely rely that the information was stored in Google Documents. The edit responses function was turned on so that students could enter the form and recheck that the information was there. The Chrome web browser added a function to allow web pages to be stored as PDFs,

Copyright by Mahidol University

and the participants in the third experimental round were highly encouraged to make a PDF backup of their completed form in this manner.

To avoid potential problems, a new form was used for each report each mCpath cycle. If the reports would have been submitted through the same form each time, no doubt there would have been confusion with both the lecturer and the students as to which session was which. Setting a different form also allowed the lecturer to shut off receiving responses after the deadline. This also helped ensure that students submitted the right reports to the right links. If students had problems, this usually meant they were using an old link.

This also meant the URL address had to be reset each mCpath session, usually Monday morning before the classes. As part of the process, an old form would be copied and edited to be made into the new report. The new URL link address would be changed on the website. Then the lecturer would test the links to make sure they worked, enter a test entry to make sure the forms were accepting responses and double-check for mistakes. Testing the new form was an important part of the process of setting up before the class. There were a few times, when response acceptance was turned off or one link was not updated.

3.3.6 DSL measurement of information literacy

Because of the issues with the TRAILS 9th-grade assessment, the Digital Search Literacy Assessment was developed from the ground up, based on the characteristics of a Thai undergraduate student. Details of this are in the DSL section of the Instrument Development chapter. This is closely linked to the constructivist philosophy that each student brings prior knowledge, skills, and perspectives to the classroom, and that an educational methodology works best if it considers students' prior experience. Following the same thread, an assessment that uses culturally relevant examples that Thai students are familiar with and uses an understandable English-language level should be more reliable measuring instrument than one based on a different cultural context with a more difficult literacy level such last the TRAILS 12th-grade level appeared to be.

Copyright by Mahidol University

3.4 Instrument development and data collection

To help measure the effect of the mCpath experiment, three measuring instruments were developed specifically for this project: a computer concept assessment used to test students. The Mobile Media Leaning Survey was used to gather information on devices and digital media used on mobile devices. The Digital Search Literacy Assessment used to measure participants' level of knowledge about information literacy.

3.4.1 Digital information literacy assessment

At first, the research tried to find an information literacy survey that could be used to measure if there was a significant difference in knowledge between the experimental sections and the control sections concerning digital information literacy. The cost of a commercial product like the SAILS Test from Kent State University or the ETS iSkills was prohibitive because it would have required about 600 cases in total: a pretest and posttest for each participant. Both were developed for university testing. Although to enter this college, the participants should have about a 550 TOEFL English skills level, but the majority were not native English speakers, so would have difficulty. One of the issues this can create a lower reliability of the instrument (Haladyna & Rodriguez, 2013).

The best candidate appeared to be the TRAILS (Tool for Real-time Assessment of Information Literacy Skills) assessment from Kent State. It is a large system with grant money from the US Department of Education and the US Institute of Museum and Library Services (IMLS). Because the instrument was developed for high school students, it was devised using the US Common Core and the Standards for the 21st Century was used instead of the ILCSHE (Kent State University Libraries, 2014a). One of the most useful part to mCpath experiment was that different versions of the test were developed for different levels of education: 3rd grade, 6th grade, 9th grade and 12th grade. Other options were that the exam could be administered online. There are two versions of each level of test to use for pretest and posttest, and the online system could randomly re-arrange questions to remove position bias (Kent State University Libraries, 2014a). Because the assessment is used heavily by US high schools, it would also provide an interesting benchmark for Thai undergraduates.

Copyright by Mahidol University

An initial pilot test using the TRAILS online testing system was used before the experimental phase. Just a week before the end of the term, a total of 52 students from section 1 and 2 took the 12th-grade-version, and 28 students from section 3 took the 9-grade-version of TRAILS. The results from the 9th-grade-version looked the most promising because the mean was .459 (SD=.139), compared to .378 (SD=.128) for the 12th-grade-version. As to a benchmark, 4.833 US students averaged .519 on the 12th-grade TRAILS, and 36,924 US students averaged .506 on the 9th-grade version (Kent State University Libraries, 2014c), tending to indicate a major gap in information literacy knowledge between Thai undergraduates and US high school students.

After advisement with the researcher's committee, it was decided that another pilot test using a paper-and-pencil version of the 9th-grade-version was needed to conduct the item-analysis of the 9th-grade TRAILS. The assessment had 25 multiple choice items.

Seventy-four undergraduate students from three biology classes took the second pilot TRAILS test. At 47 percent, many participants were first-year student, and the second largest group at 24 percent was the fourth-year or older. Second-year students came next at 23 percent and third-year students made up 5 percent of the total. The mean of .576 looked promising compared to the US benchmark of .544, but the Cronbach's Alpha of .389 showed an unacceptable level of reliability. This was likely because the items were too difficult, so there was too much guessing (Lord, 1952). If the same .33 cutoff for point biserial would have been used for the selection criteria used for the Mobile Media Learning Survey was applied to TRAILS, only 7 of the 25 items would have been left.

A closer review of the items from the 9th-grade-version of the assessment indicated that the instrument might have too much of a US cultural bias. One question highlighted this because its choices included city mayor, a term that several students asked about. The assessment also included a few questions that asked about references books and documents but no digital resources. Given the controversy of the Nature article about the accuracy of Google Search to the Encyclopedia Britannica, it was interesting to see that the correct answer to that item was the encyclopedia. Another such question asked technical questions on book structure.

Copyright by Mahidol University

Table 3.4 ILCSHE substandards used to develop DSL

ILCSHE Outcomes Mapped to DSL	Description
ILCSHE Outcome 1.1.e	Identifies key concepts and terms that describe the information need
ILCSHE Outcome 1.2.c	Identifies the value and differences of potential resources in a variety of formats (e.g., multimedia, database, website, data set, audio/visual, book)
ILCSHE Outcome 1.2.e	Differentiates between primary and secondary sources, recognizing how their use and importance vary with each discipline
ILCSHE Outcome 2.2.b	Identifies keywords, synonyms and related terms for the information needed
ILCSHE Outcome 2.2.d	Constructs a search strategy using appropriate commands for the information retrieval system selected (e.g., Boolean operators, truncation, and proximity for search engines; internal organizers such as indexes for books)
ILCSHE Outcome 3.4.e	Determines probable accuracy by questioning the source of the data, the limitations of the information gathering tools or strategies, and the reasonableness of the conclusions
ILCSHE Outcome 5.1.d	Identifies and discusses issues related to privacy and security in both the print and electronic environments

This is useful for research but less applicable for digital search literacy knowledge. One item focused on which type of library to use, showing certainly a librarian's bias.

Another issue the researcher had was that the number of answer choices averaged to 4, but it ranged from 5 to 2 choices. For measuring, it would be preferable to have consistency in the number of options per each item.

Copyright by Mahidol University

In conclusion, a new digital information literacy tool named the Digital Search Literacy Assessment (DSL) was developed for the research project using a multiple-choice format with four answer options. It was based on the ILCSHE, and each group of items was mapped directly to a specific ILCSHE outcome. A cross reference mapped three other information literacy and four academic standards to these.

Because of the issues with TRAILS, the lecturer in this project developed his information literacy assessment designed from the group up for Thai undergraduates. Outcome 1.1.e and Outcome 2.2.b are quite similar in nature, so were cross-referenced.

Of the 5 standards, there was a total of 22 subsections of outcomes, and then each of these had two to seven more sub-outcomes, so there had to be choices on which ones to give priority. The ones that were selected best worked for a multiple-choice format. Examples of outcomes not included was 1.1.b, develop a thesis statement or 2.2.a make a research plan, both certainly making a better writing assignment for an English class or Standard 4 was left out because it required an individual or a group to "uses information effectively to accomplish a specific purpose", (ACRL, 2000, p. 11) an activity better accomplished through the mCpath learning process. The questions were designed specifically designed around the expectations that students were using a search engine to find information for different disciplines. The largest group question related directly to digital information literacy and its ethics, but the other questions fell under 14 other disciplines. The information literacy and the into information literacy ethics category was discipline neutral.

The DSL went through several rounds of editing, checking for grammar and punctuation mistakes. The questions, items and answer choices were also validated by four other subject matter experts. Each question was mapped to its ILCSHE outcome, so the person validating could easily check to compare if the item matched the outcome. Any item that was deemed to have more than one possible corrected was either edited or cut. After this process, the pilot DSL had 72 items, and it was given to 85 undergraduates taking the introduction to computer class being research in their second week before the end of the term. Both the question numbers

Copyright by Mahidol University

and the order of the answer stems was randomized. The Cronbach's Alpha was a much healthier .76. Item analysis help

Priority was given to the assessment's ability to discriminate, so the difficulty was ignored. The mean difficulty of the final DSL version was .495 (SD=.196), with the minimum and maximum ranging from .195 to .923 respectively.

Items with a difficult score of .30 were included because they were helpful in boosting the tool's ability to discriminate. This also helped complete enough items in two categories, and these were also questions about newer technology that it was likely that more future students would be more familiar with, this being flash memory and multi-purpose printers.

The DSL was used as a pretest during the first lab class and the posttest was given during the last two weeks of the term. To avoid potential complications due to a restrictive proxy server on campus, a paper-and-pencil version was given instead of an online version.

Other information literacies and educational standards were mapped to the Digital Search Literacy Assessment. Although other standards were general in nature did not have specific outcomes, the mapping was to each ILCSHE outcome included in the assessment. The UK SCONUS Standards, the Australian and New Zealand Information Literacy were also included because these three countries plus the USA drive the English language standard worldwide, and in turn affect how information literacy has been defined. The other information literacy included was from UNESCO. All four have similar standards, just grouped under different categories. An example would be that ILCSHE Outcome 1.2.c to identify the value and differences of resources in different formats best matches SCONUS Standard 5 (2011, p. 11), the ability to compare and evaluate multiple sources, and UNESCO 6, know how to "fully understand found information" (F. W. Horton, 2008, p. 11). The ANZILF relates closely to the ILCSHE, so both standards relate to the same number.

A mapping to the ISTE standards was also included. This is a non-profit organization that has more of a technological outlook and less of a librarian bias than does the ILCSHE. It also appears to have more of an international perspective.

Copyright by Mahidol University

Table 3.5 Frequency table of DSL question relating to disciplines

Subject	Frequency
Information literacy	17
Information literacy ethics	8
Computer	7
Engineering	5
Regional Studies	5
English	4
Health	4
Sciences	4
Social Sciences	4
Business	3
Humanities	3
Library Studies	3
Sports Education	2
Education	1
Math	1
Media Studies	1

3.4.2 Computer concept

The computer concept assessment originally came from the test bank of 180 short-essay midterm questions that have been used for several years by the researcher in the introduction to computer class being measured. This portion of the exam focuses mainly on the computer, its parts, peripheral devices and trouble-shooting the device. Other topics were coved after the midterm or during the computer lab on Fridays. The five main categories are in an order reflecting remnant of when the

Copyright by Mahidol University

class lessons were based on introductory textbooks (Capron & Johnson, 2003; Daley, 2007; Norton, 2006; Shelly, Cashman, & Vermaat, 2008). Although some of these series have gone on to have more of a software focus, the latest Shelly Cashman still has a similar order of topics (Shelly, Freund, & Vermaat, 2011). Around 2010, this researcher was having difficulties with receiving current textbooks. Another issue was that most of these academic resources had kept a PC-centric orientation, so was hard to re-adapt the material to put more of a mobile platform perspective. Because of this, the lecturer of the course switched to using a condensed version of Wikipedia pages that related to the material covered. Certainly, the use of Wikipedia in classes has its share of controversy (Fallis, 2008; Infeld & Adams, 2013; Knight & Pryke, 2012; Llados, Aibar, Lerga, Meseguer, & Minguillon, 2013, July; Rector, 2008). Yet for computer concepts, it is a current source because the topics are revised at least monthly, quickly reflecting the addition of newer specifications of CPUs or how the adoption of SSDs has first started as hybrid device, or the development of the newest wi-fi standards, such as the 802.11ax. As of June 2014, there were 246 people registered to help edit the WikiProject Computer Science (Wikipedia, 2014) and 500 change have been made within the last 24 days. The input and editing of contributes from different parts of the computer industry and academics give a more rounded prospect than does a textbook writing by only a few authors. The one issue for an introductory class is that they level of technical detail can be overwhelming. This is handled through editing out the non-essential minutiae in the various articles down to more of the basics.

Copyright by Mahidol University

Table 3.6 Computer concepts measured in computer concept exam

#	Categories	Concept	Questions	Proportion of Total
1	1.1	General Concepts	2	.10
2	1.2	Computer platforms	2	.100
3	1.3	Internet	1	.05
4	1.4	Troubleshooting	1	.05
5	2.1	Input	2	.10
6	2.2	Monitors	2	.10
7	2.3	Printers	2	.10
8	3.1	Binary, hexadecimal	1	.05
9	3.2	CPU, memory	4	.20
10	3.3	Ports	1	.05
11	3.4	Storage	2	.10
		Total	**20**	**100%**

There was a total of 11 concepts being tested, group into three categories: general computer information, peripherals, internal hardware. Most of the concepts had one question from the assigned reading and one from materials covered in the classroom. Internet, troubleshooting, and ports had a question only from the reading, and the binary/hexadecimal group had one question that came mainly from the lecture.

Item analysis was used to select items to be used for the computer concept assessment. The eight versions of the 20-question exam had been used in the last several years, so the researcher performed item analysis on them. The sample sized for each exam results ranged from between 28 to 26 participants, with the average at exactly 27 (SD=1.07). Using classic teach theory, the number of items answered correctly was used to measure item difficulty and point biserial correlation was used for item discrimination (DeMars, 2010). The cutoff point of greater than .33 was set

Copyright by Mahidol University

for item discrimination. Cohen said when using r, .30 is considered a medium effect size (Cohen, 1988). If rpb is squared to produce the coefficient of determination (Grissom & Kim, 2012; Rosenthal & Rubin, 1982), then a point biserial correlation of .33 will explain 11 percent of the variance in an item results, slightly more robust than the 9 percent for r2 for Cohen's generic medium effect in correlations. Precedence was given to an item's ability to discriminate, so the difficulty ranged from .80 to .33. The researcher rule of thumb rule is between .90 and .40 (Haladyna & Rodriguez, 2013). When comparing discrimination with difficulty, items with a P-value above .8 had weak discrimination ability. Also, the items in this case are constructed-response short essay format, not the more commonly used selected-response multiple choice that has a guessing error, so the floor was lowered to .33.

The analysis left 81 of the original 180 items, enough to develop four versions of the computer concept exam. Each item in a category was randomly assigned to a new version. Version 1 and 2 had enough questions for all categories, but to complete version 3, item 163 from version 1 was reused, and items 60, 143 and 171 from version 2 was reused in version 4. The mean of the P-value of all items in a version was close to the total mean of .521, with version 4 falling on the outer edge with M of .532, but the difficulty level of all three version was consistent. At .023, the standard deviation of discrimination indexes of the different test versions was much higher.

Table 3.7 Computer concept versions and item analysis

CompConcept Ver.	M P-value[1]	M PBC[2]
1	0.519	0.475
2	0.514	0.522
3	0.521	0.487
4	0.532	0.518
Total M	**0.521**	**0.500**
Total SD	**0.008**	**0.023**

Copyright by Mahidol University

[1] *Proportion of questions answered correctly, measures difficulty*

[2] *Point biserial correlation, shows the discrimination*

Although the four versions were of comparable difficulty and had similar discrimination ability, it was recognized that they were not identical enough in nature to be able to use one exam for a pretest and another version as a posttest. To measure the effect of treatment on the experimental section, all students in each section took a pretest the first day of class, a posttest as part of the assessment embedded in the midterm class exam and then the retention test as the embedded final class exam a month after the midterm. Having students take the same exam three times increased the likelihood students of students remembering the questions through repetition, so one version was used for the pretest and midterm posttest and another version was used for midterm posttest and final posttest.

3.4.3 Mobile Medial Learning Survey

As part of the initial pre-experimental phase, the Mobile Media Learning Survey was developed to measure the practicality of using mobile computing devices in class. The results from this survey also helped develop the mCpath method because the because Google Search ranked way higher than any other media service on the web used by students.

During the experimental phase, the revised instrument was used as a pretest and posttest to measure usage differences.

The Mobile Media Learning Survey was based on the English version of the media used in learning that was used country-wide in Thailand (Grosch & Phillips, 2012). The original was developed as part of Grosch's doctoral these at Karlsruhe Institute of Technology, Germany (Grosch, 2012). The initial instrument was in German and was quite specifically shaped to the German academic system. The current researcher worked closely with Grosch in developing an international version in English of the Media in Education Survey. This survey was then translated into Thai, Chinese, Korean and Japanese. During the development of the international reversion, the instrument was piloted three times at the same international college, where the current research project is being conducted.

Copyright by Mahidol University

The initial international version of the Survey of Student Media Use had a lengthy 148 items in 9 sections. After the initial pilot, another 3 questions were added concerning academic background, bringing it to 151 items in the next version. It

included a list of 53 types of media, both digital and non-digital resources. Over 3,600 participants from 9 different universities in Thailand completed the survey. Using a variation of the technology acceptance model, this instrument measured acceptance of a media by the frequency of use of a media and the satisfaction with the media. This means the 53 media items were included twice, making for a length of the survey.

The pre-experimental version included the original sections but cut out the media satisfaction section. The frequency of media use section was trimmed to include only digital media, but then media directly relating to smartphones and tables, such as apps, GPS, and digital cameras was included, so the number of items in this section reduced to only 48.

An extra section on mobile devices was also included to assess the practicality of using mobile devices in a classroom. Because the purpose of the pre-experimental phase was to college as much information about the participants' prior knowledge, use of mobile devices and behavior, educational background, self-assessment of academic performance, and personal data were included. After the pre-experimental phase, a streamlined version of the assessment was developed with many of these sections trimmed out. Version 9 of the pre-experimental Mobile Media Survey contained 8 sections, coming to a total of 91 items. The instrument used in the experimental phase, version 11, had five section: mobile device used, media on mobile devices used, educational background, personal background, and comments. The assessment had a total of 71 items.

The initial Mobile Media Survey was piloted with graduate students, and the main remark with that the instrument had too many items. Through discussion and input from three other content experts, version 6 was used

The Mobile Device section measured the type of computers students used, as well as asked about the frequency of use of each type of platform. Originally, the survey asked students to rank the frequency of use of each type of device, using a Likert-like scale, with a range of 1 for "very often" and 5 for "never", with 6 being "don't know. Participants in the experimental cycle 1 found the structure to be confusing, so many did not mark the type of computer they used. In the next version used for experimental cycle 2 and experimental cycle 3, the subquestions were moved

Copyright by Mahidol University

into a block under the main questions, and then students were instructed that they could select as many types of computer equipment as they owned or used.

There were 10 main questions and 5 subsection questions, for a total of 15. In the subquestion, students were asked to mark what exact type of device. For example, for smartphones, students were asked if they use an iPhone, Android, Windows, Blackberry or other types. For desktops and laptops, the main operating systems listed were Windows, Mac OS X, Linux and other. At the time, netbooks were still being used by students, so this platform was included. Macbook Air was in the market, and the PC manufacturers just started developing outranks with a similar form factor, so these two types of computers were grouped together. Although the Samsung Galaxy Note had been out for years, this new segment of suppressed smartphones had not yet become the phablet, so this was not measured.

The frequency of use of media services on a mobile device had a total of 48 items. Thirty-seven percent of them related to services used in education, 52 percent of the related to services used on the web, and 29 percent were services used mainly on a smartphone or tablet. Almost 17 percent of the services used either software or an app installed on a computer. Another 12.5 percent of the items related to social networking.

The Personal Data section asked about age, nationality and the original native language used by the participant. Gender, year of study, and major was collected automatically from the class list, so it was not included in this survey.

3.4.4 Learning journals

What will be undergraduates' attitude in using mCpath instruction in cooperative teams in the classroom? Students' comments from their learning journal answers this question.

During all three term, participants were asked to fill out a learning journal three times during the term. The first one was due two weeks into the term, the next was assign weeks into the term, and the last one was given 10 weeks into the 12-week term. As is a part of the popular Kolb experiential learning cycle (2012), the purpose of the activity was to consciously force students to reflect on what they had learned during class. To encourage the students to write, the journals were worth 5 percent of

Copyright by Mahidol University

their total grade. If the students wrote more than just a couple of sentences per question, they would receive an automatic 100 percent. If they wrote only a sentence, their grade would be 50 percent. If they wrote at least a couple of sentences per question, their grade would be 60 percent. Students were encouraged to write whatever they thought or felt, with no consequence to the grade for this work. The comment the lecturer made during class was that if a student writes, "This is the best class I ever took," the grade would be F because it was only one sentence long. If they students complained a lot, they would get an easy A because they wrote a lot.

In the first two learning journal, students were asked five questions:

1. How did I use technology to learn?
2. What was the highest emotional moment in learning?
3. What was the lowest moment in learning?
4. What was the easiest thing to learn?
5. What was the most difficult thing to learn?

The questions came from a book teaching reflection (Brookfield, 1995). It was first tested in the pre-experimental phase, with a fifth question asking about what topics students would like to know more about. In the third learning journal, the questions were changed. All participants were asked then following two question:

1. Did the way you use technology for learning change because of this class? Please explain.
2. After this class, what areas are you interested in learning more about?

The control group was asked question 4 and question 5 again, what was the easiest thing to learn and what was the most difficult. But for question three and four for the hybrid experimental and experimental treatment groups were different than the control group, the questions obviously focused on capturing feeling and thoughts about the mCpath experience:

1. Did you learn more from the mCpath method, about the same or less than a regular class lecture, and what recommendations would you make to improve it for the next time?

Copyright by Mahidol University

2. As part of the mCpath team, do you think your group worked well together assigning and completing tasks and helping each other get ready for the midterm?

With 318 participants in this study, this means it generated over 4,000 paragraphs, creating a rich variety of qualitative data that can be used to help answer the research question, what are the participants' attitude to using mobile devices in cooperative teams in the classroom.

After each submission, the lecture would respond to each student's journal entry The learning journals were also instrumental to making adjustments to the method. In research term 1, the students submitted the reports by email. In research term 2 and term 3, they filled out a Google form.

3.5 Data analysis

Most of the research methodology is quantitative. There are three instruments used to collect data: The Mobile Media Learning Survey, the computer concept test, and the Digital Search Literacy Assessment, and the Mobile Media Learning Survey. For each instrument, there was pretest and posttest data collected from the participants. Because the computer concept test was used as part of the exam, there was a midterm posttest and a final posttest.

In the process of developing the Digital Search Literacy Assessment, item analysis was used to choose to eliminate the questions with the least discrimination ability. The original 72 items were trimmed to 50, increasing the Cronbach Alpha score to .792. When checking for the test, retest reliability, Pearson's correlation coefficient was .709 (N=180).

As to the computer concepts test, the original questions came from a test bank of questions from the lecturer of the computer class. Item analysis on former exams was used to select the exam questions used in the four versions developed for this mCpath project. Again, Pearson's correlation coefficient was used to check the test, retest reliability of the versions.

Copyright by Mahidol University

As to the Mobile Media Learning Survey, Cronbach Alpha was used for reliability analysis.

For analysis of the computer concept test and the Digital Search Literacy Assessment, if the data was normally distributed, the author was expecting to use one-way ANOVA and potentially ANCOVA to consider covariates such as different versions of the exam or to consider pretest results. If data was found to be not normally distributed, the author preferred to use Kruskal-Wallis H test, often used as a substitute for one-way ANOVA when data is nonparametric (Corder & Foreman, 2014). When comparing results from pretest to posttest, Wilcoxon matched pairs signed tracking test was used.

3.6 Ethics

Mahidol University Social Science Institutional Review Board gave approval for the research in MU-SSIRB: 2013/156.3004 (B2). Students were informed of the details of the mCpath experiment and if their section was being designated as the control, experimental or hybrid section on the first day of class. All students participating in the research were informed of the experiment the first day of class. They were given the IRB-2 Participant Information Sheet on the first day of class, informed of the assigned status of that section and then were requested to sign the sheet. They received another briefing on that Friday, and then the next week, the participants signed the IRB-3 Informed and Voluntary Consent to Participate in Research Form.

The students were briefed twice and then also notified through the Participant Information Sheet that none of the surveys or assessments were too personal in nature and that they were not obligated to answer any question that made them feel uncomfortable. Students were also informed that if they were uncomfortable with the experimental method, they would be allowed to shift to attending the Monday class at a different time with the control group, but no students ever made this request or showed undue stress over being in the experimental sections.

Students were not exposed to any undue risks that they would face in any regular classroom instruction. All research data has been anonymized before being included in this report and any other documents. Only the researcher and his advising committee had access to the documents. All digital documents were kept in a separate

Copyright by Mahidol University

email account that was secured with a password set to 12 random digits. Students' ID and names were kept in the master database as a double-check to accuracy and eliminate possible errors. The original database is stored on the researcher's private computer and the backup is on a cloud account secured by a 16-digit password.

As part of the m-learning process, the researcher asked that students share their mCpath reports with others in their group for study purposes. Some students requested that the researcher post all reports on a website. The issue this researcher had with this was a potential problem with copyright law. The sharing of website information by a group of students studying for an exam would clearly fall under Section 32.1, Part 6, of Thailand's Copyright Law, so exempted. Having the research post the same information falls into that gray area where under Section 27.2, Part 5, communication to the public, even though its main intent would have been for education purposes and not profit. Since one of the main purposes of the m-learning method was to enhance students' appreciation of the ethical dimension of web searches, this was a teaching moment for students. Another such instance was the use of the edited sections of Wikipedia pages as the assigned reading. All text in the site is registered as Creative Commons Attribution-Share Alike, so if the text has attribution, it can be shared for non-commercial purposes with anyone.

Copyright by Mahidol University

CHAPTER IV
RESULTS

4.1 Mobile Media Learning Survey results

The analysis of the Mobile Media Learning Survey helps to answer the research question 4, will the use of online searches through mobile devices in the classroom change the usage of media by undergraduates? The instrument used to collect original information about the students' use of websites and services during the pilot phase was also use pretest and posttest each term. The purpose of this was to measure to see if there was a change in the usage of these sites due to the mCpath treatment.

The results of these survey help answer the research question, how will the use of online searches through mobile devices in the classroom change the usage of media by undergraduates?

All versions of the instrument included a question about frequency of use of 48 different media. Out of the total 318 participants, 282 took this survey the first day of class, 88.7 percent of the total. Over 90 percent of the first and second years were included but only 70 percent of the third and fourth years.

Copyright by Mahidol University

Table 4.1 Posttest Mobile Media Learning Survey for all terms, top 10 media

Rank	Media	N	Mean	1[1]	2	3	4	5	6[2]
1	GoogleSearch	282	1.28	218	54	8	0	2	0
2	VideoSharing	282	1.66	168	61	38	10	5	0
3	Facebook	280	1.67	166	62	34	15	2	1
4	OnlineDictionary	281	1.7	142	96	31	10	2	0
5	emailNOTUni	267	1.72	163	70	23	1	7	3
6	MusicPlayer	282	1.74	145	84	37	13	2	1
7	PhotoCamera	281	1.75	144	79	46	8	2	2
8	MobileApps	281	1.77	139	91	33	12	6	0
9	DictionarySoftware	279	1.85	136	84	36	12	10	1
10	Wi-fiCampus	282	2.04	109	81	68	19	5	0

[1] *Scale: 1 very often, 2 often, 3 sometimes, 4 rarely, 5 never, 6 don't know*

Just as in the pilot version, the pretest results from all three terms showed Google Search way ahead. The top nine media were similar, but calendar applications moved out of the ninth spot, down to 12th place. There was some reshuffling in the order. Video sharing moved up from fifth place to third and non-university email moved from seventh place to fifth place, pushing music playing apps down from third to sixth.

Except for bibliographic software moving up and out to 35th place, the bottom 10 media used for learning were the same as for the pretest for all experimental terms and the pilot study. There were some differences in the ranking. Augmented reality and social bookmarking are examples of how the order at the lowest point is less important. At the time, there were few practical uses of augmented reality, but frequency tables for the pretest showed that 29.5 percent of the student said they use this technology somewhere between sometimes to frequently. Only 22.4 percent said

Copyright© by Mahidol University

never, and another 21.7 percent said they did not know. This should have been closer to 90 percent.

Table 4.2 Posttest Mobile Media Learning Survey for all terms, bottom 10 media

Rank	Media	N	Mean	1[1]	2	3	4	5	6
39	OnlineSelfTests	181	3.7	2	24	89	7	54	5
40	SocialBookmarking	279	3.79	12	23	83	54	60	47
41	emailUniversity	281	3.8	21	32	47	64	103	14
42	GameBaseLearning	281	3.82	11	26	64	82	61	37
43	AugmentedReality	282	3.83	7	20	76	90	58	31
44	Twitter	282	3.95	21	21	37	75	125	3
45	VirtualClassRealtime	281	4.02	11	23	49	65	119	14
46	OnlineOtherLibrary	282	4.02	7	14	48	110	96	7
47	OnlineExams	282	4.04	3	12	51	120	92	4
48	VirtualClassNonRealtime	281	4.1	2	19	53	83	104	20

[1] *Scale: 1 very often, 2 often, 3 sometimes, 4 rarely, 5 never, 6 don't know*

Social bookmarking should have also scored at the bottom. The popularity of this type of social networking had already peaked with del.icio.us in 2008. It drew academic interest (Gray, Parise, & Iyer, 2011; Haustein & Siebenlist, 2011), so it was included in this survey. It was sold off by 2012 (Lardinois, 2016, January 12). Most Thai students at the time of the study would likely not have known anything about it, but again, 30.8 percent said they had used it for learning at some point. Only 18.6 percent said they had never used it, and 30.8 said they did not know what it was. Augmented reality dropped from 39th place in the pilot to 44th place in the pretest experimental results. Social bookmarking dropped from 37th place to the more expected 47th.

Copyright by Mahidol University

Measuring 48 different media made the survey comprehensive regarding the types of services measured, but it is challenging to measure all differences in usage for 48 items. To make comparisons more comprehendible, the author grouped the mean of the variables into the following: all media, education media, web media, smartphone media, app media, and social network media. Listwise exclusion was used because one of the two options, “never used” and “don’t know.” If participants left the option blank, it was taken as them decided not to answer the question, as was their right. In order not to give too much weight to “don’t know,” it was calculated given the same value as “never used,” a 5. “Very often” was given the value 1, so a smaller mean number in this case shows a higher frequency of use.

In checking the normality of data, the Shapiro-Wilks test results of .988 (df=200, p=.1) for the pretest Mobile Medial Learning pass the .05 p test, but the posttest Shapiro-Wilk of .983 results does not (df=200, p=.017). With the treatment groups, the issues look to be with the experimental group. Its Shapiro-Wilk of .930 puts its p-value at .001. When looking at the individual grouping, there are all sorts of issues with normality. Only the pretest results for the smartphone media and social network media and the posttest for web media and social network media have a p-value greater than .05. Because of this, the author will mainly use nonparametric tests to compare differences.

Copyright by Mahidol University

Table 4.3 Grouping of 48 media into 5 categories for Mobile Media Learning Survey

		Pretest Mobile Media*		Posttest Mobile Media*	
Media	**N**	**M**	**SD**	**M**	**SD**
All 48 Media	200	3.07	0.497	2.9	0.475
Control	68	3.03	0.541	2.87	0.482
Hybrid	67	3.17	0.477	2.93	0.438
Experimental	65	3	0.459	2.9	0.509
Education Media	200	3.61	0.551	3.37	0.522
Control	68	3.59	0.577	3.38	0.533
Hybrid	67	3.69	0.55	3.38	0.497
Experimental	65	3.55	0.522	3.35	0.543
Web Media	200	3.51	0.567	3.26	0.522
Control	68	3.47	0.615	3.26	0.542
Hybrid	67	3.61	0.574	3.28	0.505
Experimental	65	3.45	0.5	3.25	0.527
Smartphone Media	200	2.61	0.606	2.53	0.576
Control	68	2.54	0.615	2.45	0.585
Hybrid	67	2.72	0.633	2.59	0.561
Experimental	65	2.58	0.56	2.53	0.582
App Media	200	2.74	0.583	2.56	0.581
Control	68	2.73	0.608	2.5	0.596
Hybrid	67	2.78	0.611	2.64	0.578
Experimental	65	2.69	0.528	2.54	0.567
Social Network Media	200	3.06	0.698	2.99	0.636
Control	68	2.98	0.737	2.95	0.627
Hybrid	67	3.2	0.677	3.03	0.649
Experimental	65	2.98	0.664	3	0.639

Copyright by Mahidol University

Table 4.4 Table Descriptive statistics of pretest and posttest results from Mobile Media Learning Survey

		Pretest Mobile Media*		Posttest Mobile Media*	
Media	**N**	**M**	**SD**	**M**	**SD**
All 48 Media	200	3.07	.497	2.90	.475
Control	68	3.03	.541	2.87	.482
Hybrid	67	3.17	.477	2.93	.438
Experimental	65	3.00	.459	2.90	.509
Education Media	200	3.61	.551	3.37	.522
Control	68	3.59	.577	3.38	.533
Hybrid	67	3.69	.550	3.38	.497
Experimental	65	3.55	.522	3.35	.543
Web Media	200	3.51	.567	3.26	.522
Control	68	3.47	.615	3.26	.542
Hybrid	67	3.61	.574	3.28	.505
Experimental	65	3.45	.500	3.25	.527
Smartphone Media	200	2.61	.606	2.53	.576
Control	68	2.54	.615	2.45	.585
Hybrid	67	2.72	.633	2.59	.561
Experimental	65	2.58	.560	2.53	.582
App Media	200	2.74	.583	2.56	.581
Control	68	2.73	.608	2.50	.596
Hybrid	67	2.78	.611	2.64	.578
Experimental	65	2.69	.528	2.54	.567
Social Network Media	200	3.06	.698	2.99	.636
Control	68	2.98	.737	2.95	.627
Hybrid	67	3.20	.677	3.03	.649
Experimental	65	2.98	.664	3.00	.639

** 1 means very often, 5 means rarely*

Copyright by Mahidol University

First, was there a difference in usage of mobile media by participants from the beginning of the term to the end. The Wilcoxon signed-ranks test was used to check the paired pretest and posttest Mobile Medial results. For the mean average of all 48 media, the test does show a significant difference (W=6.220, *p*=.000). As to subcategories, the Wilcoxon test also showed a significant difference for the education media (W=6.935, *p*=.000), for web media (W=6.906, *p*=.000), for smartphone media (W=3.215, *p*=.001), and for App media (W=5.539, *p*=.000). Social network media is the one category where the pretest and posttest Mobile Media Learning Survey are not significantly different. The p-value is .056, just on the edge of significance but not quite there. This result does make sense. Students already were heavy users of Facebook and YouTube.

To compare treatment groups, the author used the Kruskal-Wallis H test looking only at data in term 2 and term 3. For all media in the pretest mobile media survey, there was no significant difference between treatment groups (H=5.044, *df*=2, *p*=.08). At 3.0, the mean average of the experimental group showed the most usage (SD=.463, *n*=65). The hybrid experimental group showed the least usage of all media (M=3.17, SD=.477, *n*=67), and the control group usage was in the middle (M=3.03, SD=541, *n*=68). There was also no significant difference in the education media (H=2.379, *df*=2, *p*=.304), the web media (H=3.656, *df*=2, *p*=.161), smartphone media (H=4.006, *df*=2, p.135), the application media (H=1.658, *df*=2, *p*=.437), or the social network media (H=5.584, *df*=2, *p*=.061).

Finally, did the mCpath treatment influence the media usage of the participants? Again, the author used Kruskal-Wallis H test to compare. When looking at the mean results of all 48 media for the participants, there was no significant difference between the control group and the other two mCpath treatment groups (H=1.299, *df*=2, *p*=.522). In the media groupings, there was also no significant difference between treatment groups with the education media (H=.226, *df*=2, *p*=.893), web media (H=.623, *df*=2, *p*=.732), smartphone media (H=2.226, *df*=2, *p*=.329), application media (H=2.262, *df*=2, *p*=.323), and social network media (H=.541, *df*=2, *p*=.763).

Copyright by Mahidol University

4.2 Computer concept results

The computer concept pretest and posttests answer the question, to what extent will the use of online searches through mobile devices in the classroom change the level of knowledge and understanding of undergraduate students?

The computer concept assessment was given three times each term: once as a pretest, once as the midterm posttest and then last as part of the final posttest.

For the convenience of the reader of this paper, there is a summary about this measurement instrument.

Item analysis of prior test bank questions was used to create four versions of a 19-item assessment that have a similar difficulty level, and the discrimination index had a mean P-value of .521 and standard deviation of .008 or less than one percent. Different versions were developed because it would have been almost impossible to use the same exam three times in three different section for three consecutive terms without an unofficial answer key leaking out. To reduce the risk, the author used the same version of the exam for the pretest and midterm posttest and then used a different version for the posttest midterm and the final posttest test. Then the author would rotate and use a different two exams for the second experimental round.

The pretest and the final posttest used only one version of the 19-item exam. The midterm posttest included two versions, so had a total of 38 questions.

The computer concept test had two sections: nine questions about materials covered in the class sessions and 10 questions that asked questions from the assigned reading. This allowed the author to compare between how well students learned materials in class versus how well students can learn on their own by reading assigned materials. In the case of the experimental treatment groups, the author could see how well participants can learn in groups using the mCpath method versus reading and studying materials on their own.

All section in experimental term 1 and experimental term 3 took the same midterm that included version 1 and version 2 computer concept items. These two exams will be called midterm version A. The students in term 2 took a different midterm that had version 3 and version 4 of the computer concept tests. The author will label these two test together as version B. The total samples size was 307, with

Copyright by Mahidol University

203 students taking the version 1 and version 2 test, and 104 taking the version 3 and version 4 test.

At first, the author was expecting to use one-way ANOVA to analyze the computer concept midterm posttest and ANCOVA for the posttest final. At first glance, there appeared to be no issues with the normality of the data. For the midterm data, kurtosis was a mild .309 and skew of -.684. The Shapiro-Wilks test showed a p of .03, so it does not pass the normality threshold. Diving the scores by treatment group better shows the issues. The main problem is the normality of the hybrid experimental group. Its Shapiro-Wilk score flunks at .003, while the control group just passes with a p of .074, and the experimental group passes the normality test with a p of .39. The issue with the hybrid group appears to be the negative skew of -.585. If the standard error of .244 is divided into this, the 2.393 z-score goes beyond the 1.96 limit.

There are more major normality issues with the final posttest. Shapiro-Wilk test shows .000 for p. Looking at the normality of all three treatment groups, the Shapiro-Wilk's test shows .000 for both the control and hybrid group and a .01 for the experimental group. So, the treatment group in this sample is not normal. Because of this, the author will use nonparametric analysis.

During the first class, students were given one version of the midterm computer concept class exam, 19 questions, as part of the pretest. There were two versions used: version 1 for experimental term 1 and experimental term 2, and version 2 used for experimental term 3. Different versions were used because of the risk that students from the term before shared results with friends in the next term.

The grade results of both pretest computer concept versions were non-normal. Both scored a p of .000 on the Shapiro-Wilk test of normality. For version 1, the data highly positive skewed (2.979) and kurtosis was a high 11.608. Although by not as much, the pretest data for version 1 had a skew of 2.703 and kurtosis of 8.663. Because of this, nonparametric tests were used on this data.

The Kruskal-Wallis H test was used to see if there was a difference with pretest computer concept score between treatment groups. For the computer concept pretest, there was no significant difference between treatment groups in version 1 (H=5.503, *df*=2, *p*=.064, *N*=180) or for version 2 (H=2.329, *df*=2, *p*=.312, *N*=86). The mean score was higher for the control group in both version 1 and version 2.

Copyright by Mahidol University

Because there is so much in the literature about the difference in gender in computer literacy skills, the author also looked at the results between females and males, again using the Kruskal-Wallis H test. Males scored significantly higher than females on the pretest version 1 (H=10.550, *df*=1, *p*=.001, *N*=180). With the mean score of female students was 4.9 and 9.6, so although both scored miserably on the test, the males' score was almost double that of females.

With pretest scores of version 2, males (M=4.5, SD=8.4, *n*=34) still score higher than females (M=3.9, SD=6.0, *n*=52) but not at a significant difference (H=.035, *df*=1, *p*=.851, *N*=86). Since the sample size in version one was much larger that for version 2, the data had more statistical power to measure a difference.

Finally, by taking an introductory computer class, did the undergraduates' knowledge level about computer concepts improve? The results of the Wilcoxon signed rank test for showed clearly that for version 1 of the computer concept test, there was a significant improvement between the pretest and the midterm posttest (Z=8.509, *p*=.000, *N*=96). Effect size r calculates to .614, making it a large effect. Version 1 of the computer concept test showed essential the same results, that (Z=8.057, *p*=.000, *N*=86). Effect size r calculates to .614, making it a large effect.

At first the author was expecting to use one-way ANOVA to analyze the computer concept midterm posttest, but the posttest data did not pass the Shapiro-Wilk test for normality. Instead the author will use the Kruskal-Wallis H test as a substitute (Corder & Foreman, 2014; Gravetter & Wallnau, 2012). Participant in Term 1 and Term 3 took the version A of the midterm exam, and participants in term 2 took the version B. Instead of using the mean, the test makes comparison of differences based on ranking (Kruskal & Wallis, 1952).

First, the author would like to look at the descriptive statistic of version A and version B of the posttest midterm. One issue with using Shapiro-Wilk is that it calculates a ranking instead of a mean average. An ordinal statistic does not give any sense of the difference between the scores of the three different treatment groups.

Because there are issues with the normality of the data, the author boot strapped using 1,000 samples with a confidence interval of 95 percent using bias corrected acceleration was calculated as part of the descriptive statistics.

Copyright by Mahidol University

For the results of the version A midterm, the control group scored slightly more than 2 points more than the hybrid or experimental group. The results were slightly larger but similar when looking at the confidence interval for the bootstrap results. For the lower bound, there was a 2.4 gap between control and hybrid and a 2.7 difference between control and experimental group. For the upper bound of the median bootstrap results, the difference between the control and hybrid experimental group was 2.7 and 2.0 for the control to experimental.

The median average showed a similar result. The control group scored the highest, the hybrid was the next highest, and the experimental group scored the lowest.

For the Kruskal-Wallis H test, the posttest midterm grades were used as the test variable list and the treatment category was used as the grouping variable. As to the results for version A of the midterm, there was no significant difference between any of the three treatment groups (H= 1.329, df=2, p=.207, N=196). The mean ranking showed the same order as was seen in the mean average, with the control group scoring the highest at 104.8, the hybrid next highest with 96.1, and the experimental group coming in at 94.2.

When looking at the result of the questions that only related to materials covered in class, either through lecture or through the mCpath group learning activity, the results was almost the same as the Kruskal-Wallis H results for all. There was no significant different and H was at 1.313 (df=2, N=196). Again, the control group ranked the highest, with 104.7, hybrid ranked next highest at 96, and then the experimental group scored 94.3.

The descriptive statistics for version B of the computer concept midterm showed a similar pattern as did the version A. With a mean of 51.4, the control group scored the highest, and the experimental group scored 6.4 points lower. The hybrid treatment group scored in the middle, 4.4 points lower than the control. Again, because the results from the midterm did not pass the Shapiro-Wilk test for normality, the author used bootstrapping. For the lower confidence interval, the difference between the control and the other treatment groups were both 5.5. It is in the upper bounds of the confidence interval of bootstrapping where the game between control and experimental grows to a wider 7.6 and but narrows to 3.4 between the control and hybrid groups.

Copyright by Mahidol University

The median average showed the same relationship. The control group scored the highest, and hybrid and experimental treatment score 6 points lower.

Back to using Kruskal-Wallis H using midterm grades from version B as the test variable list and treatment as the grouping variable, the results show no significant difference between the scores of any of the three groups (H=1.801, *df*=2, *p*=.406, *N*=104). The ranking for the results of version B was also the same as for version A. With a mean ranking of 58.6, the control group participants scored the highest (*n*=29). The hybrid experimental group scored the next highest with a 51.6 (*n*=38), and the experimental group came in last with a mean ranking of 48.7 (*n*=37).

Because of the significant difference between genders seen in the computer concept pretest, the author was interested to see if gender still had an impact on the posttest results.

Looking at only females taking the posttest midterm, Kruskal-Wallis H still showed no significant difference for version A (H=.502, *df*=2, *p*=.778, *N*=102) or with version B (H=1, *df*=2, *p*=.607, *N*=53). As to males, there was also no significant in-between difference between the treatment group with the results from version A (H=1.331, *df*=2, *p*=.514, *N*=93) or version B (H=1.373, *df*=2, *p*=.503, *N*=51).

Next, the author will look at the portion of the Kruskal-Wallis test that relates to only material covered during the class session. Again, there were no significant differences found between subjects with the A version (H=1.313, *df*=2, *p*=.519, *N*=196).

However, with the B version of the lecturer portion of the midterm, there was a significant difference (H=6.719, *df*=2, *p*=.035, *N*=104). To conduct the post hoc test, Kruskal-Wallis was run on each combination to use a pairwise comparison. Although there is literature that suggests there does not need to be an adjustment to the p-value if there are four or fewer comparisons (Keselman, Games, & Rogan, 1986), the author, using the Dunn-Bonferroni correction (Barnette & McLean, 2005), set the p test to .017. There was a significant difference between the control group and the experimental group (H=6.652, *df*=1) because p was .01, less than the adjusted value of .017. Eta squared, calculated by taking H divided by 1-N, is .10, so there was a small effect. At 40.4, the mean rank of the control group was higher than the 28.1 mean rank of the experimental group.

Copyright by Mahidol University

Continuing the pairwise analysis for the midterm posttest that covers questions about content from the class, there was no significant difference between the control and hybrid group (H=.587, *df*=1, *p*=.444) or between the hybrid group and the experimental group (H=2.914, *df*=1, *p*=.088).

Finally, for the portion of the midterm posttest where students were asked questions based on assigned reading, the Kruskal-Wallis test showed no significant difference for either the A version (H=.213, *df*=2, *p*=.899, *N*=203) or the B version (H=.710, *df*=2, *p*=.701, *N*=104).

As to posttest portion of the final exam, the 19-item computer concept items were included as part of the final examination for all participants. Version 2 was used in the first term; version 4 in the second term; and version 1 in the third term. This makes it difficult comparing all three terms the author would like to start off the analysis looking at the result from each term.

Because the same participants took the same exam twice with about 4 weeks between, the first analysis will see if there is a significant difference between the midterm and final. The nonparametric tool used to compare two related samples was the Wilcoxon signed rank test (Corder & Foreman, 2014).

There was a positive significant improvement in the final posttest grade over the midterm grade for all participants in term 1 (Z=4.504, *n*=94, *p*=.000), term 2 (Z=6.825, *n*=103, *p*=.000), and term 3 (Z=8.942, *n*=106, *p*=.000).

There were major issues with normality with the grade distribution of the final computer concept results, so the Kruskal-Wallis H test will be used to analyze the results from each term. The final grade score relating to the computer concept items was used as the test variable. The treatment classification was used as the grouping variable.

There was no significant difference in the between-group results with the term 1 (version 2) posttest final results (H=.408, df, 2, *p*=.815, *N*=94) or with the term 2 (version 4) posttest final results (H=1.312, *df*=2, *p*=.519, *N*=104).

The mean ranking results showed a similar relationship as well. The control group ranked the highest, with 55.9 for term 1 and 64.8 for term 2. Next highest was the hybrid treatment group at 54.2 for both term 1 and term 2. Lowest rank was the experimental treatment at 45.8 for term 1 and 47.9 for term 2.

Copyright by Mahidol University

What stood out was that there was a significant in-between difference in the term 3 results (H=7.927, *df*=2, *p*=.019, *N*=106). Eta squared for term 3 calculated to .0762. Again, the author used Kruskal-Wallis for pair-wise comparison and again using an adjusted Dunn-Bonferroni correction of a p less than .017 for significance. There was no significance between the control and the hybrid group (H=4.466, df, 1, *p*=.035, *N*=66) or the hybrid to the experimental group (H=.554, *df*=1, *p*=.554, *N*=69). The comparison between control and the experimental group comes the closest to being significant (H=7.927, *df*=2, *p*=.019, *N*=106) but misses by .002.

Using Kruskal-Wallis, there was no significant difference the posttest final scores between group with term 1 participants (H=3.596, *df*=2, *p*=.166, *N*=94) or term 2 participants (H=4.04, *df*=2, *p*=.134, *N*=105). The mean ranking of only the lecturer and mCpath-related questions in term 1 showed the same pattern seen in the total final results for term 1, with control scoring the highest at 53.8, hybrid the next highest at 44.2 and the experimental group scoring the lowest at 42. This pattern does change with the term 2 results, with the hybrid group scoring the highest means rank of 58.8, the control troop scoring the next highest at 55.0, the experimental group coming in last at 45.1.

There was a significant difference between the treatment groups when looking at only the lecture and mCpath-related option of the final exam questions for the version used in term 3 (H=9.636, *df*=2, *p*=.008, *N*=106). Eta square was .093. In the pairwise analysis using Kruskal-Wallis, there was a significant different between the control and experimental group (H=8.095, *df*=1, *p*=.004, *N*=77). The mean rank of the control group of 46.5 was higher than for the experimental group (32.1).

Again, because multiple comparisons are being made, an adjusted Dunn-Bonferroni correction would set the p-value of less than .017 for the significance of a two-tail test.

There was no significant difference between the control and hybrid group (H=4.597, *df*=1, *p*=.032, *N*=66) or between the hybrid and experimental group (H=1.543, *df*=1, *p*=.214, *N*=69).

Copyright by Mahidol University

Last, as two the portion of the computer concept final that relates to question asked about material students were assigned to read on their own, Kruskal-Wallis H showed no in-between group difference with the results from term 1

(H=.203, *df*=2, *p*=.904, *N*=94) term 2 (H=.565, *df*=2, *p*=.754, *N*=105) or term 3 (H=3.788, *df*=2, *p*=.150, *N*=106). The mean ranking was highest for all treatment groups term1 (46.0) and term 2 (56.5), and the hybrid and experimental group were almost tied for term 1 at 48 and term 2 at 51. In term 3, the hybrid group ranked the highest with a 48.3, the experimental group the next highest at 50 and the control came in last at 61.3.

4.3 Digital Search Literacy results

One of the byproducts of developing the measurement instruments for digital literacy for this experiment was the measurement of digital literacy of participants. This researcher has been teaching introductory computer classes in Thailand since 1997, meaning that most of these students were born when the original IBM PC XT started being sold. While growing up, only a small percentage of those students would have used a PC, and since ThaiSarn first testing an international internet link to Japan (Koanantakool, 2001), even fewer would have connected to the web. The connection speed at most universities was so slow that this researcher had to conduct a computer lab early Saturday morning when there would be the least amount of campus use, and it was normal that the web browser would freeze up half way through the class. In short, there were plenty of reasons back then for the digital literacy of undergraduates to be low.

With the average age of participants in this study rounding up to 20-years old, this means these students were babies during Windows ’95 era. They grew up playing with PCs, and they were teenagers when the first iPhone came out. Most were required to take a computer class during high school. Almost every participant has internet access at home. It would be expected that the level of digital literacy for this 2013 cohort should be much higher that it would be for the pre-2000 undergraduates. Yet this researcher has seen the level of digital literacy skills remaining comparable through. Well, the perception up to this point was that digital literacy of undergraduates studying in Thailand was still comparatively low, but there has been no substantial quantitative evidence of this.

Copyright by Mahidol University

Although in its 2010 framework, the Thai Ministry of Information and Communications Technology has committed to increasing the level of technology of 30 percent of the total workforce (NECTEC, 2011), it has no standardized computer literacy survey and no standardized information literacy survey that will allow it to set the digital literacy baseline. Up to this point, it has no way to measure digital literacy progress or have a way to benchmark this against the level within the country, regionally or internationally. The measurement instruments developed as part of this research does start to provide this benchmark of digital literacy levels of undergraduates, that then can be expanded upon to include graduate students and adults. The TRAILS project at Kent State University tends to indicate that the testing of grade school to 12th-grade student would be more complex. The project has developed 4 different versions, from 3rd to 12th grade (Kent State University Libraries, 2014d).

There have been some regional presentations on either computer literacy or information literacy, but none are large enough to be representative of undergraduates in Thailand, and none have used a standardize measurement instrument that allows for benchmarking. As already explained in the introduction, digital literacy in this project is defined as computer literacy and information literacy, and the computer concept assessment and the Digital Search Literacy Survey were developed specifically to measure these two knowledge dimensions.

As part of the pre-experimental phase, the 12th grade and the 9th-grade version of the TRAILS information literacy assessment were pilot tested. The website has the mean average of the numerous US high schoolers that took the test, so the pilot test allows for some comparison between Thai undergraduates and the large US sample. For the 12 grade version of the TRAILS assessment, the mean for US 12-year old in 2013 was .519 (n=4,833) (Kent State University Libraries, 2014c). The pilot group of undergraduates studying in Thailand did more poorly (M=.378, n=52). Some of the test items had more or less than four choices, so the probability of guessing correctly on the high school version was .279, making it likely that the Thai students were correct around 10 percent of the time and the rest of the score was due to a lucky guess. A follow-up pilot tended to confirm this because the Cronbach's value showed low reliability of .389. Because the US data was lacking standard deviation

Copyright by Mahidol University

information, a one-sample t-test was used to compare. There was strong significance difference between the Thai undergraduates and US 12th graders, with Cohen's *d* at 1.11. It showed a sizable large effect ($t(51)=7.97$, $p<.000$). Of the US 12th graders results, 1,779 of the 4,833 were identified as students from three states: Maryland, New Jersey and Ohio. Ohio students scored the lowest, and even then, the Thai sample would not have been anywhere comparable (M=.469, $n=576$), but Cohen's *d* showed only somewhat of an effect ($d=.257$). Since most the Thai participants were non-native English speakers, the most likely reason for the large difference would be to English language abilities. The test questions used a more advance vocabulary, it has 30 questions, instead of 25 like the 9th-grade version, and it has 59 percent more words than the 9th-grade version. There could have been a higher cultural bias than on the 9th-grade version, but this would have more difficult to measure. Both versions were written from a North American perspective, including questions about electoral systems, inaugural address, and WW II, topics that Asian students would have misunderstood or would have had a different perspective about. There were also questions that had a librarian bias. Some of the questions or choices included encyclopedia, newspapers, online library index, and library catalog, terminology that does belong to library sciences but not used in general usage when students search the web.

This researcher had some issues with using the Kent State Library assessment in the current research project. Although the test has been administered to over 288,000 students and has been used since 2004(Kent State University Libraries, 2014b), publicly-available information about the reliability of it has only come out in 2014 (Joseph A. Salem, 2014). Using only one version of the 25-item survey was not enough. If both versions were used, then 42 items would cross the .83 alpha threshold. This helps explain the quite low Cronbach alpha of .389 on the second TRAILS pilot conducted after the initial pilot test.

The pilot sample did better on the 9th-grade version of TRAILS, with the undergraduates scoring a mean of .459 ($n=28$), compared to .525 for US 9th graders ($n=36,924$). Certainly, there was still a significant difference between the two scores ($t(27)=2.53$, $p=.017$), and a Cohen's *d* of .477 showed a large effect but nowhere as massive as for the 12th-grade version. If just the 9th-grade students from the lowest

Copyright by Mahidol University

scoring states of Indiana and Louisiana (M=.46, *n*=1,860) were used for comparison, there would have been no significant difference. With a mean of .61, Massachusetts and Connecticut 9th graders scored the highest and Kentucky students were next at .58. The next highest was Maryland with .55. If the three top states were removed as outliers, there would still have been a significant difference between the Thai undergraduates and 9th grader scores from the remaining 15 states, but just, with p at .04 ($t(27)=2.13$).

Out of interest, the 2012 ACT state scores compared to the TRAILS state results of 9th graders. The intent being to see if there was any relationship between state-level data on information literacy and the knowledge and skills in English, math, reading or science measured by the ACT national exam. Any generalizations from this need to be highly qualified because there is an age of the two cohorts being measured is considerably different. It would be better to compare the 12th grade version of TRAILS, but there is statistics of only three states, compared to the data from 18 states at the 9th-grade level. As to the ACT, over 1.6 million us students took this assessment. The number of graduating students that participated ranged from 100 percent for Minnesota, Illinois, Kentucky, and Michigan. Ten of the 18 states had 35 percent or less participation, the minimal being 20 percent from New Jersey (ACT, 2012). Pearson's correlation showed no significant relationship between TRAILS exam scores per state and the average composite score on the ACT ($r(18)=.422$, $p=.081$). The average English score portion of the ACT results comes closer but just barely misses passing significance with a two-tailed Pearson Correlation ($r(18)=.459$, $p=.055$). A relationship between information literacy and English language ability would make logical sense in that searching relates to understanding the nuances of various combinations of search terms. The results may be clearer if we were not comparing 9-year olds to 11-year olds. With the research in hand, the qualitative data coming from peer reports, learning journal, mCpath reports and test answers strongly suggested that English literacy and information are likely connected.

The conclusion coming from the analysis of the pilot data is that the informational literacy knowledge in English of undergraduates studying in Thailand is at best comparable to 9th graders in two US states out of 18 that scored a lower average. Because the English language requirement for entry into the international

Copyright by Mahidol University

college where this research was conducted is higher than most other international programs, it is likely that this information literacy knowledge would be at best the same as in this sample but more likely lower for undergraduates at other international programs. This is again speaking about information literacy in using English. Up to this point, there is no known research conducted on Thai information literacy or any known assessment that is used in Thai language.

It's recognized that there is likely to be bias in the TRAILS sample for several reasons. First, the sample did not equally represent students from all 50 states, especially with the 12th-grade version because there was only information from three states. With the 9th-grade participants, 3,549 of the total 36,924 had no information about which state, so it could be possible to have data from more than 18 states but it would have been a sample below 500. One explanation for the weak correlation between 9th-grade TRAILS results and the ACT scores was that there is no significant relationship between the two. Another explanation would be that the TRAILS sample was biased, so was not representative of the total US population of 9th grader. It is likely that students school districts with more active library systems are the ones that took TRAILS. This means the students more likely had more training on searching and using their library systems. Students in the school districts with more passive library systems, where the librarians are not as proactive about training students on information literacy, are less likely to be part of this sample. With 1.6 million participants, it is likely that the ACT better represents the US high school population. Again, there certainly is a difference in knowledge and skills between the 9th-grade students that took TRAILS and the 11th-grade students that took the ACT. This researcher is expecting that the ACT score can serve as a proxy to represent the skills of 9th-grade students in 2012/2013 by assuming they will have similar levels of development as does the 11th grade students that took the ACT. One issue is that although they are only two years apart, the 9th grader and 11th grader will have likely had different cultural influences. The other is that the mental development and cognitive skills are likely to be at different stages (Steinberg, 2005). This is certainly the case at a younger level (Alloway, Gathercole, Willis, & Adams, 2004), but it is

Copyright by Mahidol University

likely there are other issues with socialization, prior knowledge, economic and skill gaps and possible drug or alcohol.

TRAILS was developed to align with the Standards for the 21st Century and the High School Common Core but not the university-level information literacy standards set in the US ILCSHE that is more widely used.

Because of the issues with TRAILS, the lecturer in this project developed his own information literacy assessment designed from the group up for Thai undergraduates. The Instrument Development chapter has the specifics of how the Digital Search Literacy Assessment (DSL) was designed, tested and refined. To briefly recap, the tool was based on the ILCSHE outcome. After pilot testing, the original 72 item instrument was trimmed to 50 questions, giving a reliability index of .792 (Cronbach's Alpha). The mean average of difficulty was .495 (SD=.196), coming quite close to the ideal .50. This is because the midway point allows for the maximum amount of discrimination.

The pilot test was given to participants in the first experimental phase during the last week of class, so the sample size of those that took the pretest was only 195, including participants from experimental terms two and three. The mean average results from the pretest sample was .435 (SD=.101), quite comparable to the results from the pilot test of the 9th-grade version of TRAILS (M=.459, n=28). The highest score was .68 and minimum score was .18. Skewness was .193, close to zero, so the distribution was close to normal. Using an independent sample t-test, the difference was not significant (t=1.076, df=221).

When comparing results between females and males on the preDSL, they were statistically almost the same. Females scored .435 (SD=.091) and males scored a tiny but higher with a mean of .436 (SD=.112). A t-test confirmed what could be seen quite clearly, that there was no significant difference (t=.098, df=193). This is quite interesting because gender appears to be a major difference when looking at the computer concept pretest results. Using Pearson's correlation to check, there was no significant correlations between age and the DSL grade (r=.093, p>.05, n=189).

Copyright by Mahidol University

With year of study, there is not much difference between year 1 (M=.421, SD=.096, n=140) and year 2 students M=.4475, SD=.097, n=40). Then the third year mean average jumps up to .587 (SD=.07, n=6) and the fourth-year students settle to a

mean of .503 (SD=.115, *n*=8). There was one fifth year student, but the grade score is intentionally left out because of the ethical risk to privacy of that one students being possibly identified. The number of junior and senior participants are low probably because they are the two groups most likely not to show up on the first day of class. With year one and year students group into category 1 and then all the other students grouped into category 2, a t-test shows that these students in their first two years of studies (M=.427, SD=.096, *n*=180) score significantly lower on the DSL than do the juniors and senior students (M=.541, SD=.101, *n*=15) in this study. Because Leven's test for equality of variance was .001, less than .05, then the t-test where equal variance not assumed was used (*t*=4.244, *df*=16.2, *p*=.001). Remember there was no significant correlation between age and the score on the DSL. So, it appears that students' knowledge about information literacy does improve from the natural progression of pursuing a college education, with a distinctive jump in this ability in the third year of study.

Because each question on the test was mapped to the ICSHE outcomes, the survey can be used as a diagnostic to point out areas where students can improve their information literacy knowledge. Again, because ICSE Performance Indicator 4 relates to demonstrating the application of new knowledge, it is not possible to measure this well with a multiple-choice format. The indicator is better measured during the mCpath report process. There are two outcomes measure in ICSHE Performance Indicator 1. These are Outcome 1.1, dining and expressing the need for information and Outcome 1.2, identifying the variety and types of information. In the pretest, the participants scored the highest on ICHSE 1.1 (M=55.9, SD=15.9) and ICSHE 1.2 (M=46.0, SD=16.8). This means the students had the most knowledge about the "nature and extent of the information needed" (AASL, 2007). The outcome they had the most difficulty with was in understanding the ethics about using information, ICSHE 5.1 (M=30.7, SD=15.2). Delving down to the specific outcome, they had difficulties with the concept of copyright, public domain and creative commons (M=16.3, SD=15.2). This is certainly understandable given the issues the Western world has with intellectual property right encouragement in the country. Thailand is currently on the priority watch list for issues with intellectual property right by the United States Government, and it has been on that list since 1989 when the Special

Copyright by Mahidol University

301 Report first start being issued by the Office of the US Trade Representative (Froman, 2014, 2015). Most of this conversation focuses on software piracy, so when talking to individual students, they are not aware it is unethical and illegal to use copyrighted music and photos from the web. Mahidol University has one of the more restrictive policies about photocopying copyrighted materials, but most universities in the country have many photocopying shops around a campus that will copy complete text books. Thailand has excellent statutory rules, but as in most Asian countries, enforcement is the issue. Digging deeper into perceptions of students on the ethics of this would be quite an interesting research question on its own. This lecturer's perception is that students consider a copyright violation in the same way they would perceive illegal parking. They know there is a rule against it, but it is not that important of an issue if there is a violation. It is so minor, they do not even consider it an ethic issue they should worry about.

Looking at the three individual question in the ICSHE 5.1 group, the students had equal difficulties with identifying the difference between creative commons (M=30.4, SD=27.5) and copyright (M=30.0, SD=24.0), followed by understand public domain (M=32.6, SD=30.5).

The Digital Search Literacy Assessment (DSL) was used as a pretest and posttest only during experimental term 2 and experimental term 3. The results are used to answer the research question, to what extent will using online searches through mobile devices in the classroom change the digital information literacy of undergraduates?

Originally the author was planning on using the TRAILs information literacy assessment developed by Kent State University Libraries, but a pilot test during the pre-experimental phase showed quite low reliability (Cronbach's alpha=.389). A year after the current experiment, a dissertation was published that examined the reliability of four different version of TRAILS. It showed that that with the number of items included on the tool, only the 3rd grade version and 9th-grade version reached a coefficient alpha of just barely .70 (Salem, 2014). Because the questions on the assessment had a strong US educational bias and it was developed for high school students, not university students, the author had decided that it was better to completely develop a new tool that better fit the participants in this study.

Copyright by Mahidol University

Not all student took both the pretest and posttest. Fourteen of the 208 participants missed the pretest. Most of this was first week syndrome where students blew off the first Friday of classes, some had not returned from holiday and a few added the class in the second week. Fifteen missed the posttest. Again, this is sort of typical attendance near the end of the term where some students miss classes to complete an all-night project, study for quizzes or attend field trips for other classes. The total that took both version came to 180 or 86.5 percent of the total sample.

For the pretest, the Shapiro-Wilk test of normality statistic was .986 with a p-value of .072, above the .05, so passing the normality test. When looked at the Shapiro-Wilk statistic for each treatment group individually, all pass the normality test as well. There was a slight positive skew of .195 and Kurtosis of -.512. The Leven's test results of .888 equates to a p equal to .413, so the data is assumed to be of equal variance.

Prior sections of this thesis went into detail on how the DSL was developed and calibrated and how digital search literacy of Thai university participants compare to US high schoolers. Look at the pretest results for experimental term 2 and experimental term 3, what was apparent was that participants in the control group, hybrid experimental group and experimental group had quite similar levels of information literacy knowledge. The mean total score of 43.5 (N=194) varied between the three groups varied by less than .5 percent. The author used one-way ANOVA using treatment as the factor and score as the dependent variable. The between group analysis showed an F of .048 and a p of .953 shows almost no variation between the scores. There was also almost no difference in the information literacy scores when looking at the gender difference. The mean average for women was 43.5 (N=101) and for males, it was 43.6 (N=93). This contrasts with the pretest computer concept results that showed that women scored significantly lower than men. For basic computer concept knowledge, there is a gender gap but there is no such gender gap when looking at overall information literacy knowledge.

The posttest DSL results also pass normality tests. Its Shapiro-Wilk test results of .993 showed a p of .597, well above the .05 point. Skewness was a minor .118 and the Kurtosis of only .088 showed an almost normal tail distribution.

Copyright by Mahidol University

The DSL assessment measured information literacy based on four US ILCSHE standards:

ILCSHE 1: Determine nature extent of information needed

ILCSHE 2: Find information effectively and efficiently

ILCSHE 3: Critically evaluate information and seeking process

ILCSHE 5: Show understanding of the legal and social issues

The questions were grouped so that each category could be analyzed separately. Unlike the DSL pretest results where the mean average between groups varied quite minimally, the mean of the pretest for the treatments varied considerably. To control for the differences in the pretest, ANCOVA was used. The posttest score of each ILCSHE standard was used as the dependent variable, the treatment group was used as the fixed factor and the pretest results for each standard was used as the covariate.

Analyzing the score for each grouping of questions, the one that stands out the most is the results from ILCSHE 3, critical evaluation of information and sources. The covariance analysis of the posttest results from show a significant difference between the treatment groups (F=3.695, p=.027, df=2, 176) with a partial eta of .04 showing a small effect. Pairwise comparison showed that the largest difference was between the experimental group (est. M=53.8, n=66) and the control group (est. M=43.6, n=54), with a p of .013. The experimental score for ILCSHE 3 questions was also significantly higher (p=.039) than for the hybrid experimental group.

When looking at scores from ILCSHE 1 (F=1.623, p=.2, df=2, 176), ILCSHE 2 (F=.111, p=.895, df=2, 176) and ILCSHE 5 (F=.663, p=.517, df=2, 176), there was no significant difference between the treatment groups. The estimated mean was higher for the experimental group than for the control group in results for ILCSHE 1, ILCSHE 2, and ILCSHE 3. For ILCSHE 5 results, the estimated mean of 30.2 for the hybrid group was slightly higher than the estimated mean of 30 for the control.

For ILCSHE 5, the experimental group scored the lowest (est. M= 27.2, n=66), 3 points lower than the hybrid experimental group winners (est. M=30.2, n=50) and slightly less for the control group (est. M=29.9, n=54). ILCSHE 5 questions relate to the ethics of using copyrighted information. This topic was covered

Copyright by Mahidol University

during the computer lab on Fridays after the midterm and not in either the Monday lectures or during the mCpath work. For ILCSHE 5, the score more reflects what was learned in class during a lecture for all treatment groups, so the highest to lowest scoring group is more due to random chance or to other factors that are not powerful enough to create a significant statistical difference (F=.663, p=.517, df=2, 176).

Referring to ILCSHE 3 results, it appears that the experimental group that participated in the mCpath treatment had better knowledge about evaluating web sources. There was an 18.3 point mean difference between the experimental group and control. With a 13.7 point gap, the hybrid experimental group also did significantly better. The size effect difference was also large.

As to ILCSHE 1, students determine the information needed and ILCSHE 2, accessing information effectively and efficiency, the experimental group scored higher than the other two groups but not at a size that was significantly different. For ILCSHE 1, F was 1.623 and the p-value was .2. Looking at ILCSHE 2, F was .111 and p was .895.

To go back to the reliability of DSL, using item analysis the original 72-item instrument was trimmed to 50 questions which would have had an alpha coefficient of .79. To recheck survey reliability, the author conducted test-retest reliability using bivariate correlation on the DSL scores. The Person correlation results show .706, into the range. Considering the gap of time between the first week and tenth week of class, this result is reasonable and shows that the survey has practical use to measure information literacy.

Finally, a t-test showed a significant difference between the DSL pretest and DSL posttest results for all participants (t=8.943, df=179, p=.000, N=180). Students scored a mean of 48.6 in the posttest, 5 points higher than the mean of 43.4 in the pretest.

4.4 Learning journal results

Copyright by Mahidol University

What will be undergraduates' attitude in using mCpath instruction in cooperative teams in the classroom? The learning journal 2 results answered this. For students in the treatment group, they were asked to compare mCpath to a regular class

lecture and did they learn more, the same or less by this new method. One hundred and fifty students that filled out the journal, 71 percent of those in the treatment sections. Qualitative analysis of their responses answered this research question about attitude.

Forty-three percent said they learned more through the mCpath method, 16 percent said they learned the same, and 41 percent said they learned better through class lectures.

An example came from a female student's comments, "The mCpath method really opened me up to new information, and I feel like I have learned more than a regular class lecture. If it is just a regular class lecture, I would just take notes and do not really pay attention to the lecture (research ID 3005)." A male in the experimental treatment section better represented the development of appreciation for the method.

> *" It was difficult and confusing at first, but after time passed I got used the process and I found the process quite interactive. As I would interact with within my own group, assigning roles, working both individually and as a group simultaneously, and also interacting with you, the teacher during the time when the presenters had to present the information that we have found from our research."*
>
> (research ID 3019)

By splitting results into hybrid treatment and experimental treatment, the results change. For the experimental treatment participants, 51 percent say they learn better through lecturers than through the experimental method. Those that think mCpath is more useful dips to 36 percent, and the those in the middle shrink to 14 percent. As to the hybrid treatment participants, those that said they learned more through mCpath became the majority at 51 percent, and those in the middle were at 19 percent. Those in the hybrid group that said they learn better from lectures was a minor 30 percent.

Copyright by Mahidol University

"mCpath is one of the best methods in gathering information," said a male from one of the hybrid sections (research ID 2026). "Each and every person in the

group have to work together and gather accurate information so that the presenter will not embarrass himself with any mistake in the content."

Another male student explained, "I prefer mCpath to lecture because mCpath also always calls my concentration while I often lost my focus in the class lecture (research ID 2039).

Of those participants that said they learned less through mCpath, 54 percent in the experimental treatment sections had a negative reaction compared to only 37 percent in the hybrid treatment sections. Looking at the total, only 10 percent of the hybrid respondents disliked mCpath, but 27 percent of the experimental group did not like learning this way. Clearly, the hybrid treatment sections had a more positive acceptance level of this innovative instruction than did the experimental sections. The three subcodes were team learning, self-efficacy, and learning through the process.

After analysis, the author grouped qualitative results into three categories: team learning, self-efficacy, and learning process.

Under team learning, there were six positive factors that participants in the treatment groups said helped promote learning under mCpath. The first was that students said they learned better as a team. Through the class presentations and through having the Researcher compare differences between groups, the second element was that these undergraduates also appreciated that they could learn from other teams. A similar aspect of learning as a team was students' focus on working as a team. Each student had a role, and these realized that the positions support each other. The groups that worked well together could understand they were learning valuable skills, these being as central as what they were learning through the process. This working together leads to the next factor, team discussions. The healthier groups had disagreements and had to accept differences of opinions into the final products. Also coming from working together was the appreciation of improved social skills of being its own importance, an outcome that students thought would be essential throughout their studies and into their professional careers. Finally, a large part of the mCpath process was sharing. They shared opinions, the Auditors and Researchers shared search finding with the Reporters. Because students would rotate roles, they would share feedback from their teacher to improve the quality of their work. Those

Copyright by Mahidol University

that appreciated these team skills and actives said they learned more through this instructional method. For those that said they learned less, analysis of their learning journal comments showed five points that cause a breakdown in their ability to learn as a team. The first and most emotional one was a dislike for learning in teams. This was because assignment to a group was randomized, breaking up friendship clique. Part of this was from students that feared the group effect on their individual grades. Some also did not like to work with others. Although, this is seen as more of a Western issue. Undergraduates in countries like the United States or the UK tend to be seen as more individualistic. There are students like this in Asia as well. The learning journal gave a chance for such students to write what they thought when usually they would have reticent of expressing this in class. This leads to the other factor, preferring to learn on their own. For some, their style of learning is to go off to a library or a private place and focus on mastering the materials. To the other extreme, there are the students that are n0t that interested in learning in or outside of the class. The factor here is that these students were focused only on finishing their task. These students were not interested in socializing, were not that interested in helping others. They were assigned to finished a report, so they tried to get this done on time so they could receive a passing grade. The next aspect is that they did not bother reading the team reports. Half of the computer concept midterm questions were based on mCpath questions. Those that never reread their own reports before the midterm surely failed the midterm. Some students said when they were the Reporter, they knew their own answers but did not look at any other, they also struggled with the exam. The one symptom seen in students that did not work well or learn well in a group was about their emphasis on being confused because different groups had different answers. They had difficulty synthesizing these many difference answers into one complete response, a task that those working together called team discussion and sharing. It was missing from those that did not work well with their groups. Because of this, they were unable on their own to decide on the best answer or to be able to merge concepts into one answer. Those that said they learned less through mCpath focused more on themselves so that there were less team interaction and less team learning.

Copyright by Mahidol University

Under the self-efficacy code, there were three subcodes for those that learned better through mCpath: improved self-learning, synthesis of many sources into

one, and transferability of skills. Those that had a positive view of this m-learning treatment also showed more confidence in their abilities. First under this is they are more confident with their computer skills. They recognize that by using mobile devices to learn more about computer concepts, they are also improving their ability to use these tools in a real-world context. Connected to this is that these undergraduate have more confidence in their improved ability to search the internet class material. They can find more primary sources, from a wider range of sites, and have experience with evaluating the quality of these. Still, under improved self-learning, these participants said that the remember better when they do their own searching. They contrast this with being given a technical term during a lecture, where they do not quite understand the meaning and are reluctant to interrupt an instructor to ask. Because they had to search through many websites, the students said another improvement was their English reading abilities. The students also said that during the mCpath sessions, they were also better able to concentrate on the class materials. Finally, under self-learning, these students highlighted that the felt an increase in their ability to be responsible, for themselves as well as for their group members. Referring to improvement in self-efficacy, these students were better able to synthesize many sources together. They had reached a point where they understood that citing difference sources, different websites made for a stronger answer. Instead of being overwhelmed with too much information, these students learned to be more selective and then were able to gather one larger answers from the various bits. Finally, these students appreciate that their skills were transferrable, that they could be helpful in doing well in other classes, as well as in their work after graduation. For those where their self-efficacy did not increase because of the learning method, three elements that stood out: dislike of self-learning, confusion of learning, and difficulty with learning. Dislike of self-learning is the simplest to clarify. Those that are averse to learning this way put minimal effort into their reports. Because minimal effort was invested, there was no noticeable improvement in their self-efficacy. Under the subcode of being confused, many issues belong here. The first is that these students see that there is different information on different websites. Instead of trying to combine these into one comprehensive answer, these students are confused because they have difficulties finding the one right answer. They have not developed to where they understand that

Copyright by Mahidol University

in authentic life situation there rarely is one correct answer. The confusion over multiple sources leads to the next topic in that these students are unsure the correct answer. Their ability to critical analyze sites has not developed, so they are unsure if an answer is accurate or not, technically correct or not. Another subcode is the ability to judge credible of a source. Instead of having a healthy skepticism, these students are bewildered. Most avoid the issue by assuming the person writing content is 100 percent expert, especially if somewhere on the page the person writing this says on the website. Finally, some of these students are confused with the initial path question. This is partially intended of the process because it is the beginning of the search process, clarifying what sort of information is needed to answer the question is the first information literacy skill. Most students will need to search to understand the question, and then they will refine the search. If students still are confused, they have their team members to ask and certainly their instructor as well. These students appear to be going at it on their own, and because of this, they are unsure if they understand the questions correctly.

The third code deals with the learning process. Most of this relates to the mCpath learning process, but the students that said they learned better in a lecture, explained why they preferred an orthodox lecture over a cooperative mobile learning activity. The students that said they learn better through the mCpath process gave three reasons: it was more interesting, they could learn in different roles and they could remember better. For those that said it was more interesting, they said the process was novel, and they found information that was quite current. Instead of a lecture they know was a bit outdated or a textbook that was several years old, they were excited about finding the information on the latest technology. From this comes the next on the list, learning was not limited to what was in a lecture or in a handout. Once students found an area that was of interest to them, they appreciated that they were not limited to what the lecture had to say about the topic. They felt encouraged to explore on their own. This leads to the last two subcodes, easier to learn and also interactive. These students prefer to work with other students and using their mobile computing devices during class. They think this is easier than reading a book or listening to a long lecture. The interaction with other students and with the teacher in a less formalized setting also improves interest. Finally, these students said then when they look up the

Copyright by Mahidol University

information themselves, they will remember the content better. To contrast this with how they feel about the lecture process, these undergraduates perceive lecture classes as dull, and they have difficulty focusing on a long talk. The other issue is that these students feel pressured trying to listen and take notes at the same time. For those that said the learn more from lecture process than from the mCpath learning process, many said they do prefer listing as a way of learning. Several said that the lectures for this computer class are already interactive, so keeps their interest. Another group of students said they prefer to learn through taking their own notes. If they read from a website information does not stick as well as if they go through the process of taking their own notes and then review them after class. One of the issues raised was that some students said they did not remember as well when using the math method. For those that focused more on how they learned less from the mCpath process, some said the method was boring. This comment came mainly from those in the experimental group that went through the process four weeks in a row. One issue that was also raised by those in the experimental group was that without a lecturer giving perspective, they had difficulties understanding the purpose of a particular lesson or the overall point in how they connected. Another point for some was that this way of learning was too novel, too different from the way they have learned before. These students also referred to the mCpath roles as why they did not learn as much. A good cluster of them said that they could not hear or understand the student presentations. As to the comments from the experimental group, they thought in general that the mCpath process required too much. This included too much reading of websites, too many path questions to answer, and too much information to study.

The second question added to the treatment groups' learning journal was about the experience of team learning. Did students think they worked well together on assignments, completing tasks and helping with the midterm? There was a positive bias to the wording. The author did this intentionally to encourage reflection of what was learned through the team process. Seventy-six percent of the treatment respondents said yes, their group worked well. Twelve percent gave a qualified yes, and the other 12 percent gave a clear no, their groups had issues. For the yes, there was little difference between the hybrid group response of 75 percent and the experimental of 77 percent. For the hybrid group, there was 18 percent no responses and only 7

Copyright by Mahidol University

percent somewhat. This was reversed for the experimental group, where 13 percent said they somewhat worked well and 8 percent said no.

To answer the research question about undergraduates' attitude, the majority of the participants in the hybrid treatment group thought they learned more through the mCpath. A small minority had negative feelings about the instructional method. For the experimental treatment participants, they were evenly split as to which method was better. About a quarter of these participants had negative emotions toward mCpath. Both treatment groups thought their mCpath worked well together. Those that said they learned more through the mCpath process valued what they learned about working with others. Those that said they learned more in the classroom did not seem to connect learning with their team activities.

4.4.1 Team learning

For those that learned more through mCpath, the majority said they were involved with team learning. "It's not too bored as a normal class because you have to work with people in your groups (research ID 2019)." said a female in the hybrid group. A male in another experimental group had this comment, "I found the process quite interactive, as I would be interacting with within my own group, assigning roles, working both individually and as a group simultaneously (research ID 3019)."

Sharing was a big part of the team learning process. The same male student went on to explain that the Researcher and Reporters needed to share their reports with all members. Another male front one of the hybrid treatment group added, "I think it was a good way of learning. We can share an idea, problem, and experience as a group (research ID 2067)." One female explained this process in more detail. "During the midterm, we collect all the reports work of every week and share it in Google doc. with the team members (research ID 3004)." Some groups used Facebook as a collaborative tool. Some used Line to share information. "It is a good change because I never work with the group in term of sharing online content," a female student said (research ID 2075).

Copyright by Mahidol University

Another female student had a different take on working together. "It is a great experience for me because I have an opportunity to develop both social and academic skills, said another undergraduate (research ID 3067). She highlighted the

next point, that improved social skills became one of its own learning objective from the team interaction.

The students also learned from other groups. The Researcher was required to talk to other teams. They understood that by listening to them and by comparing differences between their members and another, they could also learn from other teams. As one female student put it, “We can listen to other group answer and compare with our answer. This makes me understanding more and even check which information is correct which is not or what details that I have been missing while searching it (research ID 2049).” Another female said something similar. “We still learn from our friend from other groups when they present their information and compare their information to our group,” she said (research ID 2025). Those that said they learned less through mCpath appeared to learn more on their own and work on tasks by themselves. A female said that her group would only work together on the three questions in class that the presenter needed (Researcher ID 2069). These participants tended to be confused when different members and different groups had different answers for the same question.

The third subcode was working as a team. A male in one of the experimental groups talked about how working together made him more responsible. “Before the homework is due, there will be a member of the group who send the email to remind and make sure that everyone in the group will not forget to finish their job,” he said (research ID 3007). The students did appear to learn that there were consequences to their team if they did not in their best effort. “If I did the wrong research, my friend will do worse because of me,” wrote one student (research ID 3002). A good part of this process was the team discussions. “If I cannot really understand, I can ask my teammates to help to explain,” said a male participant from the hybrid group (research ID 2018). One students comment best sums up this point.

> *“I learn to take responsibility on whatever I have been assign from the group. I also have to learn how to accept other people opinion even-though I don't agree*

Copyright by Mahidol University

with them sometime, but if their support seem to be strong then it is okay to follow."

(research ID 3007)

For students that said they did not learn as much through mCpath, they appeared to appear to learn less and work less as a team. A female student explained her reasons in detail. "After finishing with mCpath, we haven't talked much anymore. Maybe because each of us have friends in the class, so we mostly sit with our own friends instead (research ID 3038)." One clear subcode was that some students flatly said they did not like working with a team. One student said this almost exactly, "I do not really like doing work as a group (research ID 2002)." One male student explained in detail how one teammate pulled down the whole grade of the group. "Which is what I hate the most in group work because when you do something good you expect the outcome to be good, but then someone spoil it," he said (research ID 3022). Another male student explain it was a matter of finding time for teams to meet up. "I feel that it is hard to contact each member when we are outside the class," he said (research ID 2037). Some of the students said their group just never bonded. "As we know, the group arranged randomly, and what I noticed is that some people did not put a 100% effort in doing group work," said a female in one of the experimental sections (research ID 3033).

Some other students simply said they either preferred working on their own. The prior student was an example of this. "This is why I prefer to work individually, because the score you get is the reflection of your effort on the work (research ID 3022)".

Therefore, the students that said they learned more through mCpath were better at learning and working in teams. Those that were more focused on individual task and did not take advantage of their team's help were more likely to say they learned less though this instructional design.

Copyright by Mahidol University

4.4.2 Self-efficacy

These students also showed growth in their self-efficacy. At the end of the term, they more confident in their computer skills, in searching on the web. These

participants understood the materials better and said they saw the connection between putting in effort and learning a subject. Under the subcode of improved self-learning, there were many skills that improved throughout the term, the top on being students' confidence in their computer skills. "I have never used internet in any class as much as I have used in this class to study, said a female from an experimental section (research ID 3012). "I don't usually use mobile to learn anything unless and until it is important, but this class has taught me to do researches through my phone too." She went on to explain that she thought she had learned plenty through the practical sessions. One of the male students in an experimental section made an interesting observation about students that are usually distracted during class because of their smartphone. "Compare to other class I think that this maybe one of the rare case where no one use mobile to play games or other media entertainments," he said (research ID 3016). A female student in experiment group said, "I use the internet to help study and homework anyway but this class made use technology even more by doing research, video learning, emailing homework's etc. (research ID 3018)." She went to explain that she now regularly uses her device to make videos and is more confident of her editing abilities. Another said she uses her phone to search for class materials more (research ID 3030). One female student focused on writing notes. "Note making was painful as I had never used Evernote. Now I don't make notes physically most of the times," she said (research ID 3017).

Curtaining under self-learning were many students' comments that their searching skills improved. "I learned many techniques of using a computer," said a male student that received the hybrid treatment. (research ID 2041). "For example, how to search in Google more precisely, and how to look for reliable sources." Other students emphasized what the learned about search operators. "What I have learnt was some advance search to specify key words," said another make student from the hybrid group (research ID 2021). Another student talked about how these search function helped speed up finding better results. "Adding advanced operators behind urls helped me to get my anticipated result quickly. Usually I would just type everything in my mind into the google search bar, getting unwanted results thus slowing down my progress," he said (research ID 2026).

Copyright by Mahidol University

Relating to self-learning, students said their English reading skills improved. “When I surf the internet for finding the information, I have to evaluate those websites by reading,” said a hybrid group participant (research ID 2075). One of those in the experimental group, explained, “I did learn a lot from the mCpath, if and only if, I actually go back and revise at my dorm later (research ID 3032). To finish out this point, one other male in the experimental report went to the heart of the matter. “mCpath depend on us. If I read more I will get more,” he said (research ID 3044).

Under self-learning, students said they had better concentration. “mCpath method makes me focus better and makes it easier for me to follow,” said a female undergraduate (research ID 3005). Another student explain that it was the in-class activities that helped. “I would have more attention on listening and it would be more interesting to listen to different people with different style of talking,” said one of the male students (research ID 2018). He added that, “As I pay more attention, I could study better.”

Those that had had better self-learning said they could remember better through this m-learning instruction. We can memorize the topic better because we are the one that find the information about that topic,” said one student (research ID 2025). Another examples comes from a male student from the experimental group. “I have learned more from mCpath method because I have to analyze each sources by myself. This help me to remember information from different questions (research ID 3037).”

Still relating to the self-learning subcode, quite a number related mCpath to learning to be more responsible, both for their own work and their team mates. “mCpath class benefits me to learn in group and be responsible for the tasks I got and for the others,’ was one example of such comment (research ID 3016). Another male from an experimental section also showed such development in his maturity. “I also learn to be responsible to the work and not thinking about myself,” he said (research ID 3052).

Copyright by Mahidol University

The subcode “synthesize many sources together” comes from the many remarks that show students have learned to combine various sources of information and types of information into one complete answer. The ability to do this is not

automatic. Being that most of these students are in their first year of university study, they are still approaching learning as finding the one right answer and memorize that one for the test. This first stage is usually marked by confusion. “At first, I admitted that I was really really confused how it is use and how it should be done,” said one student (research ID 3039). She added, “The second and third time I started to understand clearly.”

The last subcode in this category is transferability. “I use mCpath method for other subjects such as EC3 (English communications),” said one student. Another male student said the skills applied to reality. “After this class, I'll bring your knowledge that you teach me about the basic computer information to use in my daily life” he said (research ID 2055). Another male student said, “Yes, I am able to use technology learning in this class in other classes. Mostly, I use it in English Communication due to lots of information to seek out (research ID 2064).” Another female in the experimental section said it helped out with classes she took in her major. “Knowing how to really use Google search engine has helped me a lot in my strategic management assignment. It made the whole researching experience a lot faster and less tiresome (research ID 3011).”

The students that said they learned less from mCpath appeared to have no improvement in their self-efficacy. They become stuck with the skills they demonstrated in mCpath round one and did not developed any further. Instead of becoming more confident in their own ability, these students tended to doubt their ability to answer questions correctly, to find accurate or credible sources. There were confused when they found different answers from different websites or when other teams had different answers than their own. They had difficulty understanding some of the questions and said they remembered materials from lectures better than from the m-learning method.

Copyright by Mahidol University

> *"How am I supposed to know whether the answer that I found is the right one or not? Because in the internet there tones of different answer but that doesn't mean that all of them are right."*
>
> (research ID 3027)

A female student said, "In my role as a reporter, and researchers that each groups have different answers and I was so confused who is correct (research ID 3053)." She went on to add, "And a lot of questions have various answers, and I do not know the exact one." Another complained that "on the internet and I hardly know which one is reliable. On the other hand, class lectures gave me precise answer from the teacher so I can answer what he likes on the test (research ID 3064)." This was the comments from a gentleman in the experiment group that had already gone through four rounds of mCpath treatment. The confusion was due to undergraduates being unsure if their answers were correct, not being sure about what websites were credible or not, and because they saw that different websites had different information. They were also confused when they saw that different mCpath teams also had different answers to the same questions.

Another subcode under those that said they learned less with mCpath was "difficult." This included difficulty in remembering or understanding, the first two steps in the Bloom Taxonomy. "Because of sharing work with friend, sometimes I cannot remember friend's part (research ID 3050)." Part of this was because there was no effort made read this. Another example was a comment from a female in another experimental section. In the in math we have to do find answers and do all work alone, so it's a bit difficult to understand all terms (research ID 3065)." Again, this person went through four rounds of treatment and is looking up answers on the internet. She is still not aware that she can still use a Google search to look up the technical terms she currently does not understand. Part of her comment was that during lectures the teacher would give the meaning. The comment that she is doing this "work alone" is also telling. Although she is part of a team, she feels uncomfortable asking her teammates.

Copyright by Mahidol University

Difficulty in searching also belongs under this subcode. As one student said, “I think that I learned from the regular lecture than the mCpath method because some time it was very difficult to find some reliable sources (research ID 3082).” One female put it succinctly, “I prefer reading it from my notebook rather than wandering around for the right answer (research ID 3068).” Another explained it as “when I do math, it was really painful for me because the answers were very hard to find (research ID 3023).”

In conclusion, those that learned more through mCpath showed development in their self-efficacy. They were aware of skills that improved, that they were more capable of synthesizing information together from many sources and that the skills they developed would be useful to them in other classes and in their careers. Those that said they did not learn as much from mCpath appeared to have minor to no self-efficacy development. This was reflected in their emphasis on how the method confused them and that they found it difficult. Some of these participants clearly said they did not like self-learning.

4.4.3 Learning process (mCpath vs. lecture)

Finally, those that said the mCpath process worked better for them appreciate the mCpath process. The three subcodes were interesting, learning from roles and remembering, understanding better.

Again, students said the mCpath was enjoyable. “In my opinion, mCpath is one of the best ways to learn by yourself. It is more fun than a regular class lecture, really,” said one of the students (research ID 3033). Some of this interest comes from the high interactivity, within the group, outside of the group and with the lecture, as was quoted in Section 4.4 (research ID 3019). One element that keeps up the interest is that again seen as easier than listening to a long lecture. A male student said, “I can understand things more easily too as I can look for more explanation. If I cannot really understand, I can ask my teammates to help to explain (research ID 2018).” A female student said, “It is very easy for us to get more information from member of my group, and we are ready for final exam (research ID 2010).” Part of the interest came from the novelty of the learning process. A male student summed up many of these elements nicely. “In the past, I just use computer to go to internet and Microsoft Word,

Copyright by Mahidol University

but now I found out that there are many tools in these programs that make it easy and fun to play with (research ID 2002).” He added, “It makes me finish my work easily. I also enjoy working with computer more and more.” Another female’s undergraduate said, “Students were allowed to use their phones and worked together doing. Through this class, I get to learn new things and how it works (research ID 3012).” Finally, the method is interesting because there were no information limits. Students were free to explore any topic that interested them. A student in the hybrid class noted this. “It helps us to learn more than just in class because in the class sometime student might focus something that not related to the lecture,” he said (research ID 2011teammates to help to explain as we have to do the work in group,” he said (research ID 2018). Another student highlighted the creative side of this. “mCpath has no limitation which sometimes allows students to think outside the box,” he said (research ID 3037).

They learned more through changing roles. The information they found was not limited to only class lecture material. The content was new, making it more interesting to learn. In general, they thought learning through mCpath was easier, and they were able to focus better. “Because we have to rotate the role and we can learn in the different ways each time,” said one participant (research ID 2033). They thought various answers from members helped create better learning content. “I had learnt a lot from mCpath more that another lecture because mCpath assigned me to do a different task in different week and required interaction between group members,” said a female participant from the hybrid treatment (research ID 2005). This student also said that the Reporter had more work to do than the others. This comment from the first term is why the author decided to change mCpath to have two Reporters instead of one. The students said they learned from participating in the mCpath roles because they rotated every time. To look at the flipside, those that thought they did not learn as much because only the Reporter or the Presenter would master the information. “Only the presenter would learn more about it since they would be the only one that would be questioned,” said a female student in the experimental section (research ID 3066). For her comments about the Reporter, she said the person would copy/paste as quickly as possible to finish the task. “Near the exam, I have to rush to cover up everything learned in a short period of time,” she added. Another female student in the hybrid section had a similar take. “Reporter have to work hard, and there are lots of questions

Copyright by Mahidol University

to do, so that the answers will not be that good because they just want to finish it on time," she said (research ID 2048). Several students had issues understanding other student presentations. "I would really wish you could explain us as many students don't explain in the right way," said one such student, a female in the hybrid treatment (research ID 2052).

The other major subcode was what one female in the experimental section best said, "For mCpath, I think it too much (research ID 3020)." This was especially so for the experimental treatment because they went through the process four weeks in a row. These complained about too much information to read for the test. "I was extremely tensed during midterms because the reading was way too much, so I did not have a chance to go through other peoples," said one of these that was in one of the experimental sections (research ID 3030). Another student said there was too much information on the internet, overwhelming them. "I think class lecture is much better than mCpath because there are hundreds of different answer on the internet," said this male student (research ID 3064). Also going back to what was said above by student 2048, these students felt overwhelmed with the number of questions asked. These comments are the reason the author implemented the hybrid version, not the experimental one, into the next phase of development for this class.

Finally, students said they preferred the lecture format because they enjoy listening to a lecture. "I love your lecture class," said one such student in the experiment section (research ID 3051). "Even though I did not take note much in class, I listen and try to understand the contents," she added. Several undergraduates said that the lectures in this class were already interactive. As a female student put it, "I can understand better and have more attention on the subject. I love to learn with a funny teacher as you and I received many knowledge after it. (research ID 3059)." The journal also helped uncover an interesting cluster of students, those that like to take notes from lectures. What stands out in the author's mind with the newer type of students is how many do not bring paper and pencil to class. This one male student sums up what this author thinks he sees as well. "I saw many people just listen to the lecture but did not write anything (research ID 3044)." Going back to those few note takes, this female student explains it as, "I could be able to listen to the lecture and write notes in my own styles (research ID 3042)." She added, "When comparing to

Copyright by Mahidol University

mCpath, I needed to rush to find answers." These students that prefer to learn through note taking are mainly female. "In the regular class we also had to take notes, and I believe that while taking down notes it helps me to memorize to a certain extent," said another female participant in the experimental treatment. Just one more comment from another student, "I get to know and note all the lecture by myself which make it more easy for me to read my own note that reading other notes (research ID 3074)."

To summarize, those participants that said they learned better from this m-learning method, they thought the method was interesting and they appreciated that by participating in the different roles, they learned a different skill. Those undergraduates that said they did not learn as much from mCpath did not appreciate the different skills sets learned through participating in the different roles, and in general, they thought the mCpath method required too much effort. There were some that emphasized that they prefer lectures because they enjoy listening and learning in this way. Some also said they learn better when they take their own notes.

Copyright by Mahidol University

CHAPTER IV
DISCUSSION

5.1 Mobile Media Learning Survey discussion

How will the use of online searches through mobile devices in the classroom change the usage of media by undergraduates? The answer is that mCpath instructional method will not change media usage by a significant amount.

Although the experimental treatment and hybrid treatment group had more experience with using their mobile devices during and after classes, the Kreskas-Wallis H showed no significant difference between treatment groups, (H=5.044, *df*=2, *p*=.08). When looking at the categories education media, web media, smartphone media, application media, and social network media, there was still no significant difference between treatment. Next question to answer is why is there no difference? Likely this is because mCpath was designed based on the media students use the most, Google search. The pretest mean of this media was already 1.25, almost a perfect 1 for "very often." The posttest score moved slightly down to 1.28. This could be because of randomized selection error, or it could also hint that students learned to use other mobile media for learning. The small variation did not affect the ranking. Google search scored number 1 spot for the pilot test, pretest, and posttest. Although the ranking order changed somewhat between the pretest and posttest, all the same media were on the top ten list.

Copyright by Mahidol University

Table 5.1 Ranking of Mobile Media Learning for pilot, pretest and posttest

Media	Rank Pilot Test	Rank PreTest	Rank PostTest[1]
GoogleSearch	1	1	1
VideoSharing	5	3	2
Facebook	2	2	3
OnlineDictionary	4	7	4
emailNOTUni	7	8	5
MusicPlayer	3	4	6
PhotoCamera	6	6	7
MobileApps	11	5	8
DictionarySoftware	8	9	9
Wi-fiCampus	10	10	10
PresentationSoftware	22	19	11
Calendar	9	11	12
Wikipedia	14	12	13
VideoCamera	13	14	14
PDFReader	20	18	15
OnlineSlides	18	22	16
WebUniversity	16	16	17
VideoCalls	15	13	18
LearningApps	24	21	19
InstantMessaging	12	15	20
OnlineNotes	25	24	21
OnlineMap	21	17	22
VideoGames	17	20	23
WordProcessing	29	26	24
AudioRecorder	23	25	25
PortalStudents	28	28	26
Organizer	19	27	27
GPS	26	23	28

Copyright by Mahidol University

Table 5.1 Ranking of Mobile Media Learning for pilot, pretest and posttest (cont.)

Media	Rank Pilot Test	Rank PreTest	Rank PostTest[1]
FileSyncing	34	34	29
GoogleBooks	30	33	30
OnlineLibraryServices	33	29	31
GooglePlus	27	30	32
eBook	32	32	33
BibliographicSoftwareWordProcessing	45	35	34
OtherSocialNetwork	31	31	35
RecordedLectures	44	40	36
elearningPlatform	35	37	37
eJournals	42	44	38
OnlineSelfTests	40	36	39
SocialBookmarking	37	43	40
emailUniversity	38	38	41
GameBaseLearning	36	39	42
AugmentedReality	39	42	43
Twitter	41	41	44
VirtualClassRealtime	43	47	45
OnlineOtherLibrary	46	46	46
OnlineExams	48	45	47
VirtualClassNonRealtime	47	48	48

[1] *Sorted by posttest ranking*

As part of the mCpath process, the Research was assigned certain search databases or services. That person needed to use the assigned search tool to find answers to path questions and then needed to write an analysis on the difference between suing the assigned website and Google search. Usually, on the first mCpath round, the Researchers were assigned to use YouTube. In the last mCpath cycle, the Research was assigned to use Google Scholar. In between these, the assigned database

Copyright by Mahidol University

could include Facebook, Bing, Reddit, Google Books and university library e-journals. YouTube and Facebook are also two of the media that make the top 10, so they already had a high score. There was not much room for more improvement.

Although the control group did not use their own mobile devices for learning during the class, they did have equal access to desktop computers during the computer lab sessions on Fridays throughout the whole 12-week term. This access plus the lesson about how computers work stimulated the same increase of awareness, increasing the usage of mobile media of all participants.

When looking at categories within the Mobile Medial Learning, social network media is the one area where there was no significant difference between the pretest and posttest results. It is likely that the participants were already heavy social media users, so there was not room for a major change in usage.

The Wilson Signed-rank test results did show a significant difference in their use of 48 different media from the control group. With a mean of 2.9 (SD=.226, n=200), the posttest results of the Mobile Media showed a more frequent use of all 48 mobile media than did the pretest mean of 3.1 (SD=.497, n=200). An introductory computer class did make students more aware of the different type of digital services

The one disheartening trend for librarians and lecturer at this institute was that e-journals stayed consistently at the bottom, ranked 44th in the pretest and 42nd in the pilot. Out of curiosity, the author looked at just first and second-year students in the pretest results, and the ranking of journals move down to 47th place, second to the bottom. With Google Search ranking first, it certainly means that the majority of freshman and sophomores start off their academic career thinking they can do a quick one-word search, grab the first website from the first-page search results and done. This is a habit of use that is difficult to break. The results of the

When looking at third-year students plus, there was good news. The sample size of 25 was quite small, but the use of e-journals moved up to the middle of the pack, to a heartening 35th place in the pretest. Older students may not like journals but they do learn to use them.

Copyright by Mahidol University

The other notable thing was that despite the institute promoting the use of Moodle to all lecturers, online exams, and all types of online classroom and learning platforms ranked near the bottom. The pilot student listed them in 35th place but

dropped to 39th in the pretest experimental results. The acceptance of these technologies appears to be quite low and is like the results from the original version of the media survey in Germany and in Thailand. There is not enough information in this survey to tell if the issue is with teachers' acceptance or with students' acceptance, but the guess of this author is that it likely the dynamics of both.

This pretest survey also gives the author another way to check to see if there is a difference between the treatment groups. In this case, the question it can answer is if there is a significant difference in how each group uses mobile media?

5.2 Computer concept pretest discussion

An element that highlighted the digital illiteracy of undergraduates was the pretest computer concept results. Expectations would be that student would score low, except that almost every one of these participants had been required to take a computer class during high school. A certain number of these students should have been able to answer some of the basics questions like what is a gigabyte, what is a pixel, what is computer hardware. The prior presumption of the lecturer before giving the assessment was that the grade would be somewhere between 20 percent to 30 percent. Of the 266 participants that took this pretest, the mean score was a surprising 6.2 percent (SD=9.78). Only seven students scored higher that 30 percent, and only two of those were in the high 60s.

Why were the students' pretest score so low despite almost 100 percent of them taking a class in high school that covered the same materials? To help answer this question, the author asked this as part of a learning journal assignment in one of the post-experimental terms.

One factor given was the cram and forget method of learning. The best comment about this was, "As you know, Thai's education, whether in high school or university, teaches students just to pass the exam, and after the exam, students would forget almost all of the lessons (research ID 5358)." During the weekly classes, students would not focus on the content. Because most of these were hands-on practice skills on how to use an application, the students were in from of a computer connected to the internet, so were easily lured to the gaming side. Several of the students said that

Copyright by Mahidol University

the computer teacher was typically new, so had difficulties controlling a class. They would have had hopeless time keep the students away from Facebook and on the lesson. As one female student puts it, “Students usually do not have to pay attention until the teacher review (research ID 5369).”

Another major reason given was that high school give low priority to computer classes. The focus was on English, math, and science because these subjects are a part of the entry exam. In some high schools, the class is an elective and not required for all students. In other schools, students need to take the class, but because there are no questions from it on the entry exam, so the class was only taught one hour a week, given just 1 credit. Even with the subject only receiving 50 minutes, several students said that they would focus on a lesson for only 30 minutes and then be allowed to play video games or access social media sites. The implication was that students could see that the teachers were not taking the subject seriously, so they did not either. Going back to instruction, some of the students said that new teachers taught computer subject. One student said she had a different new teacher every term, so she could see that the administrators at the high school did not think the topic was important. Some teachers also did not have computer expertise, and the students could also clearly see that. In teaching a complex package like Photoshop, teachers would have the whole class follow a prepared example step by step. It was likely that some of these teachers would have had difficulties explaining if they veered outside of the course material. Most respondents said the computer class was used for relaxation and entertainment. It is a subject that would be taught just before a holiday or on extra weekend classes. The software and operating system were often outdated, emphasizing to the students that the topic was of low priority.

Connecting into the students’ perception that the high school did not take computer classes seriously, was the students’ own perception that what they were learning was not useful to them. There was a group of students that said they learned more advance packages like C++ programming, Photoshop, and Dreamweaver. The issue for these students was that this utility has a specific, narrow purpose that would not be used practically in everyday life. “It is too specialized and advance like Visual Basic,” said one participant (Research ID 5367).

Copyright by Mahidol University

The method used to teach how to use these packages probably also had an impact on their attitude. Again, with these more sophisticated packages, students followed the teacher's demonstration step by step in a prepared example. These students could follow the instruction, but they never learned to the functions of something like layer modes in Photoshop and how it worked, so they had difficulties taking what they learned and applied it to create something new. From many students' comments, it was evident that instead of being encouraged to play and explore within a program, that the students were playing internet games.

In contrast, many of the students said they were taught the classic office packaged, Word, PowerPoint, and Excel. The issue with these students was that they only received a superficial lesson on how to use these packages. Most explained it as "learning the basics" but then in the introductory university computer class they were taking, it was plain to the lecturer that they had problems explaining or finding formatting features like subscript, strikethrough, text alignment, and spacing. When answering how to double space in PowerPoint, a majority of the midterm lab answer press enter twice. Several remarked that they would receive the same lesson several times in different school years. They also said the student had problems explaining or teaching about the functions. The author suspects that again, teachers were following a lesson plan example step by step but uncomfortable allowing students to explore and experiment with these features on their own because the teacher may not be able to answer the question.

The other part of students finding the computer class not relevant to life was that usually the software version was would be older. One student said her school was still using Windows XP. Even though there is not that much difference in different version of Microsoft Office, it is likely that when students saw that the version they are using on their home computer was much newer than the ones at school, the perception would be what they were being taught was out of date, so not useful.

The assessment method also did not encourage students to learn. A sizable group said that there was no formal exam in their computer class. Instead of an exam, they had a group project. They would have to produce a poster using Photoshop or make an animated sequence using Adobe Flash. Some of these said that they did not

Copyright by Mahidol University

retain much because they never had to study for an exam, so they never paid much attention in class. Others that did take an exam said that the focus was on memorizing the answers, not understanding the materials. Quite often there was a mismatch between the way the computer subject was taught and the way students were tested. Most said the focus in their high school computer class was hands-on familiarity with using specific software packages. Instead of having a computer lab test, they had a paper and pencil test on functions in the software. Although it was not written into the journals, the author understands the tediousness of having to memorize the menus and steps on accomplishing a simple task in Word like how to change the text to bold, how to align text to the right, or how to insert a page break. It would make the topic much more challenging than needed for showing understanding of simple tasks.

The other issue with assessment was that most students understood that there was an unwritten rule that no one would fail the computer exam. One student said the whole class would receive a review outline, which was the exam questions and answers. Other said that the proctoring of the exams was not strict, so many cheated, looking at answers from their friends. Out of 69 responses, only one student said that she had to study hard before the exam because she knew the test would be difficult. Finally, for the students that failed the exam, they said they knew that they would be given extra work or be retested, so they never worried about passing the exam. Because they knew this, they did not pay attention during class, so they do not remember much about what they were taught in high school about using a computer.

When looking at gender, the females scored significantly lower than the males (t=3, p=.003). Their mean average was 4.53 (SD=6.9, N=146), the median a zero. The male mean was 8.13 (SD=12.1, N=120), and the median was 5.

This would tend to indicate that undergraduate females in this study have less knowledge about computer concepts than males before taking this university class.

This would be in line with expectations. From one of the initial studies in 1986 to a recent case study in 2015, the bulk of research in this area tends to indicate that males students tend to use computers more than females students (Berdousis & Kordaki, 2015, February; Lockheed, 1985). A recent large-scale study using data from 43 economies showed that 15-year-old males use computers more than females for

Copyright by Mahidol University

entertainment (Cheema, 2015). Although Hyde has taken the novel approach of emphasizing similarities between the sexes instead of differences, saying we overemphasize small distinctions too much (Hyde, 2005; Hyde & Linn, 2006). Although she did measure that males use computers more than female students, Kay (1989) did say there were no significant differences in emotional attitude toward computers and programming skills for student teachers, both scoring quite low. One Chinese study a couple of years ago was one of the few that showed no difference in score between females and males in a computer-assisted learning program for students in rural public schools (Yang et al., 2013).

It has been recognized worldwide that males tend to do better in math and that this gap starts during high school (Hyde, 2014). This phenomenon is often used to explain why more males prefer engineering, math, computer science and physics, the math-focused subset of STEM. The basic computer concepts covered in an introductory class have a minimal amount of math involved. It is more likely that females attitude about learning computer concepts has more effect than math or spatial skills. An early 2000 paper reported that more first-year undergraduate female student did not feel as comfortable or as competent with computers as males (Schumacher & Morahan-Martin, 2001). A more current paper showed that male students still have higher confidence in their ability to use computers than do females (Sainz & Eccles, 2012). Herbert and Stipek (2005) point out that math competence starts out the same in early elementary school but then about 10th-grade girls were less confident in their math skills. These researchers indicated that teachers' and parents' perceptions might be a factor. Anderson et al. (2008) provocative title to their article may best explain it, "Because it is boring, irrelevant and I don't like computers." The actual topic of this research is to better understand the low number of females going into computer careers, but it certainly may have a seed that is useful in explaining the pretest results in this project because it focuses on that 11th grade and 12th-grade high school females in Australia. Because it started and ended as more of a qualitative project, the researchers were in a better position to dig into the why of the situation. Of the questionnaire that was developed through a pilot process, 5,863 was mailed out to 31 schools through the process, and 1,322 11th and 12th-grade female that did not take an ICT subject responded. Hands-down these non-ICT takers said the subject was boring

Copyright by Mahidol University

and not that helpful to their career path. This contrasted with the 131 responses from female high school students that did select an ICT subject at their school, which thought computers were interesting and thought the class would be useful for their future career. Most of the non-ICT class taking students said worries about math or what friends, teacher, career counselor, or family members thought was not a major issue.

5.3 Computer concept midterm and final discussion

To what extent will using online searches through mobile devices in the classroom change the level of knowledge and understanding of undergraduate students about computer concepts?

The statistics show that there was no significant difference between the control group and the mCpath treatment groups when looking at the posttest midterm results for both the A version used in experimental term 1 and B version used experimental term 2. The Kruskal-Wallis H test showed a p of .207 for version A (H=1.329, *df*=2, *N*=196) and a p of .406 (H=1.801, *df*=2, *N*=104), neither one coming close to the .05 significance point. Because this test version had 38 items, it is likely that this version had the highest test reliability. In both test version, the mean average of the score of the control group was higher that both the hybrid experimental treatment and experimental treatment but slightly more than two points. Variability in sampling group could explain this.

The answer to the research question is that there is no significant difference between treatment group and the control group with how well participants learn computer concepts.

Why was the experimental group's mean score on the midterm not higher than the control group's? The author built the mCpath instruction around the characteristics of the undergraduate students: what mobile device they use and what digital media did they use the most. From the survey results, the author designed the instructional process around using smartphones and Google searching, the top hardware platform and the top-used service. Although the definition of mobile computing devices was broad enough to include iPads and laptops, there was also a

Copyright by Mahidol University

good core of students using smartphones in class. The author's first assumption was that because students working together would be using tools they were familiar and comfortable with, they would be more motivated to learn to use these devices and services rather than learning from an individual lecture. More motivation to learn should equate to higher grades for the treatment group. Since the results show otherwise, something else is going on. What is evident is that although participants say they use Google search the most for learning, the mCpath Reporter Reports show that most do not use the service in an intensive way.

One observation was that cognitive load of finding relevant information that covered the same material as did a lecture was likely more intense than receiving the information from class instruction. In the control group, students would listen to the teacher's one presentation on a topic and take notes from the PowerPoint presentation. The students would completely accept anything the lecturer said with minimal to no critical analysis. They knew the teacher would be developing midterm questions based on what was said, so they knew what was in the PowerPoint would be on the exam.

During the mCpath treatment, the students were unsure if they had found the correct information, so they were unsure if it was correct or not. In some of the first mCpath cycles, most of the participants equated easy to understand to authoritative. They were drawn to tertiary-type sources.

During an mCpath session, some students treated a web search the same as learning from a lecturer. They would do a quick one-term search, go directly to one of the first-page search results and then take it as the ultimate truth. In many of the first Researcher Reports, students would say they give such a source a 5 out of a 5 because the web page looks authoritative. It was accurate and true information because it looked to be accurate and true. By mCpath cycle 4, some students could justify their answers by being able to look more closely into the background of the author, by better explain the source as being primary, secondary, or tertiary, and by giving specific examples of technology being explained within a document. The better students would realize that they could not rely on just one page so they would search for a range of pages. They would take parts from each source, and this would become their study material for the midterm. Recent research into computer science students'

Copyright by Mahidol University

search for help tends to point in the same direction. The research included 203 participants of which 80 percent were beginners. In their 2016 discussion, Hao et al. noted that has questions become more difficult, students prefer to ask peers rather than search online for help, suggesting that searching provides a more challenging cognitive task.

Even in the experimental group that had the most exposure to this learning method, there was always a segment that wanted to avoid having to put effort into selecting better sources of information. A comment the third learning journal of a participant in the experimental group in term 2 sums this up:

> *"I think that I learned from the regular lecture than the mCpath method because sometimes it was very difficult to find some reliable sources. Moreover, when I had to find some source for a long time, I started to (be) lazy and did not want to read the text anymore. Therefore, I think that regular class might be better for me."*
>
> (research ID 3001)

This extra cognitive load caused self-instruction in finding, evaluating and learning would explain the midterm results, where the control group scores a bit higher, the experimental groups score a bit lower, and the hybrid group falls in the middle.

Another potential explanation of why the midterm grades of the experimental participants were not higher is that the equal focus on other roles other than the Reporter watered down the effect of the process. The Reporters were the team members responsible for answering all the mCpath questions. The focus on the rest of the group was on mastering some of the answers, evaluating the quality of the answer, finding few of the answers using different media, but only the Reports had the first-hand experience in looking up and answering all the questions in a category. Although teams were supposed to share answers, it is likely that the Reporters of each group had the best expertise for the ones that they answered.

Copyright by Mahidol University

Next, we look at the computer concept final to see if there was a different effect on treatment groups. Because three versions of the computer concept final were used and because the data did not pass the test for normality, it was not possible to use ANCOVA to control the effect the different versions had. Instead, the Kruskal-Wallis H test was used to analyze each term's results. For experimental term 1 and term 2, there was no significant difference between the control group and the hybrid and experimental group. As with the midterm, with the final mean grade of the control group was the highest, the hybrid group scored in the middle, and the experimental group scored the lowest.

What did stand out for the computer concept final in term 3 was that using Kruskal-Wallis H there was a significant difference between the control group mean of 81 and the experimental group mean of 70.1 (H=8.095, *df*=2, *p*=.019). The other strange thing about the results from term was that the mean average for all section was 79, much higher than the mean of 64.4 for term 1 and mean of 65.1 for term 2.

The issue was that due to in-country protests, the final was delayed for one month. Normally, undergraduates at Thai universities have limited amount of time to study for the finals because they will have several papers or presentations due the last week of class, most will put off studying till the week before exams. Some of the better-organized students will have been putting in time studying and reading each week so that they are well prepared for the exam. The majority rely heavily on cramming for the test last week, last day, last hour. The one-month delay was a strange abnormality in that students at this university had an extra month to study with very few other distractions. Normally, the students would have traveled, went shopping and seen movies. Because of the demonstrations, most of these were forced to stay at home and study. Several of the participants during the test said they were quite pleased to take the final because they were so bored being at home.

Because of the extra month of study time allowed for the final computer concept test in term 3 that was not in term 1 or term 2, it makes the results not comparable. Therefore, the author's conclusion was that there was no significant difference between the treatment groups in their final test scores on material there were tested on during the midterm.

Copyright by Mahidol University

The significance difference in having the control group score much higher one the final computer concept test in the third term than did the experimental group does give a glimpse into how students are studying.

Participants in the mCpath treatment were randomly assigned to teams. Those in the control group were never assigned to work in a group.

Referring to the learning journal comments from those participants in the experimental group, there are some groups that were cohesive and worked and studied together. However, there were other groups that were worked together when they had to, but then for studying, they tended to do so individually or study with friends, not with members of their team. One of the often mention issue was time conflicts where others in the group were available to study. Some groups worked around this by using Google Documents and other communication networks. There were certainly some students that were more comfortable studying person to person.

For the control group, although there is not document evidence like there was for the mCpath groups through the learning journals, the author would make the connector that these students tended to study with friends. Because most of the study information came from the lecture, these students tended to focus on this information. All participants in all groups had access to the PowerPoint presentations, to videos of the lectures and a handout of each topic, but the control group likely focused more on the PowerPoint presentations and the notes taken from the lecture.

As for the treatment groups, they had information from a variety of sources. Although the lecturer gave detailed feedback on the quality of the sources, the learning journal showed that some students were unsure if their information. One of the participants in the experimental group made the comment that with a lecture, she would review her notes immediately after class. If she had a question, she would ask the lecturer directly. However with the mCpath process, she saw there were varies answers to a question, and she was unsure which one was correct. This sort of insight by the student into how the new knowledge creative process works is what most educators dream of achieving. It is what most of us as teachers do not understand for at least the first couple of years, that there is a process of picking and choosing sources, and that we are unsure of the truthfulness as well.

Copyright by Mahidol University

At the same time, with test questions that intentionally reach only the two lowest rungs of Bloom's domain, remembering and understanding, the format of the exam may favor the control, notably as all students will have seen the same questions during the midterm, so know they what parts they need the focus. A much fairer selection process would be to give a different exam from the one used for the midterm, but then this would affect the ability to compare the results between the two.

Although this was not one of the original research questions, one of the byproducts of the research is the data that answers the question if an introductory computer class at the undergraduate level can improve students' overall knowledge of computer concepts? The answer is clearly yes.

5.4 Information literacy and mCpath

The most important result from the DSL instrument was that for ILCSHE 3, the experimental treatment group scored significantly higher than did the control group. ILCSHE 3 of the US literacy standard for universities relates to a person being able to critically evaluate sources. This includes if a person can evaluate the credibility of a source and recognize potential biases in wording and domain names. ANCOVA showed a significant different between treatment groups ($F=3.695$, $p=.027$, $df=2, 176$). Pairwise comparison showed that experimental group has a significantly larger score for ILCSHE 3 portion for both the control group ($p=.013$) and for the hybrid group ($p=.039$).

The results are logical. The experimental group received 4 mCpath treatments, so each week for the first month, the students worked in teams with the Reporters finding sources that best match the questions and an Auditor spending more time on looking carefully at the sources of information and having to evaluate the credibility and bias of the information, the website, and the author. Each week, students would rotate through the four roles. In term 2 and 3, a second Reporter was added, so it was likely that most members would have a chance to work as an Auditor once and possibly a Reporter twice.

Copyright by Mahidol University

Why were the hybrid group's ILCSHE 3 score also not significantly higher? Again, there were four roles that students rotate through. With two treatments,

there was less likely to have every member have a chance to work as Auditor. With two Reporters, one Auditor, one Presenter and one Researcher, it was likely that most participants, 66 percent will have had a chance to work as the Reporter once. Because there was only one Auditor role, only 44 percent of the participants will have been an Auditor. The Auditor's task is to evaluate the quality of the website used. They do this through evaluating the accuracy and amount of technical detail, objectivity of the source, and the timeliness of the information. This means the tasks in this role relate directly to the ILCSHE 3. The Reporter's tasks indirectly related. This person's job is to find answers and include the web address of these sources. The grade for the Reporter Reports relates partially to the quality of the data, but quality of sources is also a part of the assessment. Thus, for the hybrid group, the score for ILCSHE 3 should be higher than for the control group because they had practice in evaluating information. The score for the hybrid group should be lower than it would be for the experimental group because not everyone on the group will have had as much chance to be an Auditor and a Reporter.

For ILCSHE 1, ILCSHE 2, and ILCSHE 5 standards, the experimental group also scored high but not significantly higher. What became evident throughout this research project was the shortcomings to using a multiple-choice format for measuring information literacy. The improvement in the mCpath Reporter Reports and the Auditor reports throughout the term showed the participants had better search skills, could find more information and at better quality sites. They also became better at using search terms and search filter to better target more relevant sites. That the DLS did not measure a significant difference in ILCSHE 1 and ILCSHE 2 is likely because the questions measured only general knowledge in these two areas, not the essential critical searching skills in finding information for a question. Just as with teaching someone chess, someone that would score an A on knowledge about how to play does not mean that this person also has effective skills to perform well. At the same time, someone that maybe does not score a perfect score on knowing chess rules can win because of superior skills. The author is seeing this reflected in the mCpath Reporter Reports.

Copyright by Mahidol University

Although the DSL score may be similar, the experimental group shows improvement in finding more specific information, they understand that a variety of

many sources is better than using only one or two, and some start to use more than one-word search terms, along with using filters to block out some of the more commercial sites. The Auditor Reports also show more sophisticated ability to analyze websites after several mCpath sessions. At first, the Auditors says the information appears to be more accurate and non-biased because it looks accurate and non-biases. Many emphasize the ease of being able to understand the material. In the experimental group, by the time they get to the fourth cycle, the Auditors will be justifying their answers based on technical details in the text, better understanding the issue of bias by trying to understand the writers' perspective and the background and purpose of a particulate websites. They will also start to see the differences between primary, secondary and tertiary sources.

Finally, the DSL results did show clearly that all participants scored significantly higher in the posttest than they did in the pretest. This means than an introductory computer class did improve students' knowledge of information literacy overall. Again, the shortcoming of the DSL was that it measured knowledge, not actual skill in searching.

5.5 Undergraduates' attitude toward learning with mCpath

What will be undergraduates' attitude in using mCpath instruction in cooperative teams in the classroom?

Referring back to Liveris's learning dimensions (2007), it has a continuum between content and incentive to learn, and between individual learning and social learning from the environment. The author used the model for predicting that has there was more incentive to learn, there would be more acceptance of this learning method.

For those students that thought they learned more through mCpath, one of major motivations was group interaction. Having other rely on them, having them share information. The pure pleasure of socializing in class was part of this process. They discussed answer with teammates, asked to double check answers, reminded each other of deadlines, and studied together. "We were all given our own responsibility in our own groups and since my group members were all very corporative working together. Was not only educational, it was also fun," said a

Copyright by Mahidol University

female (research ID 2051) from the hybrid treatment group in the first experimental term. She continued to explain that she had to work quickly during class so that she wouldn't let her teammates down. For the neophytes to computers, they were comfortable asking a classmate for an explanation, questions they would never have asked the lecturer because they seemed too basic to ask. The level of scaffolding is unknown, but the learning journal gives evidence of a step ladder in the corner. "Sometimes, we still learn from our friends from the other groups when they present their information and compare their information to our group," said a female from the second experimental term (research ID 2024).

The other factor was the improvement of self-efficacy. This included students' ability to learn on their own. Several of the student's remarks showed they understood that with more effort put into reading and finding information, they were learning more. "I have to read more carefully before we decide to answer in each question," said a female undergraduate in the experimental group (research ID 2022). A feeling of being more responsible was another part of increased self-efficacy. Again, part of this was due to feeling more pressure to help out the team. Some was due to the task required of the mCpath roles.

Still under self-efficacy, participants understood that by using the mobile devices, they were becoming more proficient at using a computer and also better understanding computer concepts. Eleven participants said that this instructional design helped them remember better. "It involves me searching for answers, so it would help me to remember the answers," said one student (research ID 2034). Those that said they learned more from the mCpath method also understood improved searching skills helped them. "I use mCpath method for other subjects, such as EC3," said a male participant in the experimental section in the last term (research ID 3058). He went on to explain how he uses a variety of sources and media for his papers.

The term "responsibility" was often used when talking about individual self-efficacy, as well for group learning. Several students said they didn't want to let their group down. A female in the experimental treat group said, "We can learn responsibility for each role and complete each task without depending on other group members" (research ID 3033).

Copyright by Mahidol University

As to learning through the mCpath process, those that said they learned more through this design had better the focus on the material, contrasting this with losing concentration on a long lecture or reading a long chapter in a book. Some termed this “easier to follow the material (research ID 3005).” Several students realized that their reading skills in English improve because they need to scan websites for information. Some said the novelty of finding and using the most current information made learning more interesting. One student contrasted this with regular instruction. “I do not really pay attention to the lecture as I am mainly focusing on keeping up with the notes (research ID 3005).” The students said they were more actively involved in their own learning.

There were 12 responses that recognized the key important of roles to the mCpath process. “Because we have to rotate the roles, we can learn in a different way each time,” said a female from the hybrid group (research ID 2033). Most had similar responses that they learned more through working on the tasks in a particular role. Several recognized that the key roles that drove the learning process were the Reporters and Presenter. Although one student said, “The researcher gets to research for many different topics, and it is typical that the Research will be able to understand the information better (research ID 3005).” She went on to recommend that there should be more than one Researcher per group.

Another factor under the mCpath process was that what information that was found was not confined. “mCpath had no limits which allowed students to think outside the box,” said one male student in the experimental treatment group (research ID 3037). The last one was the awareness that the feedback from the teacher on presentations and reports on each mCpath cycle also helped their learning process.

When analyzing the comments from those that thought they learned less from the mCpath method, the three major themes of team learning, self-efficacy, and learning through process provide a practical contrast.

First, for these respondents, it appears to be an absence of team learning. “I do not really like doing work as a group,” said a male student (research ID 2002).

Although these participants worked in a group, they appeared to focus only on their task. “Other team members just do their jobs, which means they might not read or pay attention in the content of the group work,” said one female participant

Copyright by Mahidol University

(research ID 2042), summing up this point of view succinctly. Others said that although they shared their reports, they didn't really take the time to read them before exams. Although some of these participants said their teams worked well together, their comments show otherwise. Their frustration with not knowing if their answers were correct or not was likely exacerbated because they were working on their own and not talking to other members. This is likely the case with those that felt overwhelmed with too many websites to search.

As to self-efficacy with those that thought they learned better from lecturer rather than mCpath, there appeared to be no development. "I kinda don't like the student self-learning method, honestly," said one female in the experimental group (research ID 3053) that had a strong "NOOOOOOOOOOOOOOOOOO" in her answer if she learned better from mCpath.

A major issue was that some students never developed the confidence that their answers to path question were correct. As one student put it, lectures were "100 percent accurate because the information source comes from the teacher (research ID 2017). These students were unsure about their own ability to find the answer. Instead of developing a moderate critical attitude and doubting the quality and credibility of a site, these types of students become fearful of finding their own answer. As one female in the experimental group put it, lectures could "be a bit more boring, but students will get accurate information and actually know what to study for (research ID 3061)."

The other issue was that some of these students did not learn there was more than one correct answer. They were confused when they found different websites with different information or when different groups had different answers.

A variation off of this was those that said the method was an ok way to learn but that the instructor should give everyone the answer. These students likely did not read the detailed responses the lecturer made for every mCpath answer. "You should send us the answers by email after every mCpath learning method to provide correct information for students whether their answers are right or wrong," said one male student (Researcher ID 2012). Several more understood that the teacher made the tests so that they wanted the teaching material from the teacher. Instead of seeing that the searching for the answer was the essential skills to be learned, they wanted to bypass the process and go directly to the materials that needed to be studied for the

Copyright by Mahidol University

exam. “When I had to find some sources for a long time, I started to get lazy and did not want to read text anymore,” said one student (research ID 3001).

Focusing on instructional process, most of the students that said they learned more from the mCpath talked only about that learning process and not about a class lecture. For those that said they learned more from a class lecture, quite a few focused mainly on the benefits of a class. Several of the students that said they didn’t dislike the new m-learning method but that they prefer to learn through listening to a lecture. A male student said that this was because “a teacher can focus on the topics or information that you want easier (research ID 2059).” Several others said that the information in a lecture was clearer and easier to understand. Some said that the lecturer in this course was already entertaining and held their interest. I think I learn the best when I write a lot and focus on what teachers say in class,” said a female in the experimental group (research ID 3039).” Several other of the students that had positive image of mCpath but said they learn more through a regular classroom said they enjoy taking notes or learned better from that process.

As to the negative side of the mCpath process, these students said that they didn’t like listening to presentations because they were boring or they weren’t sure if the information was correct. Several commented that they didn’t understand the presentations. As to being a Reporter, several made the comment that it was too much work. A student in the experimental group said that she didn’t really care what she put down on the report, just wanted to finish the report that was due (research ID 3061). A male student that was also an experimental participant said that there were too many assessments (Research ID. 3042).

Referring back to Illeris’s model, the enjoyment and support of team interaction and the confidence that comes from improved self-efficacy prove incentives to learn. They saw that the different mCpath roles helped them better different skills sets. Because of this, they put more effort into gathering high quality content. As to the continuum between individual to the whole class, the students that said they learned more appeared to work more closely together with their team.

In contrast, for those students that thought they learned less from mCpath, the mCpath process provided them less incentive to learn. They were unsure if their answers were correct, unsure of the meaning of path questions, and not clear about the

Copyright by Mahidol University

overall objective of mCpath questions. Although these students worked in teams, their focus was more on completing their own individual tasks. Because these saw less value in checking answers as a group, less value in putting effort into the mCpath roles, they only wanted to complete their reports as quickly as possible. This means the quality of the content was lower. There was less team learning and more individual struggles to master the materials and learn on their own.

To conclude, let the author include his favorite quote from one of the participants. “The problem is on the students. If they do not study, they will fail anyway (research ID 3016).”

Copyright by Mahidol University

CHAPTER IV
SUMMARY

6.1 Summary

The author invented an original way of cooperative classroom m-learning using mobile computing devices searching the internet. The instructional method is called Mobile Computing Path Learning, shortened to mCpath. This m-learning was designed to improve students' digital literacy. This includes both computer literacy and information literacy.

The method was designed based on research on undergraduates' use of mobile computing devices and the most used mobile media. Instead of receiving a lecture, the students work together during class and use their mobile computing equipment to look up answers to the path question on the internet. The information learned in this process then becomes the basis for the midterm and final assessment. During the mCpath process, the teacher's role is to assist teams during the searching process, provide detail feedback to the quality and quantity of the search result, evaluates the quality of the students' analysis on the quality of the sources and assess the quality of the presentation of these answers. The instruction was design to minimize free-riders. Students work together during class as a team, and each one selects a role. These roles have specific tasks that are given individual grades, so all members are held accountable for their work. The students in the team also need to complete a self and group assessment called a Peer Report each mCpath cycle, another way of making those that put less effort into their team accountable.

Although the pilot survey showed that every student used a smartphone, in the interest of fairness to all participants, the definition of mobile computing device was broadened out to include computing tablets and computer notebooks.

Copyright by Mahidol University

The mCpath instruction has four roles:

- Auditor
- Presenter
- Reporter
- Researcher

Reporters are responsible for answering all path questions, as well as providing the URL addresses for web sources used. The Auditor is responsible for finding high-quality sources and evaluating that quality. The Presenter is responsible for presenting the answers for selected question during the mCpath class session. The Researcher has two responsibilities. One responsibility is to search for answers to questions on an assigned search engine or database and then analyze the differences of using that search service versus using Google search. The Researcher's second task is to talk to members of other groups and then write about any difference observed between the teams.

The groups have a two-hour class period to work together and then are individually responsible for completing their individual role reports by the end of the week. The teacher grades each report and gives detailed feedback for improvement. For the next mCpath cycle, students are asked to rotate roles. The instructor also asks members to share their reports. This way, the Auditor in mCpath2 can learn from the mistakes of the Auditor mCpath1 and likewise for all the other roles. Sharing the Reporters' report with the whole group is quite important because these become the study resource for the midterm and final exams.

As the method has currently been refined, optimally five people will be randomly assigned to a group. In this configuration, there are two Reporters and one for each other role. The mCpath teams can vary by plus or minus one person before the instruct should consider re-assigning members to other groups.

Copyright by Mahidol University

This thesis covers the experimental phase of development for the mCpath instruction. The experiment was designed to measure the effect of digital literacy of participants and answer the following research questions:

1. To what extent will using online searches through mobile devices in the classroom change the digital information literacy of undergraduate students?

2. To what extent will using online searches through mobile devices in the classroom change the level of knowledge and understanding of undergraduate students about computer concepts?

3. What will be undergraduates' attitude in using mCpath instruction in cooperative teams in the classroom?

4. How will the use of online searches through mobile devices in the classroom change the usage of media by undergraduates?

To measure digital literacy, the author used a quasi-experimental design. Participants were undergraduates taking an introductory computer class for one term at a university in Thailand. For the first two terms, one of the three sections were randomly assigned to the control group, the experimental treatment group and the hybrid experimental group. In the last term, the treatment was assigned to the section that had yet to experience that treatment. For example, section 1 taught at 12 pm was randomly assigned to be the control section in term 1, randomly assigned as the hybrid treatment section in term 2, and then it was automatically assigned to be the experimental treatment section in term 3 because it was the only treatment it had not received. The treatment of the experimental group was that on Mondays, they learned through participated in the mCpath instruction instead of listening to a lecture. The experimental sections received 4 treatments and then took the midterm. For the hybrid treatment group, they received mCpath treatment one week and then on the alternative week, they would listen to a class lecture. This means they received two treatments before taking the computer concept midterm. Through the class website, all participants had equal access to the class handout that was required reading, the PowerPoint presentations for all lectures, and videos of class lectures.

Copyright by Mahidol University

In total, there were 318 undergraduate participants, 101 in term 1, 106 in term2, and 111 in term 3. The majority were first-year students, with the second years making up 28 percent of the total sample. They studied in 14 different majors, making

the same representative of the college. Females made up 53 percent of the of the sample.

The research methodology was mainly quantitative, although qualitative evaluations of the mCpath reports and learning journal assisted in answering questions raised by the quantitative results. In order measure digital literacy, the author developed three assessments: Mobile Medial Learning Survey, the computer concept Test, and the Digital Search Literacy Assessment. The instructor gave these all as a pretest and posttest.

The results of the Digital Search Literacy Assessment did show that the information literacy ability to critically evaluate was significantly improved for the experimental group. It was significantly higher than for both the control group and the hybrid experimental treatment group.

As to how the knowledge level of computer concepts was changed using the mCpath method, there was no significant difference in test scores on the computer concept test for either the midterm or final. The results from the Mobile Media Learning Survey showed there was also no significant increase in the overall usage of 48 different mobile media.

6.2 Implications

The one result from the Digital Search Literacy was that the experimental group's ability to critical evaluate the creditability and bias of web information were significantly better than the control's group. The hybrid experimental participants' score was higher than the control group but still significantly lower for this information literacy factor. Because the experimental group received four treatments and the hybrid group only two, it appears that the mCpath did have a positive effect on undergraduates' ability critical analysis websites and other forms of online information.

For the participants' ability to identify the key concept to be found, to be able to understand how to find information in different formats, to be able to distinguish between primary, secondary and tertiary sources, the experimental treatment group scored higher than the control group, but not at a level that was

Copyright by Mahidol University

significantly different. This was also true for the use of search operators and better knowing the ethical issues regarding using copyrighted and creative commons source materials. In the post-experimental phase, the lecturer has put more emphasis on having students practice using Boolean search operators and other search operators. This information was covered for all treatment group during one computer lab session. What was added to the new version was that the instructor would walk through a search example during class to show limit the number of search results and to improve the quality of the sites found. This was done through including more complex search terms and the simple use the simple operators such as “site,” “inurl,” “intitle,” and the use of quote marks to force search of a specific term. The effectiveness of this teacher demonstration awaits the results for the next research phase.

One of the issues is using the information found through this m-learning process. Students would use the content for preparing for the midterm and final. Most left the Reporters’ reports in essentially their raw form, with no other formatting or editing. The next post-experimental phase would be to focus on how students use these reports, and at least have them minimally reformat the information to be more readable.

Again, one of the limitations of the information literacy instrument was that it measured only knowledge, not skills in finding information in context. The Auditors’ reports clearly showed development in better analyzing websites. In mCpath1, students gave overly high scores for technical detail, objectivity, and scope. Often the students would use sources that were more than two years old or were unable to determine the timeliness of the material. The students in this beginning process were unable to give specific examples to support their reasoning they gave a score. If information website said that it was the best or that it was the most expert in an area, students would believe it without any attempt to verify or find more information.

In the first round, the students thought the best sources was not the one that had more technical detail but then ones that made understanding easy for them. A male student in the experimental treatment group said, “However, I think sometimes it’s hard to understand what the website say especially in the area that I am not familiar with (research ID 3052).”

Copyright by Mahidol University

Auditors in their first analysis would only write one to two sentence analysis. In mCpath4, most Auditors show large improvement. One or two were still saying a site is credible because it looks like it is and then all 5s for the criteria score. Most of them are more aware of the purpose of the website, the background of the author and if that person shows a bias through language or opinions expressed. They were also more aware if a source is primary or secondary. They understand that they should use tertiary sources in their mCpath reports.

"The source is quite accurate since it is a software and hardware company," said a female student in her auditing report (research ID 3011). "However, it can be highly biased because most companies tend to outsell their products. Information provided in the article can be highly exaggerated." This quote nicely sums up all three points, the attempt to find information and the shortcomings as well. She found a white paper from National Instruments concerning the design of an Intel i7 CPU. She could tell this company had expertise, but she was not aware that the article was about using the CPA in an embedded controller. She likely selected this source because she thought it might be a primary source of information. More likely the information came from an Intel press release because the author could see that same information was in tech journals and blogs. A 2014 journal article used much of the original language and a new version of the same diagrams in a journal known to be on the now defunct Beall's list. The student could see that information was biased but was unable to connect it to the language used by a tech company to promote a new product as being dramatically different, improved, performing better. She assumed that this was a more primary source than it was and assumed that the company was showing its bias or its product. Her answer shows she had developed past a naive trust that everything on the web is true. The student understands that the source of the data is important and that the technical detail makes the information more useful to understanding how a CPU works. She is coming up short of digging deeper to find out what is the purpose of the National Instrument's website. This is an example of a student that started knowing little about computers

The Reporter's Report also showed improvement in undergraduates more effectively finding better and more sources. In the first round, almost all the students used only one website address. The answers were one to two sentences long. In the

Copyright by Mahidol University

third and fourth round, the Reporters in the experimental group wrote at least a paragraph or two per answer and used more links.

One major conclusion was that a beginning computer class significantly improved undergraduate digital literacy and encouraged more frequent use of mobile media. The debate of the critical 21st-century skill, along with the focus on core competencies for kindergarten to 12th grade and the focus of outcome learning at the university level pushed digital literacy to the forefront of many nations' and educational system debate, especially early 2010. This decade's initial push toward developing more technical skills has lost some initial steam. The assumption in some school systems has been that post-millennials that have grown up with iPad in hand have an assumed expertise with using all types of computer technology. The computer concept pretest and initial results from the information literacy assessment show that this is sadly not the case. This iGeneration knows less about computers than they think and tend to think they are more expert at web searching than they are. The high schools in Thailand and some other countries are not taking digital literacy seriously. To better prepare undergraduates for their future career and academic pursuits, universities should still include an introductory computer class. The premise of this research project was that information literacy skills are just as important or even more important to new graduates.

As to if the mCpath instruction influenced knowledge about computer concepts, the method fell down the no-significant-difference hole that many new innovative methodologies have had issues with escaping. This has made the author highly skeptical of any education paper that performs a small classroom experiment where there are only one or two experimental treatments, and the results show a significant positive improvement, especially on the first try. If picked apart carefully, some of these articles inevitable lead to research methodology flaws that bias the results.

Going back to the no significant effect, this means that students can learn on their own, working in groups, using their mobile devices to search for information just as well as they can learn in a class lecture. The computer concept score for the experimental group was consistently slightly lower than it was for the control group. Although this was not a definitive result because random selection could have

Copyright by Mahidol University

explained this, it did tend to indicate a teacher is important in the classroom process. Again consistently, the hybrid experimental group's grade tended to be higher than the experimental group's. In some version of the exam, it was quite close to the control group, and in others, there was a point or two difference. The learning journal remarks from the hybrid group were also more appreciative of the group learning and the lecturers. They enjoyed the interaction, learning to work with new classmates, yet felt the lectures helped connect the overall picture of how different types of computer hardware work together. A good example is the following quote from a female student from the hybrid group in the second term:

> *"My group worked very well together. Each of us knows our own roles and responsibilities. We exchange our email address since the first class so there was no problem in communication. We contributed efforts to the group equally. For the midterm, we agreed that the reporter role must also send the combined answers to the rest of the group every time. So, each of us don't have to find the answers for the questions that weren't done."*
>
> (research ID 2054)

In contrast, students in the experimental group felt stressed and overworked because they had to work together every week and turn in a report every week for four weeks. Although the main purpose of the path questions was to give a guided direction to the content, many of the experimental participants did not understand how the questions or content connected. Several participants were apologetic because they did not want to hurt the lecturer's feeling and carefully explained why they preferred lectures. "When I had to find some source for a long time, I started to get lazy and did not want to read the text anymore," said one male student (research ID 3001). One student that was educated in the USA that knew almost nothing about computer said that she was confused and did not understand the information until she read the handout and watched the recorded lectures. "I could not

Copyright by Mahidol University

realize its importance or how it all connected until I listened to the lectures," she added (research ID 3080). She did go on to say that when she was reading the handout, she did better recall information that was covered during the mCpath classes. There was a good portion in the experimental section that did enjoy learning on their own and in groups. One male student in the third term said, "One big thing that I learn from mCpath method is how to work in group. I learn to take responsibility (research ID 3007)."

Because of this cognitive load placed on the experimental participants, the author of the project had decided to implement the hybrid version of mCpath permanently into the same computer class in the post-research phase. The students get the best of both processes. They still have a teacher leading the process and providing cues for which materials will likely be included on the exam. At the same time, students learn to work and accomplish tasks with peers. They practice learning on their own and develop their ability to better find information and evaluate it.

A high level of interaction between students due to the mCpath was certainly expected and observed. The one unexpected result from the process was the amount of interaction between lecturer and students. Asian students in general tend to have difficulties speaking up in class or asking questions when they do not understand the materials. An often-made comment in the learning journal was that the lecturer talked too fast in class, especially in the computer lab. During the actual class, there were no students that raised their hands asking him to slow down or to explain again.

Just the number of emails between lecture and participants was tremendous. From the beginning of the first experimental term to the end of the third term, the teacher received 3,154 emails. He sent out 2,537 during the same period. The number of conversations before class, between class and after also increased.

6.3 Limitations to the study

The main limitation of the study is that it is quasi-experimental, limiting the generalization that can be made from the results. The is a potential selection bias (Grimes & Schulz, 2002). The 318 participants could not be randomly assigned to one of the three treatment groups. There were three sections of the same computer class

Copyright by Mahidol University

taught each term, maximum of 40 students per section. The treatment group participants were in a designated section. Because there was only one instructor, it would not have been feasible to give a lecture to the control group and coordinate the mCpath activities at the same time. It would have required two classrooms and a minimum of two people to control the classrooms, and both were not available.

Because the mCpath method was being refined at the same time as the experiment was being conducted, a quasi-experiment method was appropriate. It is often used in a longer experiment design where it is the beginning of the process (Fife-Schaw, 2012). Again, it limits the generality of findings. To reduce the potential bias, the selection of section to be assigned as the control, hybrid experimental and experimental treat was done randomly the first and second term, with each section in a time slot having been selected as control, hybrid and experimental at least once. Using random list function in random.org, as experimental term 1, section 1 was assigned as control treatment, section 2 was assigned as hybrid experimental treatment, and section 3 was assigned as experimental treatment. In term 2, the same random list function assigned section 3 as control, section as hybrid and section 2 as experimental. There was no reason to randomize again this term because there was no section that had been assigned the same treatment twice. But if say section 1 was again assigned as the control group, then the author would have randomized the list until there were no sections that were assigned to a treatment more than once.

Another limitation is that the author of this project and the lecturer are the same person. This introduced a motive to bias the data toward the experimental and hybrid experimental treatment groups, consciously or unconsciously. Because the author was aware of such a potential bias, so there was also a risk that the author would over adjust, and then there would be a bias toward the control group. To help reduce potential bias, as much randomization as possible was included into all processes. The one that took plenty of extra time was to randomize the order of the grading for the midterm and final exams. Each test was assigned a random grading order. A rubric for grading the short essay answers was used to help also eliminate bias, as well as make the grading results more consistent. Again, the assignment of treatment type was also random as well for the first two terms. Even with these extra measures implemented, the ability to generalize the results was limited to both the

Copyright by Mahidol University

quasi-experimental method and that the author of this research project was the same teacher of the class where the experiment was conducted. Because of this, the initial purpose of this experiment was proof of concept.

As to the computer concept exam, there was a pretest and two posttests given three consecutive terms to three sections of a computer class. One shortcoming to this method was that the same exam could not be used three times each term with three different sections for three terms without an answer cheat sheet leaking out, reducing the effectiveness of the test in measuring students' knowledge. Because of this issue, four versions of the 19-item exam were developed from the original 180 test bank questions. Item analysis was used to select the most discriminating questions. The four final versions were carefully selected so that discrimination and difficulty for all three were similar. The author originally thought that the different version could be considered by using univariate analysis and using the version number as the covariate. Despite having over a 300 sample size, the data failed the Shapiro-Wilks test for normality. This forced the author to use nonparametric analysis that both reduced the statistical power and did not allow the author conduct analysis on all 318 participants' computer concept results.

Again, mCpath was being developed and the focus on the experiment. There were minor adjustments to the methodology during the term and then a more major revision made before the beginning of each term. This certainly had some sort of consequence on the effectiveness of the instructional design.

6.4 Points for further research

Instead of a one-shot research project that would be finished after the thisis, the author of this project designed it to be an ongoing research project. In phase two, the method would be implemented into the same computer class used to test it as a permanent addition to the instruction used. As was discussed in the prior section, the hybrid version was adopted because it still included cooperative team learning and the self-learning feature. In this version, students participate in three rounds of mCpath learning, with the first two being used to create a third of the midterm questions. The Mobile Media Learning Survey and the Digital Search Literacy are still being given as

Copyright by Mahidol University

pretest and posttest. Instead of looking at the larger picture, research in this phase will deal with getting the secret formula adjusted just right. As was noted in the discussion about the DSL results, the participants' knowledge on the ability to judge the quality and bias of sources improved significantly for the experimental group but not for the hybrid group. Again, the likely reason was that because there were only two mCpath cycles, not all participants had a chance to work as a Reporter and as an Auditor. Those were the key roles for undergraduates. A potential experiment would be to test the current implementation of the mCpath method where there are two Reporters, one Presenter, one Auditor and on Researcher with variations on a theme. Several participants said that they only learned when the participated a Reporter. One alternative would be to have everyone work as a Reporter and then have each on also take on one more role. The two different treatment would be randomly assigned to groups within the class, not to the whole section. This would change the experimental method to a true random experiment, not a quasi-experimental design.

Another potential research topic would be to look more closely at the interaction of each group and how they communicate.

Another interesting project would be to go full smartphone. The initial concept was that students would use only smartphones during class. Because of technical issues at the time of battery life, cost of internet connectivity through cell phone service and speed f connection, mobile computing was broadened out to include laptops and tablet computers. Now with phone battery life of 8 hours plus, major discounts for 4G connectivity and large Samsung Note displays become the norm, the smartphone technology has reached a point where it can challenge the notebook.

After completion of this these, the third phase is to test the mCpath method using different disciplines and different levels of education. The method is currently designed to help undergraduates taking a 100-level computer course to use their mobile devices to improve both their computer literacy and information literacy. First, the path question was designed to reach the first two steps of the Bloom Taxonomy. Some of the more thoughtful Learning Journal entries showed students showed a leap in understanding on how knowledge is created and how it is subjective, depending on the background and view of the consumer. The author would certainly like to see if this method could be a useful instructional tool to add for those that teach upper

Copyright by Mahidol University

division and graduate-level classes. The author would also like to see if the method could also be applied to science disciplines other than computers. The expectation would be that like this 100-level computer course, this process would work well for a survey class where there was plenty on the web about that topic, but for more advance areas, the student would likely need a teacher guide to help with some of the more complex areas. This author thinks this m-learning method would likely work well at the upper level of a social science or humanities class. Finally, he would be interested in going the other direction to see if mCpath could be adapted to be used at the high school level.

Copyright by Mahidol University

REFERENCES

AASL. (2007). *Standards for the 21st-Century Learner*. Chicago, IL, USA: American Library Association.

Abdullah, M. H. (1998). *Guidelines for evaluating web* D'Ambra, J. (2011). Enhancing non-task sociability of asynchronous CSCL environments. *Computers & Education, 57*(4), 2535-2547.

Ackerman, R., & Leiser, D. (2014). The effect of concrete supplements on metacognitive regulation during learning and open-book test taking. *British Journal of Educational Psychology Review, 84*(2), 329-348.

ACRL. (2000). *Information literacy standards for higher education*. Chicago, IL, USA: ACRL.

ACRL Task Force. (2001). *Objectives for information literacy instruction: a model statement for academic librarians.* Chicago, IL, USA: ACRL.

ACT. (2012). *2012 ACT national and state scores: average scores by state*. Retrieved March 11, 2015, from: http://www.act.org/newsroom.html

Adler, P., Heckscher, C., & Prusak, L. (2013). *Building a collaborative enterprise On collaboration* (1st ed.). Boston, MA, USA: Harvard Business Review Press.

Ajzen, I., & Fishbein, M. (1977). Attitude-behavior relationships: a theoretical analysis and review of empirical research. *Psychology Bulletin, 84*(5), 888-918.

Ala-Mutka, K. (2011). *Mapping digital competence: towards a conceptual understanding.* Luxembourg: Publications Office of the European Union.

Allen, M. (2014). *Misconceptions in primary science* (2nd ed.). New York, NY, USA: Open University Press.

Alloway, T. P., Gathercole, S. E., Willis, C., & Adams, A.-M. (2004). A structural analysis of working memory and related cognitive skills in young children. *Journal of Experimental Child Psychology*, *87*, 85-106.

Copyright by Mahidol University

Anastopoulou, S., Sharples, M., & Baber, C. (2011). An evaluation of multimodal interactions while learning science concepts. *British Journal of Educational Technology*, *42*(2), 266-290.

Anderson, N., Lankshear, C., Timms, C., & Courtney, L. (2008). 'Because it's boring, irrelevant and I don't like computers': why high school girls avoid professionally-oriented ICT subjects. *Computers & Education*, *50*, 1304-1318.

Anthony, S. (2015, January). How wi-fi is crippling the Ethernet standard. *PC Magazine*, 25-26.

Apple Inc. (2015). *iPhone 6.* Retrieved April 8, 2015, from https://www.apple.com/iphone-6/specs/

Arnesen, K., Korpas, G. S., Hennissen, J. E., & Stav, J. B. (2013). Experiences with use of various pedagogical methods utilizing a student response system: Motivation and learning outcome. *The Electronic Journal of e-Learning, 11*(3), 169-181.

Arthur, W., Edwards, B. D., Bell, S. T., & Villado, A. J. (2005). Team task analysis: identifying tasks and jobs that are team based. *Human Factors, 47*(3), 654-669.

ASEAN. (2000). *e-Asian framework agreement*. Singapore: ASEAN Secretariat.

ASEAN. (2010). *Master plan on ASEAN connectivity.* (ISBN 978-602-8411-62-2). Kakarta, Indonesia: ASEAN Secretariat.

Asher, A. D., Duke, L. M., & Wilson, S. (2013). Paths of discovery: comparing the search effectiveness of EBSCO Discovery Service, Summon, Google Scholar, and conventional library resources. *College & Research Libraries, 74*(5), 464-488.

Ashman, A. F., & Gillies, R. M. (2013). Collaborative learning for diverse learners. In C. E. Hmelo-Silver, C. A. Chinn, C. K. K. Chan, & A. O'Donnell (Eds.), *The international handbook of collaborative learning* (1st ed.). New York, NY, USA: Taylor & Francis.

Autin, F., & Croizet, J. C. (2012). Improving working memory efficiency by reframing metacognitive interpretation of task difficulty. *Journal of Experimental Psychology: General, 141*(4), 610-618.

Copyright by Mahidol University

Badenhorst, E., Mamede, S., Hartman, N., & Schmidt, H. G. (2014). Exploring lecturers' views of first-year health science students' misconceptions in biomedical domains. *Advances in Health Sciences Education Theory and Practice*, 1-18.

Baikady, M. R., & Mudhol, M. V. (2013). Computer literacy and use of web resources: A survey on medical faculty and students. *International Journal of Information Dissemination and Technology, 3*(1), 27-32.

Ballantine, J. A., Larres, P. M., & Oyelere, P. (2007). Computer usage and the validity of self-assessed computer competence among first-year business students. *Computers & Education*, *49*, 976-990.

Barnette, J. J., & McLean, J. E. (2005). Type I error of four pairwise mean comparison procedures conducted as protected and unprotected tests. *Journal of Modern Applied Statistical Methods, 4*(2), 446-459.

Bawden, D. (2008). Origin and concepts of digital literacy. In C. Lankshear & M. Knobel (Eds.), *Digital literacies: concepts, policies and practices* (1st ed., pp. 17-32). New York, NY, USA.

Belshaw, D. A. J. (2012). *What is digital literacy?: a pragmatic investigation*. (Ed.D.), Durham University, UK. Retrieved from http://etheses.dur.ac.uk/3446

Benkraouda, M., Madi, M., Abada, A., & Qamhieh, N. (2013). A systematic study of the efficacy of the peer-instruction method in teaching introductory courses using Blackboard. *Education, 3*(6), 344-347.

Berdousis, I., & Kordaki, M. (2015, February). *Gender differences and achievement in computer science: a case study*. Paper presented at the World Conference on Educational Science, Malta.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., et al. (2012). Defining twenty-first century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (1st ed., pp. 17-66): Springer Science+Business Media.

Bluetooth SIG Proprietary. (2014). *Specification of the Bluetooth system: version 4.2 Vol. 0, Part B* (pp. 75-90).

Copyright by Mahidol University

Blum, E. K. (2011). Introduction and prologue. In E. K. Blum & A. V. Aho (Eds.), *Computer science: the hardware, software and heart of it* (1st ed., pp. 3-17). New York, NY, USA: Springer Science+Business Media.

Bo, G. (2002). *MOBILearn: next-generation paradigms and interfaces for technology supported learning in a mobile environment exploring the potential of ambient intelligence.* (IST-2001-37187). Sestri Levante, Italy: MOBILearn.

Boyle, E. A., Connolly, T. M., Hainey, T., & Boyle, J. M. (2012). Engagement in digital entertainment games: a systematic review. *Computers in Human Behavior*, 28, 771-780.

Braasch, J. L. G., Lawless, K. A., Goldman, S. R., Manning, F. H., Gomez, K. W., & Macleod, S. M. (2009). Evaluating search results: an empirical analysis of middle school students' use of source attributes to select useful sources. *Journal of Educational Computing Research, 41*(1), 63-82.

Brewer, J. K. (1972). On the power of statistical tests in the "American Educational Research Journal". *American Educational Research Journal, 9*(3), 391-401.

Bright, L. F., Kleiser, S. B., & Grau, S. L. (2015). Too much Facebook? an exploratory examination of social media fatigue. *Computers in Human Behavior, 44*, 148-155.

Brin, S., & Page, L. (1998). The anatomy of a large-scale hypertextual web search engine. *Computer Networks and ISDN Systems, 30*, 107-116.

Brookfield, S. D. (1995). *Becoming a critical reflective teacher* (1st ed.). San Francisco, CA, USA: Jossey-Bass Inc.

Brown, C., & Krumholz, L. R. (2002). Integrating information literacy into the science curriculum. *College & Research Libraries, 63*(2), 111-123.

Bruce, C., Edwards, S. L., & Lupton, M. (2006). Six frames for information literacy education. Innovation in Teaching and Learning in Information and *Computer Sciences, 6*(1), 1-18.

Bucher, S. G. (2012). *344 questions: the creative person's do-it-yourself guide to insight, survival, and artistic fulfillment*. Berkeley, CA, USA: New Riders.

Copyright by Mahidol University

Bundy, A. (2004). *Australian and New Zealand information literacy framework* (2nd ed.). Underdale, Australia: Library Publications, University of South Australia.

Capron, H. L., & Johnson, J. A. (2003). *Computers: tools for an information age* (8th ed.). Englewood Cliffs, N.J., USA: Prentice Hall.

Cartelli, A. (2005). Computing and ICT: from students' misconceptions and mental schemes to the monitoring of the teaching-learning process. In D. D. Carbonara (Ed.), *Technology literacy application in learning environments* (pp. 37-48). Hershey, PA, USA: Information Science Publishing.

Catts, R. (2005). *Council of Australian University Librarians Information Skills Survey: technical manual* (1st ed.). Canberra, ACT, Australia: Council of Australian University Librarians.

Charkaoui, S., Adraoui, Z., & Benlahmar, E. H. (2014, October 20-22). *Cross-platform mobile development approaches.* Paper presented at the Information Science and Technology (CIST), Third IEEE International Colloquium in Science and Technology, Tetuan, Morocco

Chee, T. S., Sing, C. C., Beng, L. C., Timothy, T. K. G., Wenli, C., Ling, J. K. H., et al. (2010). *Evaluation of implementation of the it masterplan 3 and its impact on Singapore schools instrumentation and baseline study* (ISSN 2010-3093, Research Brief No. 11-001). Retrieved from http://www.nie.edu.sg/files/NIE_research_brief_11-001.pdf

Cheema, J. R. (2015). Differences in computer use for entertainment between boys and girls: evidence from a global survey. *Entertainment Computing*, *9-10*, 1-10.

Chen, Y. S., Kao, T. C., & Sheu, J. P. (2003). A mobile learning system for scaffolding bird watching learning. *Journal of Computer Assisted Learning, 19*, 347-359.

Cheong, C., Bruno, V., & Cheong, F. (2012). Designing a mobile-app-based collaborative learning system. *Journal of Information Technology Education: Innovations in Practice, 11*, 97-119.

Childers, S. (2003). Computer literacy: necessity or buzzword? *Information Technology and Libraries, 22*(3), 100-104.

Copyright by Mahidol University

Chomsky, N. (2008). *The essential Chomsky* (A. Arnove Ed.). New York, NY, USA: The New Press.

Cochrane, T. (2012). Secrets of mlearning failures: confronting reality. *Research in Learning Technology, 20*, 123-134.

Cochrane, T. (2013). A summary of critique of m-learning research and practice. In Z. L. Berge & L. Y. Muilenburg (Eds.), *Handbook of mobile learning* (1st ed.). New York, NY, USA: Routledge.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). New York, NY, USA: Psychology Press, Taylor & Francis Group.

Committee on Undergraduate Science Education-National Research Council. (1997). *Science teaching reconsidered: a handbook.* Washington, D.C., USA: National Academy Press.

Compendium Institute. (2012). *Community.* Retrieved June 16, 2015, from http://compendiuminstitute.net/community/community.php

Corder, G. W., & Foreman, D. I. (2014). *Nonparametric statistics: a step-by-step approach* (2nd ed.). Hoboken, NJ, USA: John Wiley & Sons.

Cordova, J. R., Sinatra, G. M., Jones, S. H., Taasoobshirazi, G., & Lombardi, D. (2014). Confidence in prior knowledge, self-efficacy, interest and prior knowledge: influences on conceptual change. *Contemporary Educational Psychology, 39*, 164-174.

Cote, J. A., & Buckley, M. R. (1987). Estimating trait, method, and error variance: generalization across 70 construct validation studies. *Journal of Marketing Research, 24*, 315-318.

Culp, K. M., Honey, M., & Mandinach, E. (2003). *A retrospective on twenty years of education technology policy*. Washington, D.C., USA: US Department of Education.

da Cruz, F. (2015). *Columbia University computing history: a chronology of computing at Columbia University*. Retrieved January 1, 2015, from http://www.columbia.edu/cu/computinghistory/

Daley, B. (2007). *Computers are your future* (9th ed.). Upper Saddle River, NJ, USA: Pearson Education.

Copyright by Mahidol University

Davidson, N., & Major, C. H. (2014). Boundary crossings: cooperative learning, collaborative learning, and problem-based learning. *Journal on Excellence in College Teaching, 25*(3&4), 7-55.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management Science, 35*(8), 982-1003.

Davison, D. (2005). *Truth, language and history*. Oxford, UK: Oxford University Press.

DeMars, C. (2010). *Item response theory*. New York, NY, USA: Oxford University Press.

Dennen, V. P., & Hoardley, C. (2013). Designing collaborative learning through computer support. In C. E. Hmelo-Silver, C. A. Chinn, C. K. K. Chan, & A. O'Donnell (Eds.), *The international handbook of collaborative learning* (1st ed., pp. 371-384). New York, NY, USA: Taylor & Francis.

DeRue, D. S., & Hollenbeck, J. R. (2012). The search for internal and external fit in teams. In C. Ostroff & T. A. Judge (Eds.), *Perspectives on organizational fit* (pp. 259-285). East Sussex, UK: Psychology Press. (Reprinted from: 2007).

Dimova, Y., & Kamarska, K. (2015). Rediscovering John Dewey's model of learning through reflective inquiry. *Problems of Education in the 21st Century, 63*, 29-39.

Doyle, W. (1979). Classroom effects. *Theory Into Practice, 18*(3), 138-144.

Dunn, K. (2002). Assessing information literacy skills in the California State University: a progress report. *The Journal of Academic Librarianship, 28*(1), 26-35.

Edzan, N. N. (2008). Information literacy development in Malaysia: A review. *Libri, 58*, 265-280.

Ellis, P. D. (2010). *The essential guide to effect sizes*. Cambridge, UK: Cambridge University Press.

Eshet-Alkalai, Y., & Chajut, E. (2010). You can teach old dogs new tricks: the factors that affect changes over time in digital literacy. *Journal of Information Technology Education, 9*, 173-181.

Copyright by Mahidol University

Faix, A. (2014). Assisting students to identify sources: an investigation. *Library Review, 63*(8/9), 624-636.

Fallis, D. (2008). Toward an epistemology of Wikipedia. *Journal of the American Society for Information Science and Technology, 59*(10), 1662-1674.

Fanelli, D. (2012). Negative results are disappearing from most disciplines and countries. *Scientometrics, 90*(3), 891-904.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2009). Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behavior Research Methods, 41*(4), 1149-1160.

Ferrari, A. (2012). *Digital competence in practice: an analysis of frameworks* (ISBN 978-92-79-25093-4). Seville, Spain: European Commission.

Ferrari, A. (2013). *DIGCOMP: A framework for developing and understanding digital competence in Europe* (ISBN 978-92-79-31465-0). Seville, Spain: European Commission.

Fife-Schaw, C. (2012). Quasi-experimental designs. In G. Breakwell, S. M. Hammon, & C. Fife-Schaw (Eds.), *Research methods in psychology* (4th ed., pp. 75-92). Thousand Oaks, CA, USA: Sage Publications.

Fishbein, M., & Ajzen, I. (2005). The influence of attitudes on behavior. In D. Albarracin, B. T. Jognson, & M. P. Zanna (Eds.), *The handbook of attitudes* (1st ed., pp. 173-222). New York, NY, USA: Psychology Press.

Forest Woody Horton. (2007). *Understanding information literacy: a primer*. Paris, France: UNESCO.

Franz, T. M. (2012). *Group dynamics and team interventions: understanding and improving team performance* (1st ed.). Malden, MA, USA: Wiley-Blackwell.

Franz, T. M. (2012). *Group dynamics and team interventions: understanding and improving team performance* Malden, MA, USA: Wiley-Blackwell.

Copyright by Mahidol University

Froman, M. B. G. (2014). *2014 special 301 report*. Washington, DC, USA: US Trade Representative.

Froman, M. B. G. (2015). *2015 special 301 report*. Washington, DC, USA: : US Trade Representative.

Fujiwara, T., Laulathaphol, P., & Phillips, B. J. (2012, January). *Thai university students' scientific epistemic beliefs: relationships with past learning experiences*. Paper presented at the International Conference on Education & Educational Psychology (ICEEPSY 2012), Istanbul, Turkey.

Gafni, R. (2009). Quality metrics for PDA-based m-learning information systems. *Interdisciplinary Journal of E-Learning and Learning Objects*, *5*(1), 359-378.

Gardner, D. P., Larsen, Y. W., Baker, W. O., Campbell, A., Crosby, E. A., Francis, N. C., et al. (1983). *A nation at risk: the imperative for educational reform*. Washington, D.C., USA: US Department of Education.

Gillies, R. M. (2007). *Cooperative learning: integrating theory and practice* (1st ed.). Thousand Oaks, CA, USA: Sage.

Gilson, L. L., Maynard, M. T., Young, N. C. J., Vartiainen, M., & Hakonen, M. (2014). Virtual teams research: 10 years, 10 themes, and 10 opportunities. *Journal of* Management, 41(5), 1313-1337.

Gitelman, L. (2006). *Always already new: media, history, and the data of culture* (1st ed.*)*. Cambridge, MA, USA: MIT Press.

Glassman, E. (2011). *Creative triggers for college students* (1st ed.). USA: CreateSpace.

Gok, T. (2012). The impact of peer instruction on college students' beliefs about physics and conceptual understanding of electricity and magnetism. *International Journal of Science and Mathematics Education, 10*, 417-436.

Goldman, S. R., Braasch, J. L. G., Wiley, J., Graesser, A. C., & Brodowinska, K. (2012). Comprehending and learning from internet sources: processing patterns of better and poorer learners. *Reading Research Quarterly, 47*(4), 356-381.

Gong, M. X., Hart, B., & Mao, S. (2014). Advanced wireless LAN technologies: IEEE 802.11 ac and beyond. *ACM Mobile Computing and Communications Review, 18*(4), 48-52.

Copyright by Mahidol University

Grafstein, A. (2002). A discipline-based approach to information literacy. *The Journal of Academic Librarianship, 28*(4), 197-204.

Gravetter, F. J., & Wallnau, L. B. (2012). *Statistics for the behavior sciences* (9th ed.): Cengage Learning.

Gray, P. H., Parise, S., & Iyer, B. (2011). Innovation impacts of using social bookmarking systems. *MIS Quarterly*, 35(3), 629-643.

Green, P. J. (2003). *Peer instruction for astronomy* (1st ed.). Upper Saddle River, NJ, USA: Prentice Hall.

Grimes, D. A., & Schulz, K. F. (2002). Bias and causal associations in observational research. *The Lancet*, 359, 248-252.

Grissom, R. J., & Kim, J. J. (2012). *Effect sizes for research* (2nd ed.). NewYork, NY, USA: Routledge, Taylor & Francis Group.

Grosch, M. (2012). *Mediennutzung im studium.* Karlsruher Institut für Technologie, Aachen, Germany.

Grosch, M., & Phillips, B. J. (2012). Media usage by Thai international students – an empirical survey. *International Proceedings of Economic Development Research, 27*, 64-68.

Gross, J. J. (2014). Emotions regulation: conceptual and emperical foundations. In J. J. Gross (Ed.), *Handbook of emotional regulation* (2nd ed.). New York, NY, USA: Guilford Press.

Haladyna, T. M., & Rodriguez, M. C. (2013). *Developing and validating test items* (1st ed.). Oxon, UK: Routledge.

Hao, Q., Wright, E., Barnes, B., & Branch, R. M. (2016). What are the most important predictors of computer science students' online help-seeking behaviors? *Computers in Human Behavior*, *62*, 467-474.

Hardy, J., & Nanni, A. (2015). Technology-based change in Thai education: the one tablet per child initiative. *International Journal of Technologies in Learning*, *22*(4), 41-47.

Harris, R. (2015). *Evaluating internet research sources.* Retrieved July 31, 2015, from http://www.virtualsalt.com/evalu8it.htm

Copyright by Mahidol University

Hattie, J. A. C. (2008). *Visible learning: a synthesis of over 800 meta-analyses relating to achievement* (1st ed.). New York, NY, USA: Routledge. Taylor & Francis Group.

Haustein, S., & Siebenlist, T. (2011). Applying social bookmarking data to evaluate journal usage. *Journal of Informetrics, 5*, 446-457.

Helms-Park, R., & Stapleton, P. (2006). How the views of faculty can inform undergraduate web-based research: implications for academic writing. *Computers and Composition*, *23*, 444-461.

Herbert, J., & Stipek, D. (2005). The emergence of gender differences in children's perceptions of their academic competence. *Applied Developmental Psychology, 26*, 276-295.

Hess, C. A. (1994). Computer literacy: an evolving concept. *School Science and Mathematics, 94*(4), 208-214.

Hill, J. B., Macheak, C., & Siegel, J. (2013). Assessing undergraduate information literacy skills using Project SAILS. *Codex: the Journal of the Louisiana Chapter of the ACRL, 2*(3), 23-37.

Hofer, B. K. (2006). Domain specificity of personal epistemology: resolved questions, persistent issues, new models. *International Journal of Educational Research, 45*, 85-95.

Horton, F. W. (2008). *Understanding information literacy: a primer.* Paris, France: UNESCO.

Horton, F. W. (2014). *Overview of information literacy resources worldwide.* Paris, France: : UNESCO.

Hsieh, J. S. C., Wu, W.-C. V., & Marek, M. W. (2016). Using the flipped classroom to enhance EFL learning. *Computer Assisted Language Learning, 30*(1-2), 1-24.

Hwang, G. J., Tsai, C. C., & Yang, S. J. H. (2008). Criteria, strategies and research issues of context-aware ubiquitous learning. *Educational Technology & Society, 11*(2), 81-91.

Hyde, J. S. (2005). The gender similarities hypothesis. *American Psychologist, 60*(6), 581-592.

Copyright by Mahidol University

Hyde, J. S. (2014). Gender similarities and differences. *Annual Review of Psychology, 65,* 373-398.

Hyde, J. S., & Linn, M. C. (2006). Gender similarities in mathematics and science. *Science, 314*, 599-600.

IEEE P802.11. (2013). *Status of project IEEE 802.11ax.* Task Group AX. Retrieved December 23, 2014, from http://www.ieee802.org/11/Reports/tgax_update.htm

Illeris, K. (2007). *How we learn: learning and non-learning in school and beyond.* New York, NY, USA: Routledge, Taylor & Francis Group.

Illeris, K. (2009). *A comprehensive understanding of human learning* (1st ed.). New York, NY, USA: Routledge, Taylor & Francis Group.

Illeris, K. (2014). Transformative learning re-defined: as changes in elements of the identity. *International Journal of Lifelong Education, 33*(5), 573-586.

Infeld, D. L., & Adams, W. C. (2013). Wikipedia as a tool for teaching policy analysis and improving public policy content online. *Journal of Public Affairs Education, 19*(3), 445-459.

Ingre, M. (2013). Why small low-powered studies are worse than large high-powered studies and how to protect against "trivial" findings in research: comment on Friston (2012). *NeuroImage, 81*, 496-498.

Jacobson, T. (2002). *University at Albany: the new general education program.* Paper presented at the ACRL Best Practices in Information Literacy Invitational, Atlanta, GA, USA.

Jeno, L. M., Grytnes, J.-A., & Vandvik, V. (217). The effect of a mobile-application tool on biology students' motivation and achievement in species identification: a self-determination theory perspective. *Computers & Education, 107*, 1-12.

Johnson, D. H., & Johnson, F. P. (2014). *Joining together: group theory and group skills* (11th ed.). Essex, UK: Pearson Education Limited.

Joseph A. Salem. (2014). *The development and validation of all four TRAILS (Tool For Real-Time Assessment of Information Literacy Skills) tests for K-12 students.* (Ph.D. Dissertation), Kent State University, Kent, OH, USA.

Copyright by Mahidol University

Juul, J. (2013). *The art of failure: an essay on the pain of playing video games* (1st ed.). Cambridge, MA, USA: MIT Press.

Karpov, Y. V. (2014). *Vygotsky for educators* (1st ed.). New York, NY, USA: Cambridge University Press.

Katz, I. R. (2007). Testing information literacy in digital environments: ETS's iSkills Assessment. *Information Technology and Libraries, 26*(3), 3-12.

Katz, R. N. (2009). *Introduction: higher education-a movable feast?* Boulder, CO, USA: Educause.

Kay, R. H. (1989). Gender differences in computer attitudes, literacy, locus of control and commitment. *Journal of Research on Computing in Education, 21*(3), 307-316.

Kempler, T., Linnenbrink-Garcia, L., & Didonato, N. (2013). Motivation in collaborative groups. In C. E. Hmelo-Silver, C. A. Chinn, C. K. K. Chan, & A. M. O'Donnell (Eds.), *The international handbook of collaborative learning* (pp. 234-251). New York, NY, USA: Routledge.

Kent State University Libraries. (2014a). *More about the assessment: TRAILS: tool for real-time assessment of information literacy skills*. Retrieved June 20, 2014, from http://www.trails-9.org/overview2.php?page=about

Kent State University Libraries. (2014b). *Steps to Using TRAILS: TRAILS: tool for real-time assessment of information literacy skills.* Retrieved June 20, 2014, from http://www.trails-9.org/howTrailsWorks2.php?page=works

Kent State University Libraries. (2014c). *TRAILS benchmark data: 2012-2013: TRAILS: tool for real-time assessment of information literacy skills.* Retrieved June 20, 2014, from http://www.trails-9.org/index.php

Kent State University Libraries. (2014d). *TRAILS development timeline. TRAILS: tool for real-time assessment of information literacy skills.* Retrieved June 20, 2014, from http://www.trails-9.org/history2.php?page=about

Keselman, H. J., Games, P. A., & Rogan, J. C. (1986). Protecting the overall rate of Type I errors for pairwise comparisons with an omnibus test statistic. *Psychological Bulletin, 86*(4), 884-888.

Khan, A. I., Al-khanjari, Z., & Sarrab, M. (2016, October 13-15). *Crowd sourced testing through end users for mobile learning application in the context of*

Copyright by Mahidol University

bring your own device. Paper presented at the Information Technology, Electronics and Mobile Communication Conference (IEMCON), IEEE, Vancouver, BC, Canada.

Khemaja, M., & Taamallah, A. (2016). Towards situation driven mobile tutoring system for learning languages and communication skills: application to users with specific needs. *Educational Technology & Society, 19*(1), 113-128.

Kiili, C., Laurinen, L., & Marttunen, M. (2008). Students evaluating internet sources: from versatile evaluators to uncritical readers. *Journal of Educational Computing Research, 39*(1), 75-95.

King, W. R., & He, J. (2006). A meta-analysis of the technological acceptance model. *Information & Management, 43,* 740-755.

Kirkwood, A., & Price, L. (2014). Technology-enhanced learning and teaching in higher education: what is 'enhanced' and how do we know? a critical literature review. *Learning, Media and Technology, 39*(1), 6-36.

Klingberg, T. (2010). Training and plasticity of working memory. *Trends in Cognitive Sciences, 14*, 317-324.

Knight, C., & Pryke, S. (2012). Wikipedia and the university, a case study. Teaching in Higher Education, 17(6), 649-659.

Koanantakool, T. (2001). The Internet in Thailand: our milestones. Retrieved September 3, 2015, from http://www.nectec.or.th/users/htk/milestones.html

Kolb, A. Y., & Kolb, D. A. (2012). Experiential Learning Theory: a dynamic, holistic approach to management learning, education and development. In N. M. Seel (Ed.), *Encyclopedia of the sciences of learning* (pp. 42-68): Springer & Business Media, LLC.

Kolb, D. A. (1981). Learning styles and disciplinary differences. In A. W. Chickering (Ed.), *The modern American college: responding to the new realities of diverse students and a changing society* (1st ed., pp. 232-255). San Francisco, CA, USA: Jossey-Bass Inc.

Kori, K. l., Pedaste, M., Leijen, A. l., & Maeots, M. (2014). Supporting reflection in technology-enhanced learning. *Educational Research Review, 11*, 45-55.

Copyright by Mahidol University

Koutromanos, G., & Avraamidou, L. (2014). The use of mobile games in formal and informal learning environments: a review of the literature. *Educational Media International, 51*(1), 1-17.

Krathwohl, D. R. (2002). A revision of Bloom's Taxonomy: an overview. *Theory Into Practice, 41*(4), 212-218.

Kruskal, W. H., & Wallis, W. A. (1952). Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association, 47*(260), 583-621.

Kua, H. Y., Tseng, H. W., & Akarasriworn, C. (2013). Collaboration factors, teamwork satisfaction, and student attitudes toward online collaborative learning. *Computers in Human Behavior, 29*(3), 922-929.

Kuo, Y.-C., Belland, B. R., & Kuo, Y.-T. (2016). Learning through blogging: students' perspectives in collaborative blog- enhanced learning communities. *Educational Technology & Society, 20*(2), 37-50.

Lam, S. L., Wong, K., Mohan, J., Xu, D., & Lam, P. (2011, December). *Classroom communication on mobile phones – first experiences with web-based 'clicker' system.* Paper presented at the ASCILITE - Australian Society for Computers in Learning in Tertiary Education Annual Conference 2011 Hobart, Tasmania, Australia.

Lampert, L. (2005). "Getting psyched" about information literacy: a successful faculty-librarian collaboration for educational psychology and counseling. *The Reference Librarian, 89/90*, 5-23.

Lankshear, C., & Knobel, M. (2008). Digital literacies-concepts, policies and practices. In C. Lankshear & M. Knobel (Eds.), *Digital literacies: concepts, policies and practices* (1st ed., pp. 1-16). NY, New York, USA.

Lankshear, C., & Knobel, M. (2011). *New literacies: everyday practices and social learning* (3rd ed.). Berkshire, England, UK: Open University Press, McGraw-Hill Education.

Lanning, S. (2012). *Concise guide to information literacy* (1st ed.). Santa Barbara, CA, USA: ABC-CLIO, LLC.

Copyright by Mahidol University

Laohajaratsang, T. (2013, October). *The effects of tablet-based learning on preservice teachers' learning experiences at Chiang Mai University*. Paper presented

at the IEEE 63rd Annual Conference International Council for Educational Media (ICEM) Singapore.

Lardinois, F. (2016, January 12). Delicious, former web 2.0 darling, is now managed by new alliance, rolls back most recent changes. *TechCrunch.*

Larkin, D. (2012). Misconceptions about "misconceptions": preservice secondary science teachers' views on the value and role of student ideas. *Science Education, 96*(5), 927-959.

Laronde, G., & MacLeod, K. (2012). Modeling various teaching methods in a faculty of education in science education: chalk and talk, virtual labs or hovercrafts. *Journal of College Teaching & Learning, 9*(2), 107-114.

Leckie, G. J., & Fullerton, A. (1999). Information literacy in science and engineering undergraduate education: Faculty attitudes and pedagogical practices. *College & Research Libraries, 6*(1), 9-29.

Lee, C. L., & Huang, M. K. (2014). The influence of computer literacy and computer anxiety on computer self-efficacy: the moderating effect of gender. *Cyberpsychology, Behavior, and Social Networking, 17*(3), 172-180.

Leibiger, C. A., & Schweinle, W. E. (2007, March/April). *The South Dakota Information Literacy Exam: a tool for small to medium-sized universities to document and assess information literacy.* Paper presented at the ACRL Thirteenth National Conference, Baltimore, MD, USA.

Leinonen, T., Keune, A., Veermans, M., & Toikkanen, T. (2016). Mobile apps for reflection in learning: a design research in k-12 education. *British Journal of Educational Technology, 47*(1), 184-202.

Lencioni, P. (2005). *Overcoming the five dysfunctions of a team: a field guide for leaders, managers, and facilitators* (1st ed.). San Francisco, CA, USA: Jossey-Bass.

Lew, B. (2017). *IOS Res: a quick reference for IOS devices.* Retrieved April 14, 2017, from http://iosres.com/

Lindsay, E. B., Cummings, L., Johnson, C. M., & Scales, B. J. (2006). If you build it, will they learn? assessing online information literacy tutorials. *College & Research Libraries, 67*(5), 429-445.

Copyright by Mahidol University

Lindstrom, J., & Shonrock, D. D. (2006). Faculty-librarian collaboration to achieve integration of information literacy. *Information Literacy and Instruction: Reference & User Services Quarterly, 46*(1), 18-23.

Llados, J., Aibar, E., Lerga, M., Meseguer, A., & Minguillon, J. (2013, July). *An empirical study on faculty perceptions and teaching practices of Wikipedia*. Paper presented at the EDULEARN13, Barcelona, Spain.

Lockheed, M. E. (1985). Women, girls, and computers: a first look at the evidence. Sex Roles. *Journal of Educational Computing Research, 13*(3/4), 115-122.

Lord, F. M. (1952). The relation of the reliability of multiple-choice tests to the distribution of the item difficulties. *Psychometrika, 17*(2), 181-194.

Lumsden, J., Leung, R., D'Amours, D., & McDonald, D. (2010). ALEX©: a mobile adult literacy experiential learning application. *International Journal of Mobile Learning and Organisations, 4*(2), 172-191.

Luo, L. (2010). Web 2.0 integration in information literacy instruction: an overview. *The Journal of Academic Librarianship, 36*(1), 32-40.

Lupton, M., & Bruce, C. (2010). Windows on information literacy worlds: Generic, situated and transformative perspectives. In A. Lloyd & S. Talja (Eds.), *Practising Information Literacy: Bringing Theoris of Learning, Practice and Information Literacy Together*. Southbank, VIC, Australia: Chandos Publishing.

Lym, B., Grossman, H., Yannotta, L., & Talih, M. (2010). Assessing the assessment: how institutions administered, interpreted, and used SAILS. *Reference Services Review, 38*(1), 168-186.

Macarthur, J., Jones, L., & Suits, J. (2011). Faculty viewpoints on teaching large-enrollment science courses with clickers. *Journal of Computers in Mathematics and Science Teaching, 30*(3), 251-270.

Mackey, T. P., & Jacobson, T. E. (2011). Reframing information literacy as a metaliteracy. *College & Research Libraries, 72*(1), 62-78.

Madison Assessment. (2014). *The information literacy test (ILT): test manual*. Harrison, VA, USA: JMU Center for Assessment and Research Studies.

Copyright by Mahidol University

Magnuson, M. L. (2013). Web 2.0 and information literacy instruction: aligning technology with ACRL standards. *The Journal of Academic Librarianship, 39*(3), 244-251.

Martin-Blas, T., & Serrano-Fernandez, A. (2009). The role of new technologies in the learning process: Moodle as a teaching tool in physics. *Computers & Education, 52,* 35-44.

Martins, L. L., Gilson, L. L., & Maynard, M. T. (2004). Virtual teams: what do we know and where do we go from here? *Journal of Management, 30*(6), 805-835.

Marzano, R. J., & Kendall, J. S. (2007). *The new taxonomy of educational objectives* (2nd ed.). Thousand Oaks, CA, USA: Corwin Press.

Maxwell, S. E. (2004). The persistence of underpowered studies in psychological research: causes, consequences, and remedies. *Psychological Methods, 9*(2), 147-163.

Mayer, J., & Bowles-Terry, M. (2013). Engagement and assessment in a credit-bearing information literacy course. *Reference Services Review, 41*(1), 62-79.

Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). New York, NY, USA: Cambridge University Press.

Mazure, E. (1997). *Peer instruction: a user's manual* (1st ed.). Upper Saddle River, NJ, USA: Prentice Hall.

Meluso, A., Zheng, M., Spires, H. A., & Lester, J. (2012). Enhancing 5th graders' science content knowledge and self-efficacy through game-based learning. *Computers & Education, 59*, 121-128.

Michaelsen, L. K., & Sweet, M. (2008). Fundamental principles and practices of team-based learning. In L. K. Michaelsen, D. Parmelee, K. K. McMahon, & R. E. Levine (Eds.), *Team-based learning for health professions education.* Sterling, VA, USA: Stylus Publishing.

Miller, K., Lasry, N., Lukoff, B., Schell, J., & Mazur, E. (2014). Conceptual question response times in peer instruction classrooms. *Physical Review Special Topics - Physics Education Research, 10*(2), 020113/020111-020113/020116.

Copyright by Mahidol University

Ministry of Education-Thailand. (2008). *The basic education core curriculum* (Vol. OBEC 293/2551). Thailand: Ministry of Education-Thailand.

Momsen, J., Offerdahl, E., Kryjevskaia, M., Montplaisir, L., Anderson, E., & Grosz, N. (2013). Using assessments to investigate and compare the nature of learning in undergraduate science courses. *CBE—Life Sciences Education, 12,* 239-249.

Morris, R., Hadwin, A. F., Gress, C. L. Z., Miller, M., Fior, M., Church, H., et al. (2010). Designing roles, scripts, and prompts to support CSCL in gStudy. *Computers in Human Behavior, 26,* 815-824.

MOZ. (2015). *Google algorithm change history.* Seattle, WA, USA: MOZ.

Muis, K. R., Bendixen, L. D., & Haerle, F. C. (2006). Domain-generality and domain-specificity in personal epistemology research: Philosophical and empirical reflections in the development of a theoretical framework. *Educational Psychology Review, 18*, 3-54.

National Academy of Sciences. (2012). *Continuing innovation in information technology* (978-0-309-25962-0). Washington, DC, USA: The National Academies Press.

National Institute of Education-Singapore. (2009). *A teacher education model for the 21st century.* Singapore: National Institute of Education-Singapore.

NECTEC. (2011). *Executive summary Thailand information and communication technology policy framework (2011-2020): ICT2020*. Bangkok, Thailand: Ministry of Information and Communications Technology.

Nedungadi, P., & Raman, R. (2012). A new approach to personalization: integrating e-learning and m-learning. *Educational Technology Research and Development, 60,* 659-678.

NetMarketShare. (2014). *Desktop operating system-world market share.* Retrieved May 9, 2014, from: http://www.netmarketshare.com/

Norton, P. (2006). *Introduction to computers* (6th ed.). Singapore: McGraw-Hill International.

O'Rourke, J., MacDonald, I., & Goldschmidt, D. (2010). Learning computer science concepts using iPhone applications. *The Journal of Computing Sciences in Colleges, 25*(6), 121-128.

Copyright by Mahidol University

OECD. (2013). *PISA 2012 results in focus: what 15-year-olds know and what they can do with what they know*. Geneva, Switzerland: OECD Programme for International Student Assessment.

OnePlus. (2015). *OnePlus 2 specifications.* Retrieved August 4, 2015, from https://oneplus.net/2/specs

Oravet, C. (2014). *Library instruction for UNIV instructors.* Auburn, AL, USA: Auburn University Libraries.

Oreskovic, A. (2014, December 12). Facebook dumps Microsoft web search results. *Reuters*.

Ornstein, A. C. (1995). Synthesis of research: teaching whole-group classrooms. *Peabody Journal of Education, 70*(2), 105-116.

Paas, F., & Sweller, G. (2014). Implications of cognitive load theory for multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed.). New York, NY, USA: Cambridge University Press.

Parmelee, D., Michaelsen, L. K., Cook, S., & Hudes, P. D. (2012). Team-based learning: a practical guide: AMEE Guide No. 65. *Medical Teacher, 34*(5), e275-e287.

Pea, R. D. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. *The Journal of the Learning Sciences, 13*(3), 423-451.

Pfeiffer, V. D. I., Gemballa, S., Jarodzka, H., Scheiter, K., & Gerjets, P. (2009). Situated learning in the mobile age: mobile devices on a field trip to the sea. ALT-J, *Research in Learning Technology, 17*(3), 187-199.

Piaget, J., & Inhelder, B. (2000). *The psychology of the child* (H. Weaver, Trans. 2nd ed.). New York, NY, USA: Basic Books.

Pierce, W. D., & Gray, C. E. (1981). *Teaching in the three domains of learning.* Blue Ridge Summit, PA, USA: University Press of America, Rowman & Littlefield Publishing Group

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879-903.

Copyright by Mahidol University

Podsakoff, P. M., MacKenzie, S. B., & Podsakoff, N. P. (2012). Sources of method bias in social science research and recommendations on how to control it. *Annual Review of Psychology, 63*, 539-569.

Procee, H. (2006). Reflection in education: a Kantian epistemology. *Educational Theory, 56*(3), 237-253.

Quine, W. V. O. (1959). *Word and object*. USA: MIT Press.

Quinn, C. (2000). *mLearning: mobile, wireless, in-your-pocket learning.* Retrieved June 9, 2014, from http://www.linezine.com/2.1/features/cqmmwiyp.htm

Ragan, E. D., Jennings, S. R., Massey, J. D., & Doolittle, P. E. (2014). Unregulated use of laptops over time in large lecture classes. *Computers & Education, 78,* 78-86.

Rauniar, R., Rawski, G., Yang, J., & Johnson, B. (2014). Technology acceptance model (TAM) and social media usage: an empirical study on Facebook. *Journal of Enterprise Information Management, 27*(1), 6-30.

Rector, L. H. (2008). Comparison of Wikipedia and other encyclopedias for accuracy, breadth, and depth in historical articles. *Reference Services Review, 36*(1), 7-22.

Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. In C. O'Malley (Ed.), *Computer-Supported Collaborative Learning* (pp. 69-197). Berlin, Germany: Springer Verlag.

Rose-Wiles, L., & Hofmann, M. M. (2013). Still desperately seeking citations: undergraduate research in the age of web-scale discovery. *Library Publications, 53*, 147-166.

Rosenthal, R., & Rubin, D. B. (1982). A simple, general purpose display of magnitude experimental effect. *Journal of Educational Psychology, 74*(2), 166-169.

Russell, B. (2009). *Human knowledge: its scope and limits.* New York, NY, USA: Routledge.

Russell, T. L. (1999). *No significant difference phenomenon* (1st ed.). Raleigh, NC, USA: North Carolina State University.

Sainz, M., & Eccles, J. (2012). Self-concept of computer and math ability: gender implications across time and within ICT studies. *Journal of Vocational Behavior, 80*, 486-499.

Copyright by Mahidol University

Sakawee, S. (2014, February 3). Thailand's One Tablet Per Child faces another dead end as a Chinese manufacturer cancels the deal. *TechInAsia*. Retrieved August 14, 2016, from https://www.techinasia.com/thailands-tablet-child-faces-dead-chinese-manufacturer-cancels-deal

Salem, J. A. (2014). *The development and validation of all four TRAILS (Tool for Real-Time assessment of Information Literacy Skills) tests for k-12 students*. (Doctor of Philosophy), Kent State University.

Samsung. (2015). *Samsung Galaxy S6 Edge.* Retrieved August 4, 2015, from http://www.samsung.com/us/mobile/cell-phones/SM-G925TZDATMB

Sana, F., Weston, T., & Cepeda, N. J. (2013). Laptop multitasking hinders classroom learning for both users and nearby peers. *Computers & Education, 62*, 24-31.

Saunders, L., Kurbanoglu, S., Boustany, J., Dogan, G., Becker, P., Blumer, E., et al. (2015). Information behaviors and information literacy skills of LIS students: an international perspective *Journal of Education for Library and Information Science, 56*, S80-S99.

Scaramozzino, J. M. (2010). Integrating STEM information competencies into an undergraduate curriculum. *Journal of Library Administration, 50,* 315-333.

Schumacher, P., & Morahan-Martin, J. (2001). Gender, Internet and computer attitudes and experiences. *Computers in Human Behavior, 17,* 95-110.

Schwartz, B. (2013, March 15). *Google Panda update 25 seems to have hit.* Search Engine Land. Retrieved August 2, 2015, from http://searchengineland.com/google-panda-update-25-seems-to-have-hit-151732

SCONUL. (2004). *Learning outcomes and information literacy.* London, UK: SCONUL.

SCONUL. (2011). *The SCONUL seven pillars of information literacy: core model: Society of College, National and University Libraries.* London, UK: SCONUL.

Copyright by Mahidol University

Sha, L., Looi, C. K., Chen, W., & Zhang, B. H. (2011). Understanding mobile learning from the perspective of self-regulated learning. *Journal of Computer Assisted Learning, 28*(4), 366-378.

Sharan, S., Sharan, Y., & Tan, I. G. C. (2013). The group investigation approaches to cooperative learning. In C. E. Hmelo-Silver, C. A. Chinn, C. K. K. Chan, & A. M. O'Donnell (Eds.), *The international handbook of collaborative learning* (pp. 334-353). New York, NY, USA: Routledge.

Sharples, M. (2000). The design of personal mobile technologies for lifelong learning. *Computers & Education, 34*, 177-193.

Shelly, G. B., Cashman, T. J., & Vermaat, M. E. (2008). *Discovering computers.* Boston, MA, USA: Thompson Course Technology.

Shelly, G. B., Freund, S. M., & Vermaat, M. E. (2011). *Introduction to computers* (8th ed.). Boston, MA, USA: Course Technology, Centage Learning.

Sheppes, G., Scheibe, S., Suri, G., Radu, P., Blechert, J., & Gross, J. J. (2014). Emotion regulation choice: A conceptual framework and supporting evidence. *Journal of Experimental Psychology: General, 143*(1), 163-181.

Simonsohn, U., Nelson, L. D., & Simmons, J. P. (2014). P-curve: a key to the file drawer. *Journal of Experimental Psychology: General, 143,* 534-547.

Smith, A. (2012). *46% of American adults are smartphone owners.* Washington, D.C., USA: Pew Internet.

Smith, A. G. (1997). Testing the surf: criteria for evaluating internet information resources. *The Public-Access Computer Systems Review, 8*(3), 5-23.

Snyder, L., Aho, A. V., Linn, M., Packer, A., Tucker, A., Ullman, J., et al. (1999). *Being fluent with information technology.* Washington, DC, USA: National Academy Press.

Soloway, E., Norris, C., Curtis, M., Krajcik, J., Marx, R., Fishman, B., et al. (2001). Making palm-size computers the PC of choice for K-12. *Learning and Leading with Technology, 28*(7), 32-35.

Stahl, G., Koschmann, T., & Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 409-426). Cambridge, UK: Cambridge University Press.

Copyright by Mahidol University

Steinberg, L. (2005). Cognitive and affective development in adolescence. *Trends in Cognitive Sciences, 9*(2), 69-74.

Stowell, J. R. (2015). Use of clickers vs. mobile devices for classroom polling. *Computers & Education, 82,* 329-334.

Stratter, S. (2012). *What's In a CPU?* Retrieved September 1, 2015, from https://www.youtube.com/watch?v=FbAilmI_QSc

Sung, H. Y., & Hwang, G. J. (2013). A collaborative game-based learning approach to improving students' learning performance in science courses. *Computers & Education, 63*, 43-51.

Thoman, E., & Jolis, T. (2005). *Literacy for the 21st century: an overview & orientation guide to media literacy education.* Malibu, CA, USA: Center for Media Literacy.

Thompson, S., & Cody, J. (2003). *Information Literacy Meeting of Experts.* Prague, Czech Republic: United States Commission on Libraries and Information Science.

Tomcho, T. J., & Foels, R. (2009). The power of teaching activities: statistical and methodological recommendations. *Teaching of Psychology, 36,* 96-101.

Townsend, K., Cufi, C., Davidson, A., & Davidson, R. (2014). *Getting started with Bluetooth low energy: tools and techniques for low-power networking* (1st ed.). Sebastopol, CA, USA: O'Reilly Media.

Tremblay, E. A. (2010). Educating the Mobile Generation: Using personal cell phones as audience response systems in post-secondary science teaching. *Journal of Computers in Mathematics and Science Teaching, 29*(2), 217-227.

Tseng, H. W., Tang, Y., & Morris, B. (2016). Evaluation of iTunes University courses through instructional design strategies and m-learning framework. *Educational Technology & Society, 19*(1), 199-210.

Tuominen, K., Savolainen, R., & Talja, S. (2005). Information literacy as a sociotechnical practice. *Library Quarterly, 75*(3), 329-345.

UNESCO Institute for Statistics. (2014a). Ratio of female to male tertiary enrollment. Retrieved July 10, 2014, from: http://data.worldbank.org/indicator/SE.ENR.TERT.FM.ZS/countries/1W

Copyright by Mahidol University

UNESCO Institute for Statistics. (2014b). Tertiary Education (ISCED 5 and 6) Enrolment / All Genders - Thailand. Retrieved July 23, 2014, from: http://data.un.org/Data.aspx?d=UNESCO&f=series%3aE_56

Vadillo, M. A., Konstantinis, E., & Shanks, D. R. (2016). Underpowered samples, false negatives, and unconscious learning. *Psychonomic Bulletin & Review, 23*(1), 87-102.

Vavoula, G., & Sharples, M. (2009). Meeting the challenges in evaluating mobile learning: a 3-level evaluation framework. *International Journal of Mobile and Blended Learning, 1*(2), 54-75.

Vinovskis, M. (2009). *From a nation at risk to no child left behind: national education goals and the creation of federal education policy.* New York, NY, USA: Teachers College Press.

Viriyapong, R., & Hartfield, A. (2013). Facing the challenges of the One-Tablet-Per-Child policy in Thai primary school education. *International Journal of Advanced Computer Science and Applications, 4*(9), 176-184.

Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2013). Challenges to learning and schooling in the digital networked world of the 21st century. *Journal of Computer Assisted Learning, 29*, 403-413.

Vygotski, K. S. (2012). *Thought and language* (E. Hanfmann, G. Vakar, & A. Kozulin, Trans. A. Kozulin Ed. Revised & expanded ed.). Cambridge, MA, USA: MIT Press.

Walkling, L. (2011). *Introduction to digital resolution.* Retrieved from http://www.ala.org.au/wp-content/uploads/2011/10/Introducton-to-Resolution.pdf

Wang, A. L. (2015). From e-learning to m-learning: the emergence of a third digital divide—learning. *Journal of Education Research, 9*(2), 225-238.

Wang, N., Chen, X., Song, G., Lan, Q., & Parsaei, H. R. (2017). Design of a new mobile-optimized remote laboratory application architecture for m-learning. *IEEE Transactions on Industrial Electronics, 64*(3), 2382-2391.

Wang, Q. (2009). Design and evaluation of a collaborative learning environment. *Computers & Education, 53*, 1138-1146.

Copyright by Mahidol University

Webber, S., & Johnston, B. (2000). Conceptions of information literacy: new perspectives and implications. *Journal of Information Science, 26*(6), 381-397.

Webster, E. A., & Hadwin, A. F. (2014). Emotions and emotion regulation in undergraduate studying: examining students' reports from a self-regulated learning perspective. *Educational Psychology: An International Journal of Experimental Educational Psychology, 34*, 1-25.

Wikipedia. (2014). *Wikipedia:WikiProject computer science*. Retrieved June 18, 2014, from http://en.wikipedia.org/wiki/Wikipedia:WikiProject_Computer_science

Wilder, S. (2005, January 7). Information literacy makes all the wrong assumptions. *The Chronicle of Higher Education, 51*(18), b18.

Winterman, B. (2009). Building better biology undergraduates through information literacy integration. *Issues in Science and Technology Librarianship, 58,* 194-201.

Winterman, B., Donovan, C., & Slough, R. (2011). Information literacy for multiple disciplines. *Communications in Information Literacy, 5*(1), 38-44.

Wittgenstein, L. (2001). *Tractus logico-philosophicus* (D. F. Pears & B. F. McGuinness, Trans. Revised ed.). New York, NY, USA: Routledge & Kegan Paul.

Woolwine, D. E. (2010). Generic versus discipline-specific skills. In A. Lloyd & S. Talja (Eds.), *Practising information literacy: bringing theoris of learning, practice and information literacy together*. Southbank, VIC, Australia: Chandos Publishing.

Yang, Y., Zhang, L., Zeng, J., Pang, X., Lai, F., & Rozelle, S. (2013). Computers and the academic performance of elementary school-aged girls in China's poor communities. *Computers & Education, 60*, 335-346.

Zheng, L., Huang, R., & Yu, J. (2014). Identifying Computer-Supported Collaborative Learning (CSCL) research in selected journals published from 2003 to 2012: a content analysis of research topics and issues. *Educational Technology & Society, 17*(4), 331-351.

Copyright by Mahidol University

Zimmerman, B. J., & Kitsantas, A. (2014). Comparing students' self-discipline and self-regulation measures and their prediction of academic achievement. *Contemporary Educational Psychology, 39*, 145-155.

Copyright by Mahidol University

APPENDICES

Copyright by Mahidol University

APPENDIX A
DIGITAL SEARCH ASSESSMENT-MASTER STANDARDS MAPPING

Information Literacy Outcomes from Informational Literacy Competency Standards for Higher Education (ILCSHE) used to develop the Digital Search Assessment

ILCSHE Outcome 1.1.e & ILCSHE Outcome 2.2.b

Standard	**Description**
ILCSHE Outcome 1.1.e	Identifies key concepts and terms that describe the information need
ILCSHE Outcome 2.2.b	Identifies keywords, synonyms and related terms for the information needed
CC9-10RH/SS4	Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social studies.
CC.11-12.R.I.4	Craft and Structure: Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze how an author uses and refines the meaning of a key term or terms over the course of a text (e.g., how Madison defines faction in Federalist No. 10).
CC11-12RH/SS4	Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10).
CC.11-12.L.4.a	Vocabulary Acquisition and Use: Use context (e.g., the overall meaning of a sentence, paragraph, or text; a word's position or function in a sentence) as a clue to the meaning of a word or phrase.

Copyright by Mahidol University

Standard	Description
CC.9-10.R.L.1	Key Ideas and Details: Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
SCONUL 3	The ability to construct strategies for locating information
ISTE 3.a	Research and Information Fluency: Plan strategies to guide inquiry.
AASL 1.1.3	Develop and refine a range of questions to frame the search for new understanding.
UNESCO 2	Know how to accurately identify and define the information needed to meet the need, solve the problem, or make the decision
ANZILF 1	The information literate person recognizes the need for information and determines the nature and extent of the information needed
TRAILS 1	Develop topic
TQF 3	Cognitive skills
TCC 2	Capacity for analytical, synthetic, constructive, critical and systematic thinking, leading to creation of bodies of knowledge or information for judicious decision-making regarding oneself and society.
TCC 5	Ability to choose and apply different technologies; skills in application of technological processes for development of oneself and society in regard to learning, communication, working, and problem-solving through constructive, proper, appropriate and ethical means.

Copyright by Mahidol University

ILCSHE Outcome 1.2.c

Standard	Description
ILCSHE Outcome 1.2.c	Identifies the value and differences of potential resources in a variety of formats (e.g., multimedia, database, website, data set, audio/visual, book)
CC11-12RH/SS7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.
SCONUL 5	The ability to compare and evaluate information obtained from different sources
ISTE 3.b	Research and Information Fluency: Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
ISTE 3.c	Research and Information Fluency: Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
AASL 1.1.4	Find, evaluate, and select appropriate sources to answer questions.
AASL 1.2.3	Demonstrate creativity by using multiple resources and formats.
UNESCO 6	Know how to fully understand found information, or know where to go for help if needed to understand it.
ANZILF 1	The information literate person recognizes the need for information and determines the nature and extent of the information needed
TRAILS 2	Identify potential sources
TQF 3	Cognitive skills
TCC 2	Capacity for analytical, synthetic, constructive, critical and systematic thinking, leading to creation of bodies of knowledge or information for judicious decision-making regarding oneself and society.
TCC 5	Ability to choose and apply different technologies; skills in application of technological processes for development of oneself and society in regard to learning, communication, working, and problem-solving through constructive, proper, appropriate and ethical means.

Copyright© by Mahidol University

ILCSHE Outcome 1.2.e

Standard	Description
ILCSHE Outcome 1.2.e	Differentiates between primary and secondary sources, recognizing how their use and importance vary with each discipline
CC11-12RH/SS1	Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.
CC9-10RH/SS9	Compare and contrast treatments of the same topic in several primary and secondary sources.
SCONUL 5	The ability to compare and evaluate information obtained from different sources
ISTE 3.c	Research and Information Fluency: Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
AASL 1.1.4	Find, evaluate, and select appropriate sources to answer questions.
UNESCO 6	Know how to fully understand found information, or know where to go for help if needed to understand it.
ANZILF 1	The information literate person recognizes the need for information and determines the nature and extent of the information needed
TRAILS 2	Identify potential sources
TQF 3	Cognitive skills
TCC 2	Capacity for analytical, synthetic, constructive, critical and systematic thinking, leading to creation of bodies of knowledge or information for judicious decision-making regarding oneself and society.
TCC 5	Ability to choose and apply different technologies; skills in application of technological processes for development of oneself and society in regard to learning, communication, working, and problem-solving through constructive, proper, appropriate and ethical means.

Copyright by Mahidol University

ILCSHE Outcome 2.2.d

Standard	Description
ILCSHE Outcome 2.2.d	Constructs a search strategy using appropriate commands for the information retrieval system selected (e.g., Boolean operators, truncation, and proximity for search engines; internal organizers such as indexes for books)
CC.11-12.W.7	Research to Build and Present Knowledge: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
SCONUL 4	The ability to locate and access information
ISTE 3.b	Research and Information Fluency: Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
AASL 1.1.8	Demonstrate mastery of technology tools for accessing information and pursuing inquiry
UNESCO 4	Know how to find the needed information if you have determined that it does, indeed, exist.
ANZILF 2	The information literate person finds needed information effectively and efficiently
TRAILS 3	Develop, use and revise search
TQF 3	Cognitive skills
TCC 2	Capacity for analytical, synthetic, constructive, critical and systematic thinking, leading to creation of bodies of knowledge or information for judicious decision-making regarding oneself and society.
TCC 5	Ability to choose and apply different technologies; skills in application of technological processes for development of oneself and society in regard to learning, communication, working, and problem-solving through constructive, proper, appropriate and ethical means.

Copyright by Mahidol University

ILCSHE Outcome 3.4.e

Standard	Description
ILCSHE Outcome 3.4.e	Determines probable accuracy by questioning the source of the data, the limitations of the information gathering tools or strategies, and the reasonableness of the conclusions
CC.11-12.W.8	Research to Build and Present Knowledge: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and over reliance on any one source and following a standard format for citation.
CC.9-10.SL.2	Comprehension and Collaboration: Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, orally) evaluating the credibility and accuracy of each source.
CC.9-10.SL.3	Comprehension and Collaboration: Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.
CC.9-10.R.I.1	Key Ideas and Details: Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
CC.9-10.R.I.8	Integration of Knowledge and Ideas: Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and fallacious reasoning.
CC.11-12.R.I.7	Integration of Knowledge and Ideas: Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.
SCONUL 5	The ability to compare and evaluate information obtained from different sources

Copyright by Mahidol University

Standard	Description
ISTE 3.c	Research and Information Fluency: Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
AASL 1.1.5	Evaluate information found in selected sources on the basis of accuracy, validity, appropriateness for needs, importance, and social and cultural context.
AASL 1.1.7	Make sense of information gathered from diverse sources by identifying misconceptions, main and supporting ideas, conflicting information, and point of view or bias.
AASL 1.2.4	Maintain a critical stance by questioning the validity and accuracy of all information.
AASL 1.3.2	Seek divergent perspectives during information gathering and assessment.
UNESCO 7	Know how to organize, analyze, interpret and evaluate information, including source reliability.
ANZILF 3	The information literate person critically evaluates information and the information seeking process
TRAILS 4	Evaluate sources and information
TQF 3	Cognitive skills
TCC 2	Capacity for analytical, synthetic, constructive, critical and systematic thinking, leading to creation of bodies of knowledge or information for judicious decision-making regarding oneself and society.
TCC 5	Ability to choose and apply different technologies; skills in application of technological processes for development of oneself and society in regard to learning, communication, working, and problem-solving through constructive, proper, appropriate and ethical means.

Copyright by Mahidol University

ILCSHE Outcome 5.1.a

Standard	Description
ILCSHE Outcome 5.1.a	Identifies and discusses issues related to privacy and security in both the print and electronic environments
CC.11-12	None
SCONUL	None
ISTE 5.a	Digital Citizenship: Advocate and practice safe, legal, and responsible use of information and technology.
AASL 1.3.1	Respect copyright/intellectual property rights of creators and producers.
AASL 1.3.3	Follow ethical and legal guidelines in gathering and using information.
AASL 1.3.5	Use information technology responsibly.
UNESCO 11	Know how to dispose of information no longer needed, and safeguard information that should be protected.
ANZILF 6	The information literate person uses information with understanding and acknowledges cultural, ethical, economic, legal, and social issues surrounding the use of information
TRAILS 5	Recognize how to use information responsibly, ethically, and legally
TQF 1	Ethical and Moral Development:
TCC 3	Problem-Solving Capacity

Copyright by Mahidol University

ILCSHE Outcome 5.1.d

Standard	Description
ILCSHE Outcome 5.1.d	Demonstrates an understanding of intellectual property, copyright, and fair use of copyrighted material
CC.11-12.W.8	Research to Build and Present Knowledge: Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and over reliance on any one source and following a standard format for citation.
SCONUL	None
ISTE 5.a	Digital Citizenship: Advocate and practice safe, legal, and responsible use of information and technology.
AASL 1.3.1	Respect copyright/intellectual property rights of creators and producers.
AASL 1.3.3	Follow ethical and legal guidelines in gathering and using information.
AASL 1.3.5	Use information technology responsibly.
UNESCO	None
ANZILF 6	The information literate person uses information with understanding and acknowledges cultural, ethical, economic, legal, and social issues surrounding the use of information
TRAILS 5	Recognize how to use information responsibly, ethically, and legally
TQF 1	Ethical and Moral Development:
TCC 3	Problem-Solving Capacity

Copyright by Mahidol University

Referenced standards mapped to each outcome

Code	Full name
AASL	AASL Standards for the 21st-Century Learner
Description:	Published by American Association of School Librarians in 2009. To be used by school libraries. The organization is a part of the American Library Association (ALA), a standards organization that works closely with National Education Association (NEA) in the United States.
ANZILF	Australian and New Zealand Information Literacy Framework
Description:	Published in 2004, this standard drives information literacy standards for the Oceana region. It is the basis for the Information Skills Survey (ISS) developed by the Council of Australian University Librarians (CAUL).
CC	Common Core State Standards
Description:	As part of accountability, the National Governors Association and the Council of Chief State School Officers have worked with state school to develop standards. The English and mathematics standards were published 2010, and as of Jan. 15, 2013, 46 of the 50 states have adopted some part of the standards. AASL encourages the use of including references to appropriate common core skills in course syllabi, and an example of this being used is in course plans developed by Google Education for searching skills.
ILCSHE	Information Literacy Competency Standards for Higher Education
Description:	Written by the Association of College and Research Libraries and published by the ALA in 2000, this has been adopted as the basis of the SAILS Information Literacy Assessment, the Information Literacy Test (ILT), and iSkills™ assessment. It is popular because it is the only information literacy with defined outcomes, thus the reason it is being used in developing the DigitalSearchAssessment.
SCONUL	SCONUL Seven Pillars of Information Literacy
Description:	Society of College, National and University Libraries (SCONUL) defines its information literacy for the UK and Ireland.

Copyright by Mahidol University

Code	Full name
TCC	Basic Education Core Curriculum-Thailand
Description:	Developed by the Ministry of Education and approved in 2008, this newer standard will supplement the first Basic Education Curriculum passed in 2001. It is to apply to all grade school by 2012. It includes Thai Language, mathematics, science, social studies, health, occupation and technology and foreign languages. What is included in this mapping is the Learners' Key Competencies
TQF	National Qualifications Framework for Higher Education in Thailand
Description:	Issued in 2006, all Thai universities have been required to incorporate Domains of Learning in their academic curriculum at all levels of university education, from advance diploma to doctoral study.
TRAILS	Tools for Real-time Assessment of Information Literacy Skills
Description:	This information literacy assessment was developed by Kent State University to be used with grade school children in the USA. Because numerous students throughout the USA have taken the survey, it provides a good benchmark against that information literacy student standard. The categories are more loosely based on a simplified version of the Common Core State Standards and the AASL
UNESCO	UNESCO Eleven Stages of Information Literacy Life Cycle
Description:	United Nations Educational, Scientific, and Cultural Organization included information in its Alexandria Proclamation and has developed it own framework with 11 steps

Copyright by Mahidol University

APPENDIX B

PARTICIPANTS GROUPED BY TERM AND TREATMENT

Participants grouped per year of study

Year of study	Term 1	Term 2	Term 3	Total per Year	P^1 Year of Study
1	40	66	4	110	0.346
2	44	29	84	157	0.494
3	3	6	15	24	0.075
4	14	5	8	27	0.085
Total	**101**	**106**	**111**	**318**	**1.000**

Term 1

Year of study	Control 1	Hybrid 1	Exp. 1	Total Term 1	p^1 of Term 1
1	15	9	16	**40**	0.396
2	14	21	9	**44**	0.436
3	3	5	0	**8**	0.079
4	6	0	3	**9**	0.089
Total Term 1	**38**	**35**	**28**	**101**	**1.000**

Term 2

Year of study	Control 2	Hybrid 2	Exp. 2	Total Term 2	p^1 of Term 2
1	22	33	11	**66**	0.623
2	6	4	19	**29**	0.274
3	2	1	3	**6**	0.057
4	0	1	4	**5**	0.047
Total Term 2	**30**	**39**	**37**	**106**	**1.000**

Copyright by Mahidol University

Term 3

Year of study	**Control 3**	**Hybrid 3**	**Exp. 3**	**Total Term 3**	***p*[1] of Term 3**
1	2	1	1	**4**	0.036
2	33	24	27	**84**	0.757
3	4	4	7	**15**	0.135
4	0	3	5	**8**	0.072
Total Term 3	**39**	**32**	**40**	**111**	**1.000**

[1] *Proportion of total*

Copyright by Mahidol University

APPENDIX C

PRETEST RESULTS MOBILE MEDIA LEARNING SURVEY

Pretest Results of Mobile Medial Learning Survey

Rank	Media	N	M	1[1]	2	3	4	5	6
1	GoogleSearch	282	1.25	219	59	2	1	1	0
2	Facebook	282	1.65	167	66	32	15	1	1
3	VideoSharing	282	1.72	154	73	40	10	5	0
4	MusicPlayer	282	1.78	139	83	47	8	4	1
5	MobileApps	282	1.79	1	2	3	4	5	0
6	PhotoCamera	281	1.84	129	89	42	20	1	0
7	OnlineDictionary	282	1.85	118	99	55	8	2	0
8	emailNOTUni	281	1.91	125	85	50	13	7	1
9	DictionarySoftware	282	1.92	136	77	39	16	12	2
10	Wi-fiCampus	282	2.21	93	77	79	25	8	0
11	Calendar	282	2.23	85	90	68	34	3	2
12	Wikipedia	282	2.47	46	98	101	34	3	0
13	VideoCalls	278	2.49	70	66	92	36	13	1
14	VideoCamera	282	2.55	61	70	94	49	8	0
15	InstantMessaging	282	2.63	61	63	92	51	12	3
16	WebUniversity	281	2.65	22	87	140	30	2	0
17	OnlineMap	282	2.74	48	72	86	56	17	3
18	PDFReader	282	2.76	39	83	94	40	16	10
19	PresentationSoftware	281	2.81	39	85	80	45	27	5
20	VideoGames	282	2.84	59	54	74	62	29	4
21	LearningApps	281	2.90	27	62	119	57	14	2
22	OnlineSlides	281	2.91	19	86	102	50	22	2
23	GPS	280	3.07	36	58	79	64	39	4
24	OnlineNotes	282	3.14	12	60	118	61	25	6
25	AudioRecorder	279	3.18	29	32	104	89	22	3
26	WordProcessing	280	3.33	29	64	63	35	36	53
27	Organizer	282	3.37	29	41	76	69	29	38
28	PortalStudents	281	3.41	10	38	113	66	22	32
29	OnlineLibraryServices	281	3.43	13	31	103	90	39	5
30	GooglePlus	282	3.43	43	30	56	68	74	11

Copyright by Mahidol University

Rank	Media	N	M	1[1]	2	3	4	5	6
31	OtherSocialNetwork	282	3.45	41	44	48	44	58	47
32	eBook	280	3.55	6	39	90	86	47	12
33	GoogleBooks	282	3.57	18	33	79	74	59	19
34	FileSyncing	281	3.66	25	32	61	58	59	46
35	BibliographicSoftware WordProcessing	282	3.67	10	43	77	52	57	43
36	OnlineSelfTests	282	3.78	0	17	97	99	60	9
37	elearningPlatform	281	3.91	4	19	82	88	59	28
38	emailUniversity	280	3.92	8	32	57	61	100	22
39	GameBaseLearning	278	3.94	10	28	50	72	56	62
40	RecordedLectures	280	3.94	4	22	60	96	94	4
41	Twitter	281	4.01	26	16	34	59	142	4
42	AugmentedReality	281	4.05	5	16	62	74	63	61
43	SocialBookmarking	279	4.05	8	21	57	55	52	86
44	eJournals	282	4.11	6	12	56	80	58	70
45	OnlineExams	282	4.15	0	7	61	96	112	6
46	OnlineOtherLibrary	280	4.17	4	11	51	81	124	9
47	VirtualClassRealtime	281	4.23	4	20	41	57	125	34
48	VirtualClassNonRealtime	281	4.29	2	9	43	78	115	34

[1] *Scale: 1 very often, 2 often, 3 sometimes, 4 rarely, 5 never, 6 don't know*

Copyright by Mahidol University

APPENDIX D

POSTTEST RESULTS MOBILE MEDIA LEARNING SURVEY

Posttest Results of Mobile Medial Learning Survey

Rank	Media	N	M	1[1]	2	3	4	5	6
1	GoogleSearch	282	1.28	218	54	8	0	2	0
2	VideoSharing	282	1.66	168	61	38	10	5	0
3	Facebook	280	1.67	166	62	34	15	2	1
4	OnlineDictionary	281	1.70	142	96	31	10	2	0
5	emailNOTUni	267	1.72	163	70	23	1	7	3
6	MusicPlayer	282	1.74	145	84	37	13	2	1
7	PhotoCamera	281	1.75	144	79	46	8	2	2
8	MobileApps	281	1.77	139	91	33	12	6	0
9	DictionarySoftware	279	1.85	136	84	36	12	10	1
10	Wi-fiCampus	282	2.04	109	81	68	19	5	0
11	PresentationSoftware	282	2.10	83	120	56	13	6	4
12	Calendar	281	2.17	71	115	74	17	4	0
13	Wikipedia	282	2.23	67	107	86	20	2	0
14	VideoCamera	282	2.46	67	68	104	36	4	3
15	PDFReader	282	2.46	54	103	79	33	7	6
16	OnlineSlides	182	2.48	37	9	103	29	3	1
17	WebUniversity	282	2.53	30	107	114	28	2	1
18	VideoCalls	282	2.55	73	57	87	53	12	0
19	LearningApps	182	2.74	28	86	8	50	8	2
20	InstantMessaging	280	2.75	62	51	80	69	17	1
21	OnlineNotes	282	2.79	19	93	107	55	7	1
22	OnlineMap	282	2.84	36	70	100	54	21	1
23	VideoGames	282	2.88	48	65	74	62	32	1
24	WordProcessing	282	2.91	62	64	58	34	29	35
25	AudioRecorder	268	3.07	28	48	98	92	1	1
26	PortalStudents	281	3.09	17	54	125	57	13	15
27	Organizer	282	3.11	26	50	106	67	20	13
28	GPS	282	3.11	25	66	75	84	30	2
29	FileSyncing	279	3.18	38	51	70	62	43	15
30	GoogleBooks	281	3.19	29	46	88	80	36	2

Copyright© Vanhdoi University

Rank	Media	N	M	1[1]	2	3	4	5	6
31	OnlineLibraryServices	182	3.21	14	46	17	78	26	1
32	GooglePlus	282	3.28	46	32	71	63	68	2
33	eBook	281	3.30	15	60	83	72	45	6
34	BibliographicSoftware WordProcessing	282	3.40	19	50	75	75	47	16
35	OtherSocialNetwork	281	3.42	38	33	64	64	59	23
36	RecordedLectures	281	3.61	9	25	91	97	59	0
37	elearningPlatform	279	3.65	2	33	85	101	48	10
38	eJournals	279	3.66	14	28	77	80	55	25
39	OnlineSelfTests	181	3.70	2	24	89	7	54	5
40	SocialBookmarking	279	3.79	12	23	83	54	60	47
41	emailUniversity	281	3.80	21	32	47	64	103	14
42	GameBaseLearning	281	3.82	11	26	64	82	61	37
43	AugmentedReality	282	3.83	7	20	76	90	58	31
44	Twitter	282	3.95	21	21	37	75	125	3
45	VirtualClassRealtime	281	4.02	11	23	49	65	119	14
46	OnlineOtherLibrary	282	4.02	7	14	48	110	96	7
47	OnlineExams	282	4.04	3	12	51	120	92	4
48	VirtualClassNonRealtime	281	4.10	2	19	53	83	104	20

** Scale: 1 very often, 2 often, 3 sometimes, 4 rarely, 5 never, 6 don't know*

Copyright by Mahidol University

APPENDIX E
DIGITAL SEARCH LITERACY ASSESSMENT GIVEN IN TERM 3

1.Which of the following would search for the exact phrase, near field monitors?

A. +near +field +monitors

B. “near field monitors”

C. near field monitors

D. near AND field AND monitors

2. Which of the following uses an .ORG domain name?

A. Amazon

B. Wikipedia

C. Google search

D. Facebook

3. Which of the following searches performs SAME as the advance search function that looks for exact word or phrase?

A. “organic crystal”

B. organic ~crystal

C. organic AND crystal

D. organic OR crystal

4. Which of the following terms MOST CLOSELY relates to civil engineering?

A. Carbon capture

B. International Building Code

C. Logistics

D. Nanotechnology

5. Which website would BEST find a book about Greek philosophy?

A. Facebook

B. Amazon

C. Google Scholar

D. Google Search

Copyright by Mahidol University

6. Which of the following terms has NO relationship to badminton
   A. Smash
   B. League
   C. Deuce
   D. Bunt
7. Which web source would provide the MOST links to a peer-reviewed journal articles?
   A. Facebook
   B. Amazon
   C. Google Search
   D. Google Scholar
8. If you write a book, what is the minimum you have to do to copyright the content?
   A. Put a copyright symbol, © year and then name at the bottom of the printed version
   B. Register with a patent form at the Thai government
   C. It becomes protected by copyright law automatically when created
   D. Register it with the Thai Department of Intellectual Property
9. Which of the following searches performs exactly the SAME as the advance search function “all of these word”?
   A. “pantomime Asia”
   B. pantomime -Asia
   C. pantomime Asia
   D. pantomime OR Asia
10. Which type of site is MOST LIKELY to have a positive bias toward particular computer brand name?
   A. .org
   B. .com
   C. .gov
   D. .edu

Copyright by Mahidol University

11. A shared document on WordPress.com that analyses what Plato wrote about Socrates posted is an example of which of the following?
    A. Opinion
    B. Secondary data
    C. Primary data
    D. Tertiary data
12. A Wikipedia entry on the Middle East is an example of which of the following?
    A. Opinion
    C. Primary source
    B. Secondary source
    D. Tertiary source
13. Which term MOST narrowly defines a type of software?
    A. Dragon Age
    B. PC video games
    C. Role-playing games
    D. Final Fantasy XI
14. Which of the following licenses RESTRICT you from manipulating a digital photo?
    A. Attribution-NoDerivs CC BY-ND
    B. Attribution-NonCommercial CC BY-NC
    C. Attribution-ShareAlike CC BY-SA
    D. CC0
15. Which of the following would BEST LIMIT search results to websites at top US research universities?
    A. Site:.org
    B. site:.us
    C. site:.com
    D. site:.edu
16. Which of the following search terms BROADEN the number of search results the most?
    A. vector AND geometry
    B. vector -geometry

Copyright by Mahidol University

C. vector OR geometry

D. vector ~geometry

17. What does verbatim in Google's search tools do?

A. It search exactly for only that word or term

B. It removes results from that search term

C. It searches for words that are similar to the search term

D. It broaden search results for a search term

18. Which of the following terms means does NOT mean search?

A. Look

B. Investigate

C. Examination

D. Charge

19. Which of the following statements appear to have the LEAST amount of bias either for or against the US Foreign Intelligence Act?

A. FISA gives procedures for the surveillance of foreign intelligence information between foreign powers

B. FISA has procedures on how to eavesdrop on foreign governments and agents of foreign powers

C. FISA severely restricts monitoring of US citizens and targets only potential foreign threats

D. FISA gives the US government the right to monitor electronic communications of foreigners abroad

20. Which of the follow would be the MOST INEFFICIENT place to search for detailed information on tracking evolutionary effects on mitochondrial DNA in fighting fish?

A. EBSCO A to Z

B. Google Search

C. sciencedirect.com

D. Google Scholar

Copyright by Mahidol University

21. A Thai copyright expires when?

A. After 25 years if published by a company

B. After 20 years from the filing date

C. After 50 years, when the individual author publishes

D. Life of the author plus 50 years

22. Which of the following terms MOST CLOSELY relates with the term Mahanyanan?

A. Torah

B. Dharma

C. Baha'i

D. Koran

23. Copyright BEST fits which situation?

A. A programmer created a new iPhone app

B. The Minister of Information and Communications Technology gives a public speech

C. A cell phone manufacture created a brand new display technology

D. A computer company created a unique logo

24. Which of the following search terms means ALMOST the SAME as contract?

A. Commitment

B. Document

C. Authorization

D. Scholarship

25. The search electrical standards is the SAME as which of the following searches?

A. electrical OR standards

B. "electrical standards"

C. electrical AND standards

D. electrical -standards

26. Published research of statistical findings on customer acceptance of online banking with analysis is an example of which of the following?

A. Primary source

B. Tertiary source

C. Opinion

D. Secondary source

Copyright by Mahidol University

27. If a music recording has an Attribution CC By license, it means which of the following?

A. You can use the music in your own video but can NOT sell your video
B. You do NOT need the author's permission but must cite the author if used in your material
C. MUST get permission in writing to use the video to use.
D. You can use the music in your video without any restrictions

28. Which of the following term is the MOST general?
A. Broadcasting
B. Weather report
C. Media
D. Newspaper

29. Which of the following terms means ALMOST the SAME as innovation?
A. Advancement
B. Technology
C. Supplemental
D. Revision

30. Which of the following searches would BEST locate a data table?
A. filetype:wav
B. filetype:doc
C. filetype:xls
D. filetype:ppt

31. Which of the following websites would MOST LIKELY use the top domain name .AU?
A. Sydney Airport
B. Assumption University
C. Austin College
D. Dubai Trade Office in the Arab Emirates

32. Which of the following would be illegal to use without permission?
A. The printed version of original Thai Ramkien
B. Digital photos of Grand Palace from 1880
C. A pamphlet of the Constitution of the Kingdom of Thailand
D. A video of the morning newscast of Channel 3

Copyright by Mahidol University

33. If a student used a music track from a famous pop group in a YouTube video, this would be an example of which?
    A. Exclusive rights
    B. Copyright infringement
    C. Patent violation
    D. Fraudulent usage
34. Which of the following search terms is BROAD enough to contain the results of all the others?
    A. Monoplane
    B. Aircraft
    C. Boeing
    D. B29 Superfortress
35. Which type of site is likely to contain bias information from a special interest group, such as either for or against cutting down forests?
    A. .edu
    B. .org
    C. .gov
    D. .com
36. Which of the following health terms is the MOST specific?
    A. Liver cancer
    B. Advanced disease
    C. Age-related illnesses
    D. Fatigue
37. Which of the following would BEST LIMIT search results to finding information at an Egyptian website?
    A. site:.ge
    B. site:.org
    C. site:.com
    D. site:.eg
38. Which of the following terms is MOST specific geographic subdivision of a Thai government area?
    A. Phetchaburi

Copyright by Mahidol University

B. Southern District

C. Din Daeng

D. Phra Nakhon Si Ayutthaya

39. Which of the following search terms means ALMOST the SAME as waste?

A. Disposal

D. Materials

C. Paraphernalia

B. Rework

40. Which of the following will LIMIT searches to Thai universities?

A. site:.co.th

B. site:.ac.th

C. site:.go.th

D. site:.or.th

41. A videocast on Best Japanese quick response yoyos to buy is an example of which of the following?

A. Tertiary data

B. Secondary data

C. Primary data

D. Opinion

42. Which of the following searches performs exactly the SAME as the advance search function that looks for any of these words?

A. aviation ~history

B. aviation AND history

C. “aviation history”

D. aviation OR history

43. Which is an example of a primary source in science?

A. Article on the results of a clinical trial in gene therapy in the respected nature.com

B. A youtube.com video on distillation techniques for organic chemistry

C. The darwinproject.ac.uk with letters from Charles Darwin talking about details on specimen collection

D. Index of all files offered at archive.org

Copyright by Mahidol University

44. Which of the following would allow anyone to make changes to a digital photo and use it in their own material legally without asking permission?
    A. Trademark
    B. Public Domain
    C. Fair Use
    D. Creative Commons No Derivate Works
45. Which Creative Commons license allows you to give up all rights to your creation?
    A. Attribution-NonCommercial CC BY-NC
    B. CC0
    C. Attribution-NoDerivs CC BY-ND
    D. Attribution-ShareAlike CC BY-SA
46. Which of the following is the LEAST credible source of information on the nutritious value of Thai red curry
    A. Research published in online Kasetsart Journal
    B. DVD nutrient database from Mahidol University
    C. Blog site from a Thai nutritionist
    D. App from fitness site
47. Which of the terms would MOST narrowly define a clothing type?
    A. Boot-cut denim jeans
    B. Cardigan sweater
    C. Wedding apparel
    D. Sportswear
48. What is the MOST LIKELY source of the phrase, "…makes for the best software even on an IOS device"?
    A. An entry in Wikipedia
    B. An online article on education technology
    C. A message post in Facebook
    D. A review on Redditt
49. Which of the following search terms is BROAD enough to contain the results of all the others?
    A. Life science
    B. Biology

Copyright by Mahidol University

C. Genetics

D. Biochemistry

50. The search Bollywood stars is the SAME as which of the following searches?

A. “bollywood stars”

B. bollywood OR stars

C. bollywood AND stars

D. bollywood ~stars

Copyright by Mahidol University

APPENDIX F

MAPPING OF ILCSHE OUTCOMES TO DIGITAL SEARCH LITERACY ASSESSMENT

	Item	Standard	Description
	Standard	1	The information literate student determines the nature and extent of the information needed
	Performance Indicators	1.1	The information literate student defines and articulates the need for information
	Outcomes	1.1.e	Identifies key concepts and terms that describe the information need
	Number of questions	14	
#	Item	Standard	Description
1	Category	1.1.e	Distinguishing more narrow search terms in different hierarchical categories
1	Outcome Measured	1.1.e	The participant can recognize the search term that narrows to a more defined category.
1	Question1.1.e.01	1.1.e	Which of the following terms is MOST specific geographic subdivision of a Thai government area?
2	Category	1.1.e	Distinguishing more narrow search terms in different hierarchical categories
2	Outcome Measured	1.1.e	The participant can recognize the search term that narrows to a more defined category.
2	Question1.1.e.02	1.1.e	Which of the terms would MOST narrowly define a clothing type?
3	Category	1.1.e	Distinguishing more narrow search terms in different hierarchical categories
3	Outcome Measured	1.1.e	The participant can recognize the search term that narrows to a more defined category.
3	Question1.1.e.03	1.1.e	Which of the following health terms is the MOST specific?

Copyright by Mahidol University

#	Item	Standard	Description
4	Category	1.1.e	Distinguishing more narrow search terms in different hierarchical categories
4	Outcome Measured	1.1.e	The participant can recognize the search term that narrows to a more defined category.
4	Question1.1.e.04	1.1.e	Which term MOST narrowly defines a type of software?
5	Category	1.1.e	Distinguishing broader search terms in different hierarchical categories
5	Outcome Measured	1.1.e	The participant can recognize the search term that defines a broader category.
5	Question1.1.e.05	1.1.e	Which of the following search terms is BROAD enough to contain the results of all the others?
6	Category	1.1.e	Distinguishing broader search terms in different hierarchical categories
6	Outcome Measured	1.1.e	The participant can recognize the search term that defines a broader category.
6	Question1.1.e.07	1.1.e	Which of the following search terms is BROAD enough to contain the results of all the others?
7	Category	1.1.e	Distinguishing broader search terms in different hierarchical categories
7	Outcome Measured	1.1.e	The participant can recognize the search term that defines a broader category.
7	Question1.1.e.08	1.1.e	Which of the following term is the MOST general?
8	Category	1.1.e	Search terms associated with each other
8	Outcome Measured	1.1.e	The participant can recognize terms that have an associate relationship.
8	Question1.1.e.10	1.1.e	Which of the following terms MOST CLOSELY relates to civil engineering?
9	Category	1.1.e	Search terms associated with each other
9	Outcome Measured	1.1.e	The participant can recognize terms that have an associate relationship.
9	Question1.1.e.11	1.1.e	Which of the following terms MOST CLOSELY relates with the term *Mahanyanan*?

Copyright by Mahidol University

#	Item	Standard	Description
10	Category	1.1.e	Search terms associated with each other
10	Outcome Measured	1.1.e	The participant can recognize terms that have an associate relationship.
10	Question1.1.e.12	1.1.e	Which of the following terms has NO relationship to *badminton*
11	Category	1.1.e	Search terms that are similar to each other
11	Outcome Measured	1.1.e	The participant can recognize search terms that have similar meaning.
11	Question1.1.e.13	1.1.e	Which of the following terms means does NOT mean *search*?
12	Category	1.1.e	Search terms that are similar to each other
12	Outcome Measured	1.1.e	The participant can recognize search terms that have similar meaning.
12	Question1.1.e.14	1.1.e	Which of the following terms means ALMOST the SAME as *innovation*?
13	Category	1.1.e	Search terms that are similar to each other
13	Outcome Measured	1.1.e	The participant can recognize search terms that have similar meaning.
13	Question1.1.e.15	1.1.e	Which of the following search terms means ALMOST the SAME as *contract*?
14	Category	1.1.e	Search terms that are similar to each other
14	Outcome Measured	1.1.e	The participant can recognize search terms that have similar meaning.
14	Question1.1.e.16	1.1.e	Which of the following search terms means ALMOST the SAME as *waste*?

Copyright by Mahidol University

	Item	Standard	Description
	Standard	1	The information literate student determines the nature and extent of the information needed
	Performance Indicators	1.2	The information literate student identifies a variety of types and formats of potential sources for information
	Outcomes	1.2.c	Identifies the value and differences of potential resources in a variety of formats (e.g., multimedia, database, website, data set, audio/ visual, book)
	Number of questions	9	
#	**Item**	**Standard**	**Description**
15	Category	1.2.c	Differentiating between different media sources
15	Outcome Measured	1.2.c	The participant can identify the types of information found in well-known online databases.
15	Question1.2.c.01	1.2.c	Which website would BEST find a book about Greek philosophy?
16	Category	1.2.c	Differentiating between different media sources
16	Outcome Measured	1.2.c	The participant can identify the types of information found in well-known databases.
16	Question1.2.c.03	1.2.c	Which of the follow would be the MOST INEFFICIENT place to search for detailed information on *tracking evolutionary effects on mitochondrial DNA in fighting fish*?
17	Category	1.2.c	Differentiating between different media sources
17	Outcome Measured	1.2.c	The participant can identify the types of information found in well-known databases.
17	Question1.2.c.04	1.2.c	Which web source would provide the MOST links to a peer-reviewed journal articles?

Copyright by Mahidol University

#	Item	Standard	Description
18	Category	1.2.c	Differentiating information based on top-level domain name
18	Outcome Measured	1.2.c	The participant can distinguish sources of data based on the top-level domain name.
18	Question1.2.c.06	1.2.c	Which of the following would BEST LIMIT search results to websites at top US research universities?
19	Category	1.2.c	Differentiating information based on top-level domain name
19	Outcome Measured	1.2.c	The participant can distinguish sources of data based on the top-level domain name.
19	Question1.2.c.07	1.2.c	Which of the following would BEST LIMIT search results to finding information at an Egyptian website?
20	Category	1.2.c	Differentiating information based on top-level domain name
20	Outcome Measured	1.2.c	The participant can distinguish sources of data based on the top-level domain name.
20	Question1.2.c.08	1.2.c	Which of the following uses an .ORG domain name?
21	Category	1.2.c	Differentiating information based on top-level domain name
21	Outcome Measured	1.2.c	The participant can distinguish sources of data based on the top-level domain name.
21	Question1.2.c.09	1.2.c	Which of the following websites would MOST LIKELY use the top domain name .AU?

Copyright by Mahidol University

#	Item	Standard	Description
22	Category	1.2.c	Differentiating information based on second-level domain name
22	Outcome Measured	1.2.c	The participant can distinguish sources of data based on the second-level domain name.
22	Question1.2.c.10	1.2.c	Which of the following will LIMIT searches to Thai universities?
23	Category	1.2.c	Differentiating types of source file
23	Outcome Measured	1.2.c	The participant understands how to search for particular file formats.
23	Question1.2.c.13	1.2.c	Which of the following searches would BEST locate a data table?

Copyright by Mahidol University

	Item	Standard	Description
	Standard	1	The information literate student determines the nature and extent of the information needed
	Performance Indicators	1.2	The information literate student identifies a variety of types and formats of potential sources for information
	Outcomes	1.2.e	Differentiates between primary and secondary sources, recognizing how their use and importance vary with each discipline
	Number of questions	5	
#	**Item**	**Standard**	**Description**
24	Category	1.2.e	Selecting examples of primary sources
24	Outcome Measured	1.2.e	The participant can differentiate if information comes from a primary source in specific examples in different disciplines.
24	Question1.2.e.01	1.2.e	Which is an example of a primary source in science?
25	Category	1.2.e	Differentiating between primary, secondary and tertiary sources
25	Outcome Measured	1.2.e	The participant can differentiate if information comes from a primary source, secondary source or tertiary source in specific examples.
25	Question1.2.e.06	1.2.e	*Published research of statistical findings on customer acceptance of online banking with analysis* is an example of which of the following?
26	Category	1.2.e	Differentiating between primary, secondary and tertiary sources
26	Outcome Measured	1.2.e	The participant can differentiate if information comes from a primary source, secondary source or tertiary source in specific examples.
26	Question1.2.e.07	1.2.e	A Wikipedia entry on the *Middle East* is an example of which of the following?

Copyright by Mahidol University

#	Item	Standard	Description
27	Category	1.2.e	Differentiating between primary, secondary and tertiary sources
27	Outcome Measured	1.2.e	The participant can differentiate sources of information.
27	Question1.2.e.09	1.2.e	A videocast on *Best Japanese quick response yoyos to buy* is an example of which of the following?
28	Category	1.2.e	Differentiating between primary, secondary and tertiary sources
28	Outcome Measured	1.2.e	The participant can differentiate sources of information
28	Question1.2.e.10	1.2.e	A shared document on WordPress.com that analyses what Plato wrote about Socrates posted is an example of which of the following?

Copyright by Mahidol University

	Item	Standard	Description
	Standard	2	The information literate student accesses needed information effectively and efficiently
	Performance Indicators	2.2	The information literate student constructs and implements effectively-designed search strategies
	Outcomes	2.2.d	Constructs a search strategy using appropriate commands for the information retrieval system selected (e.g., Boolean operators, truncation, and proximity for search engines; internal organizers such as indexes for books)
	Number of questions	8	
#	**Item**	**Standard**	**Description**
29	Category	2.2.d	Using Boolean operator AND
29	Outcome Measured	2.2.d	The participant understand equivalent search terms to AND.
29	Question2.2.d.01	2.2.d	The search *electrical standards* is the SAME as which of the following searches?
30	Category	2.2.d	Using Boolean operator AND
30	Outcome Measured	2.2.d	The participant understand equivalent search terms to AND.
30	Question2.2.d.03	2.2.d	The search *Bollywood stars* is the SAME as which of the following searches?
31	Category	2.2.d	Using Boolean operator AND
31	Outcome Measured	2.2.d	The participant understand equivalent search terms to AND.
31	Question2.2.d.04	2.2.d	Which of the following searches performs exactly the SAME as the advance search function “all of these word”?
32	Category	2.2.d	Using Boolean operator OR
32	Outcome Measured	2.2.d	The participant understands when to use OR.
32	Question2.2.d.05	2.2.d	Which of the following search terms BROADEN the number of search results the most?

Copyright by Mahidol University

#	Item	Standard	Description
33	Category	2.2.d	Using Boolean operator OR
33	Outcome Measured	2.2.d	The participant understands when to use OR.
33	Question2.2.d.06	2.2.d	Which of the following searches performs exactly the SAME as the advance search function that looks for any of these words?
34	Category	2.2.d	Phrase Boolean operator
34	Outcome Measured	2.2.d	The participants understand when to use a phrase operator.
34	Question2.2.d.07	2.2.d	Which of the following searches performs SAME as the advance search function that looks for exact word or phrase?
35	Category	2.2.d	Phrase Boolean operator
35	Outcome Measured	2.2.d	The participants understand when to use a phrase operator.
35	Question2.2.d.08	2.2.d	Which of the following would search for the exact phrase, *near field monitors*?
36	Category	2.2.d	Phrase Boolean operator
36	Outcome Measured	2.2.d	The participants understand when to use a phrase operator.
36	Question2.2.d.10	2.2.d	What does verbatim in Google's search tools do?

Copyright by Mahidol University

	Item	Standard	Description
	Standard	3	The information literate student evaluates information and its sources critically and incorporates selected information into his or her knowledge base and value system
	Performance Indicators	3.4	The information literate student compares new knowledge with prior knowledge to determine the value added, contradictions, or other unique characteristics of the information
	Outcomes	3.4.e	Determines probable accuracy by questioning the source of the data, the limitations of the information gathering tools or strategies, and the reasonableness of the conclusions
	Number of questions	5	
#	**Item**	**Standard**	**Description**
37	Category	3.4.e	Bias in wording
37	Outcome Measured	3.4.e	The participant is aware of bias in the wording in text.
37	Question3.4.e.01	3.4.e	Which of the following statements appear to have the LEAST amount of bias either for or against the US Foreign Intelligence Act?
38	Category	3.4.e	Bias in wording
38	Outcome Measured	3.4.e	The participant is able to identify the source of information based on the bias in the wording in text.
38	Question3.4.e.03	3.4.e	What is the MOST LIKELY source of the phrase, "…makes for the best software even on an IOS device"?
39	Category	3.4.e	Potential bias from domain names
39	Outcome Measured	3.4.e	The participant can evaluate the potential bias from a domain name.
39	Question3.4.e.05	3.4.e	Which type of site is MOST LIKELY to have a positive bias toward particular computer brand name?

Copyright by Mahidol University

#	Item	Standard	Description
40	Category	3.4.e	Potential bias from domain names
40	Outcome Measured	3.4.e	The participant can evaluate the potential bias from a domain name.
40	Question3.4.e.07	3.4.e	Which type of site is likely to contain bias information from a special interest group, such as either for or against cutting down forests?
41	Category	3.4.e	Evaluating expertise of information source
41	Outcome Measured	3.4.e	The participant can evaluate the credibility of an online source
41	Question3.4.e.12	3.4.e	Which of the following is the LEAST credible source of information on the nutritious value of Thai red curry

Copyright by Mahidol University

	Item	Standard	Description
	Standard	5	The information literate student understands many of the economic, legal, and social issues surrounding the use of information and accesses and uses information ethically and legally
	Performance Indicators	5.1	The information literate student understands many of the ethical, legal and socio-economic issues surrounding information and information technology
	Outcomes	5.1.d	Determines probable accuracy by questioning the source of the data, the limitations of the information gathering tools or strategies, and the reasonableness of the conclusions
	Number of questions	9	
#	Item	Standard	Description
42	Category	5.1.d	Understanding copyright law
42	Outcome Measured	5.1.d	The participant understands what constitutes copyright infringement.
42	Question5.1.d.01	5.1.d	If a student used a music track from a famous pop group in a YouTube video, this would be an example of which?
43	Category	5.1.d	Understanding copyright law
43	Outcome Measured	5.1.d	The participant knows when a copyright comes legally into existence?
43	Question5.1.d.02	5.1.d	If you write a book, what is the minimum you have to do to copyright the content?
44	Category	5.1.d	Understanding copyright law
44	Outcome Measured	5.1.d	Participant understands the length of term for a copyright.
44	Question5.1.d.03	5.1.d	A Thai copyright expires when?
45	Category	5.1.d	Understanding copyright law
45	Outcome Measured	5.1.d	The participant understands public domain.
45	Question5.1.d.04	5.1.d	Copyright BEST fits which situation?

Copyright by Mahidol University

#	Item	Standard	Description
46	Category	5.1.d	Understanding public domain
46	Outcome Measured	5.1.d	The participant understands what is in the public domain.
46	Question5.1.d.05	5.1.d	Which of the following would allow anyone to make changes to a digital photo and use it in their own material legally without asking permission?
47	Category	5.1.d	Understanding public domain
47	Outcome Measured	5.1.d	The participant understands what is in the public domain.
47	Question5.1.d.06	5.1.d	Which of the following would be illegal to use without permission?
48	Category	5.1.d	Understanding Creative Commons licenses
48	Outcome Measured	5.1.d	Participant understands various creative commons licenses and their uses.
48	Question5.1.d.07	5.1.d	Which of the following licenses RESTRICT you from manipulating a digital photo?
49	Category	5.1.d	Understanding Creative Commons licenses
49	Outcome Measured	5.1.d	Participant understands various creative commons licenses and their uses.
49	Question5.1.d.08	5.1.d	If a music recording has an Attribution CC By license, it means which of the following?
50	Category	5.1.d	Understanding Creative Commons licenses
50	Outcome Measured	5.1.d	Participant understands various creative commons licenses and their uses.
50	Question5.1.d.9	5.1.d	Which Creative Commons license allows you to give up all rights to your creation?

Copyright by Mahidol University

APPENDIX G
MOBILE MEDIA LEARNING SURVEY

I. Introduction

Thank you for participating in this survey.

The findings are intended to help to improve the understanding of media and information usage patterns of students. I assure you that all data will be handled strictly confidential. The survey will be completely anonymous. If you have questions regarding the project, you can contact me at any time:

Brian Phillips
E-mail: icns141@gmail.com, frbjph@gmail.com

Instructions

The completion of this questionnaire is voluntary. If you do not understand a question, please mark *Don't know*. You can leave a comment if you want to make a suggestion or if you have a problem with the questionnaire.

Most questions have scales, and the meaning of the scale is always written on top of the question section.

Copyright by Mahidol University

Selection one choice for each question

2.	**Which of the following <u>MOBILE DEVICES</u> do you use?**	**1. Very often**	**2. Often**	**3. Sometimes**	**4. Rarely**	**5. Never**	**6. Don't know**
2.1	Smartphone						
2.3	Tablet computer						
2.4	Ultrabook or MacAir						
2.5	Notebook computer						
2.6	Netbook computer						
2.7	Desktop PC						
2.8	Internet connection at home						
2.9	ebook reader (Kindle, Nook, Sony Reader)						
2.10	Handheld game console						

In this section, select as many options as apply

2.1.1 Type of smartphone (can select more than one)									
	iPhone		Android		Windows		Blackberry		Other
2.3.1 Type of tablet (can select more than one)									
	iPad		Android		Windows		Blackberry		Other
2.4.1 Operating system used on ultrabook (can select more than one)									
	Windows		Mac OS X		Linux		Other		
2.5.1 Operating system used on notebook/netbook (can select more than one)									
	Windows		Mac OS X		Linux		Other		

Copyright by Mahidol University

Selection one choice for each question

3.	**Which of the following media services on a <u>MOBILE DEVICE</u> do you use?**	**1. Very often**	**2. Often**	**3. Sometimes**	**4. Rarely**	**5. Never**	**6. Don't know**
3.1	Wireless connection (Wi-Fi, WLAN) on campus						
3.2	Learning software/apps						
3.3	University website						
3.4	Web portal for online student web services						
3.5	E-learning platform (Moodle, Blackboard)						
3.6	Online lecture notes and journals from teacher						
3.7	Online slides (PowerPoint, Keynote) from teacher						
3.8	Recorded lectures (audio, video)						
3.9	Virtual class in realtime (virtual lectures, webconferences)						
3.10	Virtual class in non-realtime (web seminars)						
3.11	Online exams						
3.12	Interactive online tests/self tests						
3.13	Mobile apps						
3.14	Online dictionary						
3.15	Dictionary software installed on your mobile device						
3.16	Online services of the university/faculty library						
3.17	Online services of other libraries (not own university)						
3.18	E-Books (pdf or other formats)						
3.19	University e-mail account						
3.20	E-mail account not from university (MSN, Yahoo, Gmail)						
3.21	Wikipedia						
3.22	Google Search						
3.23	Google Books						
3.24	Social bookmarking (Delicious)						
3.25	Facebook						
3.26	Google+						
3.27	Other social networks (LinkedIn)						
3.28	Instant messengers (MSN Messenger, Yahoo						

Copyright by Mahidol University

3.	**Which of the following media services on a <u>MOBILE DEVICE</u> do you use?**	**1. Very often**	**2. Often**	**3. Sometimes**	**4. Rarely**	**5. Never**	**6. Don't know**
	Messenger, Skype)						
3.29	Video sharing websites (YouTube)						
3.30	Twitter						
3.31	Video calls (Facetime, Skype)						
3.32	Bibliographic software (Endnote, Zotero)						
3.33	Wordprocessing						
3.34	Presentation software (PowerPoint, Keynote)						
3.35	Game-based learning (stock simulation)						
3.36	Augmented Reality apps (Geotagging in Google Earth)						
3.37	Video games						
3.38	Music player						
3.39	Audio recorder						
3.40	E-version journals						
3.41	File syncing (Dropbox, Sugersync, Skydrive)						
3.42	PDF reader						
3.43	Online maps (Google Earth, Google Map)						
3.44	GPS						
3.45	Video camera						
3.46	Photo camera						
3.47	Organizer						
3.48	Calendar						

Please write in answer

7. Personal data
7.2 How old are you?
7.3 What is your nationality?
7.4 What is your native language?

8. Comments:

Copyright by Mahidol University

APPENDIX H
CODING OF LEARNING JOURNAL ABOUT LEARNING FROM MCPATH

Code	Student learning more from mCpath
Team Learning	Learn as a team
	Sharing
	Learn from other teams
	Work as a team
	Team discussions
Team Learning	Learn on their own
	Didn't read team reports before exam
	Dislike working with a team
	Focused only on finishing task
Code	**Student learning more from mCpath**
Self-efficacy	Improved self-learning
	Better computer skills
	Better concentration, remembering
	Better English reading skills
	Improvement in searching
	More responsible
	Synthesize many sources together
	Transferability of skills to other classes
Self-efficacy	Confused
	Other groups found different information
	Unsure of correct, credible answer
	Websites have different answers
	Difficulty
	Remembering, understanding information
	Searching for information
	Dislike self-learning

Copyright by Mahidol University

Code	Student learning more from mCpath
mCpath Process	Interesting
	Easier to learn
	Interactive
	Novel
	No information limits
	Learn from roles
	Different Tasks
Code	**Students learning less from mCpath**
mCpath Process	Don't understand main point of lesson
	Roles
	Can't understand Presenter
	Only Reporter important
	Too much
	Information to study for exam
	Questions to answer
	Reading from websites
Lecture process	Enjoy listening to lecture
	Lectures already interactive
	Learn best by taking notes

Copyright by Mahidol University

APPENDIX I
GUIDE TO IMPLEMENTING MCPATH

Introduction

Like any new introduced into the classroom, leave plenty room for the learning curve, for both the students and yourself. Expect Murphy's first law to be in full effect, that if anything can go wrong, it will. Any change in process in the classroom will have issues the first time. This is true of any teaching heavily relying on technology. I still remember the awkwardness of using PowerPoint the first few time. There was no plugin near the laptop, so the laptop battery ran out. There was the old issue with knowing the mystical, magical key sequence in each different laptop to send video out. I stood right in front of the screen for three weeks until one meek student finally said could I please move because he couldn't read the slides.

With mCpath, students are exposed to the vagaries of wi-fi connection and speed. With universities protected with a proxy server, first-year students will still be waiting on passwords and older seniors will have lost theirs. Smartphones and iPads will hang. This is where you learn the restart sequence for different mobile platforms is different than the desktop method, holding the button till it shuts down.

The objective of this method is to have students do meaningful learning by overcoming these obstacles. My recommendation is to pilot test first, have a plan, and be willing to switch to option B when needed.

I'm a believer in piloting anything new in the class. You can put a vast amount of thought, effort, and planning into that first sesson, have a fire brigade ready in the side hall, but still, you are stepping into the great unknown. The best way to control for a likely crash is to keep the risk small. This also goes for the assessment. Pilot test grading the first mCpath session. Because this is the first go, you also have no idea how you are going to grade the work or what to expect as the base-line mark.

Copyright© by Mahidol University

The best way to prepare to implement mCpath is to prepare. This means have a plan and stick to it - until the power goes out. If you are unsure of what you

want to do and accomplish, your bright undergraduates will sense this and will push you to what they want to do. An example of this randomizing groups. If you plan and organize these group in advance, there will be a few pleas, but most will accept their fate and work with their assign group. If you are unsure about this, the students are quite sure they want to stay with their life-long friends.

Finally, do have a backup plan in case the internet goes black, everyone's battery is down to 1 percent, and half of the class can not attend because roads are flooded.

Orientation session

Be prepared to brief the students a couple of times and be willing to explain the roles over and over again. The students will often nod their head and look like they understand, but they will better appreciate what they need to do when they actually participate in the first mCpath session.

The sooner you can assign mCpath groups, the better. This first meeting can be awkward, so allocate some class time and have them work together in an ice-breaking activity. Because I assign group the first computer lab class, I have the groups work together draw avatars representing themselves using Gimp for the first time. They are given a quick overview to the interface and some of the drawing tools. None are familiar with this program, so there is initial high interaction. They are all slightly confused and asking each other what should they do next.

Since the method focuses on students using mobile devices, creating activities around using these would work well. A British pub quiz night format with the assistance of a phone works well. Jump ahead in some of the topics covered in class and see how well the teams can find the answers. Team selfies make sense. For this, set three to five themes a keep a tight time limit, so it has a game atmosphere. Here are some examples:

- We are the champions
- Happiest team
- Making the ugliest face

Copyright by Mahidol University

- Duck face
- Supper sexy

Another quick one would be to have students video an introduction of themselves. Record each in sequence, so that there is no need for editing. They have to say their name, talk about their favorite movie, and say the word that best describes themselves. Given the stage of virtual assistants, a recorded interview of Siri answering students' questions

The voice to text function in smartphones also makes for an interesting test experience. The version they read can be songs, famous speeches or just simply from the textbook. Have some students read this into their phone and have other member read it back. In front of the class is preferred. A variation of this is to use Google Translate. The telephone game has been a traditional icebreaker, and it works very much the same when the other person is your phone.

Technology required for the class

The minimal requirement for instructors is that they have access to some communication tool and that they can use this will all of their class with that service. It needs to have two functions:

- Site or service that allows teachers to communicate to students
- Private way for teacher and students to talk

mCpath was originally pilot tested using only email. I did quickly include a website so that students could read the path questions on any device. In the currently implementation, I still heavily rely on my website, Google Forms, and email. The Line app, Evernote, Dropbox, Microsoft OneDrive and other cloud services are fine for sharing information. Even turnitin.com would work well, although it depends if you require the Reporters to paraphrase what they find or allow them to copy/paste.

The one issue is that the individual grades are something that the teacher should not share with others. The same with students' peer report. If one student gives another one a poor grade, it will cause unnecessary conflict and hurt the instructor's credibility if that information is shared with the group. I also do not share mCpath

Copyright by Mahidol University

reports with the whole group or the whole class. Those students that wrote the report must share it with their group.

The advantage of a learning platform like Moodle and Blackboard is that the teacher can share information with everyone and at the same time keep individual grades confidential. One prevalent external service is Canvas. The issue with learning platforms is that instead of being a helpful tool, it can become a full-time job on its own. Usually, it takes time setting the system up and maintaining it.

There is a new generation of social network software that allows better team communication. I am using the educational version of Basecamp, one of the originators in this field. An issue is it is like Facebook in that I cannot be sure if I can post a private message, so I don't use it to share grades.

mCpath teams

Ideally, there will be 5 students per term. This should vary from a minimum of 4 to a maximum of 6. If there only 4 students, there should be the two reporters and then for the other three roles, the team can decide which one they will not perform that time. For 6 members, there should be 2 Presenters. If a team drops to 3 members, either some may have to take on more responsibility of completing two roles, or the team needs to be broken up and reassigned to other teams.

Because there is no way to know which student has more knowledge or more skills and which one has less, the fairest way to assign teams is randomly. Emphasizing to the students that each had an equal chance of being selected for each group is the fairest way to select members as well.

mCpath roles

The members of the groups should decide on which role each student selects. Part of the team dynamics comes from them deciding on how to make such decisions. During the orientation and also during the mCpath session, encourage the students to work as a team, to help each other find information and double-check the quality of the reports. Emphasize that they are all individually responsible for their reports. If they help each other, their grades will be higher, so that their group score will be higher.

Copyright by Mahidol University

For my scoring, 10 percent of their total grade is the individual grade, 10 percent is the group score, the mean average score of all the individuals, and the other 5 percent is the peer score. This means the mCpath is a sizable portion of the grade, but the midterm and final still mainly determines their score. I assume the peer scores for most students will be a high 5 or 4. This means a student can survive low individual scores but not if they don't complete their reports.

For each mCpath cycle, the students should rotate roles, so that they will learn new skills.

The reports are all due at the end of the week. I've experimented with giving extra week, and the quality of the reports does not improve. The Presenters need to speak during the class, but as part of their report, they are asked to upload a video recording of their presentation and answer some questions. There can be technical difficulties with some of these free services, but I highly recommend putting the responsibility on the students. If there was an issue receiving a Google form, if students made a backup, then it isn't a big deal to have them send that as proof that they did the work. The day before the reports are due, I always remind students that if they wait untill the last minute of the day, there are many things that can go wrong. Their service provider may take their service offline. There could be a power outage. The service may lock up because too many students are submitting at the same time.

I've also experimented with not grading the first mCpath or giving everyone an A. The issue is that students think they will receive an A for every session, and then will put less effort into learning the next time. I've found that being tough on grading the first round forces students to take the method seriously. They will put more effort into improving if they receive clear feedback on how.

Path questions

The path questions need to be broad enough that students will find the same materials they would have received through a lecture on a chapter on a book. What I have implemented now is that there will be six path questions for each path and two paths. This means the contents of the class need to be covered in 12 questions. The majority need to be broad enough that it can generate large swatches of content. At the same time, there will be specific terminology or technology or technique that

Copyright by Mahidol University

needs to be covered. Using computer concepts as an example, I want students to sensibly compare between different display technologies and be able to explain the advantages and disadvantages to each. At the same time, they need to know the meaning of pixel, dot pitch, resolution and response rate.

The other issue for computer technology is that there is constant development. Back to displays, quantum-dot displays may or may not revolutionize the industry. For a while, the race for the maximum dots per inch in smartphone displays slowed down but is again heating up. Finally, OLED has allowed for the curved phone screens. For storage, we are at the edge of helium and HAMR drives. Even something mundane as USB draws controversy with the Apple forced introduction of USB C. The mCpath process is one method for finding these new technology trends, and in turn, the types of questions asked will change each term. Your path questions should be the bread and butter of what you are covering. Just don't forget to add the peppers, pickles, and cheese that adds an interesting, creative taste. Certainly, throw in a question that covers that new issue about voting security in the USA and your country or the world-wide WannaCry ransomware attack. This m-learning method should help you cover the basics and also be relevant and fresh.

If you are at a loss of where to start or what questions to ask, the review questions in the back of the chapter are a suitable inspiration. If you use test banks, strip away the choices and use the stem as the question. For my class, up to the midterm point I consciously focused on having students remember and understand. The tried and test action verbs that relate to this are define, list recall, and identify for remembering. For understanding, I often ask students to explain, illustrate, give an example. Because all undergraduates need practice analyzing, I use plenty of questions that include compare, contrast, differences, and similarities.

Reporter

The Reporters need to answer all of their path questions, along with listing the websites they use by the end of the week. Emphasize this several times and also include it in their instructions every time. Most will complete their reports, but there are always a couple that interpret any instruction so that they put in the least amount of

Copyright by Mahidol University

effort. Certainly, give the grade such minimal work deserve. This is the advantage of the mCpath, that those students that try to get a free ride get a lower grade.

The mCpath report includes the answer and also the URL addresses they use in their search for each question.

For the Reporters, I also remind them several times that the more sources they use, the better will be the final information. In general, the answers for the first round will tend to be too short. Students will tend to use only one source. You will also often see the same websites being used. This is mainly because these students are using a short one-word search term, and then taking information from the first page of their first search result.

Your feedback and the grade you give that first time will drive the quality of the reports.

How you want students to write the answers depends on what you would like to accomplish. If you would like to include a writing element, where students need to synthesize several different sources into a coherent answer, certainly give them the appropriate instructions and grade accordingly. For my class, what I want the students to do is get enough information that they can use it for study purposes, to prepare for their midterm and final. Because of this, I will allow students to copy directly from the source material. The issue is that it needs to enough that there is good detail to be used for studying but not so much that it confuses students. Students shouldn't copy/paste a whole website.

The first time through, students will gravitate to blogs or click bait sites that have a quick dictionary type of explanation that leads to top 10 embarrassing moments for movie stars or best buys on digital cameras. I try to wean them away from these sites by first allowing them to use them but then on the next mCpath, I will have a list of websites students can not use. For the thin sites, those that have copied content from other better sites, I try to get the students to realize they need to recognize that the content is copied and that one technique is to dig some to find the original site.

Copyright by Mahidol University

Presenter

The Presenter present at the end of the class period. They need to get up and present on two path questions and need to be able to answer questions. They have a maximum of 10 minutes per each presentation. The pressure put on that person to find information in a short period creates the learning dynamics. This will force the teams to quickly assign roles, and then members will help the Presenter find the information in time in time.

Right now, I have the students record a video, and then they upload it to YouTube as unlisted. In their Presenter report, I have the students send me their YouTube link and also answer one question, “What would they do differently if they were to present again?”

Having students record their presentations allows me to focus on listening to the students. I am not distracted because I am trying to grade and listen at the same time. When I am grading the presentations, I can be fairer because I can grade more consistently. I can also give better feedback because I do have the luxury of being able to view their presentations as many times as possible.

The other advantage of having students record their presentation is that they have a chance to see what they look and sound like when they present. They can see when they do not make eye contact or fidget and move around too much. The question about how to improve is to stimulate them to watch their video and be aware of what they should do next time.

Having students record the video also allows them a second chance to improve. I emphasize that if anyone wants to redo their video, they can.

Some lecturers or some high schools may have issues with privacy concerns. This is where a learning platform can be helpful. Most of these can handle videos and photos. Worst case, you will have to grade presentations and listen to them at the same time.

A different group will have different techniques for helping the Presenter. The more interactive groups will work closely together to find answers, with plenty of discussions and some disagreements on the right one. Some may quietly focus only on their tasks and then share the information at the end. One of the weaker methods is where the Presenters make no attempt to find their information. They wait for their

Copyright by Mahidol University

group to present them a script to read. These usually do quite poorly because they have no understanding at all of what they are reading. And they are reading. No presenting but reading. Some of the presentations will be done amazingly well, and the students will surprise themselves on what they were able to learn in a short time.

The key to improvement is the questions you asked. If you focus on asking what website was used, then next time all Presenters will make sure to note down what websites. If you focus is on how current is the information, the same thing will happen. If your focus is on the content and which of the detail is correct and what is left out, the students will again spend more time fixing that the next mCpath. The first time around, this is also something new to you as the teacher. You will have used some of the same websites, but hearing this from the students' perspective and doing this in a critical way will give you some insights as well. After grading all of these reports and considering yourself which websites are biased, which are not, which are current, which are not, you'll have a better perspective the next time you use this method for a class.

Auditor

Auditors are responsible for finding better quality web sources. If you follow what I am doing, they need to find sources for two questions: one for path 1 and one for path 2. I allow them to select which one and encourage them to help their Reporter by giving them a copy of the link.

Emphasize that they only need to list one source for one question. The factors they are evaluating are as follows:

1. Technical detail
2. Objectivity
3. Scope
4. Timeliness

You are welcome to change, modify, add or delete as best fits your purpose. My recommendation is that you have no more than five factors or students will be confused. It also means more grading for you.

Copyright by Mahidol University

I have a Likert-type scale, with a 1 being the least and a 5 being the most. Then there will be room for the analysis, where the students write on a competing explanation of why they gave that score.

When grading these, I will do my evaluation and my analysis, and then I will compare my results to what the students say. In this way, I give students a model of what I look for when evaluating the quality of a source. Again, the first time you go through this process, you will likely take more time because you are rethinking why you picked the websites that you do to support your class materials. The second time you use this method, you'll have your rational. Each discipline has its way of building its body of knowledge and verifying what is accepted as fact and what is not.

They can wait till their Reporters give them the links, but the role of the Reporters is different than the Auditors. For Reporters, more sources of information and a variety of information will make for a better report. For Auditors, they need to focus on the quality of one site. For most, it is better if they actively search for their source, filtering out the blogs, wikis and how to high school tutorials and searching for more primary information. The issue usually is that there is a tradeoff with most information found. An e-book in Google Book may have a huge scope, high technical detail, but then most of these references will be older. Corning develop Gorilla class, so its website will have some of the best technical details, but it certainly will have a bias toward its product. The point is to get students past using only Wikipedia or numerous quick and easy tutorials to looking at authentic research and having to answer the interesting questions about bias, expertise, along with questioning is this current technology or obsolete and no longer relevant?

Some of the more interesting discussions have been because students that have stumbled across predatory journals that were formerly listed by Beall. For computers, the articles have technical names, the background of the authors' looks impressive, but then the information s outdates and usually is copied from some other book or website.

Again, emphasize to them that they only need to find one source for one question. If they do list more than one, I usually select the first source and will evaluation what they wrote based on that, else it would take too long to grade.

Copyright by Mahidol University

They should spend time looking into the background of the website. How long has the website been open, is it commercial, nonprofit, a blog as a hobby or is it class material for a university? If there is an author or none listed can be important. This is because how else can you see that person's expertise or bias if you don't know who wrote the material? Some students do this, but then will write down exactly what the website or the author wrote about themselves.

On the first mCpath, most Auditors will give the sites they find all 5s. When they write their analysis, the beginner will usually say this is highly objective because it looks highly objective. The technical detail is high because this student can understand what the website says because they make it easy. They will give a 5 for scope, even though the detail ranges from a sentence-long definition to maybe half a page of text. Many times they won't be able to find a publication date but still will say the information looks current.

Improvement usually comes from showing them how you would score and evaluate the same page. The goal is to make them more aware of why peer-reviewed research articles have better quality information that most random blog. The flip side of this is when the students help you find those rare web nuggets.

During my research mine were a beautifully designed history of the original IBM Watson Lab at Columbia University, patent and description of the original mouse from Xerox, and a 12-year-old making university caliber YouTube videos on

Researcher

The Researcher has two jobs. One is to experiment with using search engines or services other than Google Search. The other is to help their group and other group consider how they participate as a team. For both, they need to do the same thing, talk about differences.

For the first question, the students are assigned a service. They should use it to help answer as many path questions as they can. For their report, they should give at least one example by giving the ULR address to one type of media they used. These can vary from videos to podcasts to PDFs and other types of files. The first assignment, I will assign students to use YouTube and then compare how YouTube is

Copyright by Mahidol University

different from Google Search. In the next mCpath round, I will change the service. Bing is an interesting comparison because it has similarity to Google but different results. Yahoo used to be of interest, but right now it appears to use the Bing engine. Other social networking services can give interesting results. Reddit has gossip about future technology. It provides one of the best examples of high bias. I have yet to experiment with Twitter, but this could prove stimulating as well.

In the later classes, certainly use Google Scholar, Google Books, and whatever search service your university or school provides.

For the second question, students need to compare how their team is different than other teams. This question is left open so that students can write about any factor. Some will look at how the mCpath answers are different. For others, they will focus on how the group communicates and what programs or services they use.

For each question, I grade on how many differences students find and how detailed of an example from their mCpath search experience do they use to support what they say about differences.

Grading reports

Five percent of the grades in my class comes from the peer grades, the score students give themselves and their other group members. I ask the students to give a score to each person by the title of their role. There is a chance for error in this, but usually this works out. You are more than welcome to have students give score to other members by using their names.

For those that do not fill out the peer report by the due date receive an automatic zero.

For those that don't fill out the report, email them to inform them that you didn't receive their report. Remind them that next time they will have another chance to fill it out. Make sure to do so or their peer grade will be zero for the term because they already missed the first report. It is up to you if you accept excuses for not filling this out, but there usually is a connection between those students that don't send in the peer report. These are the students that also do not finish their other mCpath report or put little effort into them. If you have students with the same first name or similar names, this is a good time to double check that you have the right grade for the right

Copyright by Mahidol University

students. It is easy to mix these up and causes confusions because the students know it isn't their work.

For the peer grades, most students will give themselves and their members 4s and 5s. This is fine because it will allow you to give a rigorous grade to their mCpath reports. What you are looking for are low grades given to other members. This could be a sign that students aren't working well with their group or that there is a conflict.

When using Google Form or other services, there can be technical difficulty with submitting information. You'll have to decide on a case to case basis if you accept a late submissions.

When grading reports, I use a 5 point scale. I've experimented with several ways to cover this to a more regularly used 100 percent scale. This is the calculation I am currently using: 40+(score)*12. Using this formula, the grades will be as follows: 0=40%, 1=52%, 2=64%, 3=76%, 4=88%, 5=100. This give a wide enough scale that I can reward the students that work hard and the student that do less, get the appropriate grade. Once again, the peer score and also the group score will tend to soften the effect. If you give a 1 to students that read their presentations, they understand clearly that this is not allowed, but if students score a 5 on the peer grade and a 3 on their team grade, the end results will be a 2.6, close to a C. If you need a more gentle grading scheme, move the bottom up from 40 to 50 or 60. If by 50, then multiply by 10. If the base is 60, multiply by 8.

Copyright by Mahidol University

Grading Presenters

Usually, I will grade the Presenters first. This is because I remember watching their presentations, and the connection speed in the morning is better for YouTube.

1. Under the Responses, select Individual.
2. Assuming again you are using Google Forms, turn off accepting responses.
3. Click on the three dot menu selection in the upper right corner/Download responses (.cvs)
4. Open the file
5. In the Spreadsheet, select Data/Sort. Sort by Name in descending order and sort by Timestamp from Largest to Smallest. In this way, you will grade the last report first, just in case a student sent in more than one form.
6. Right click the column A and B on the top of the cells, Insert. This will add two more columns.
7. Name Column A Grade and name Column B Comments. The grading I use is 1 to 5, with 5 being the highest, 1 the lowest.

Usually, I'll put 0 into the Columns A & B. This is because if they are blank, sometimes they won't sort correctly with the rest of the data.

For grading in a spreadsheet, it can be easier to transpose rows to columns and columns to rows. Do this by copying your data. Go to a blank spreadsheet, right click the A1 cell, Paste Special and select Transpose in the bottom right corner.

For the columns with longer text, right click on the column, Format Cells/Alignment/select Wrap text. Adjust the width of the column.

Copyright by Mahidol University

Grading Reporters

1. In Google Forms, go to Responses
2. Switch of Accepting responses
3. In to right corner, select the triple dot menu, Download responses (.cvs)
4. In Excel, Data/Sort. Sort by Name, descending then by Timestamp, ascending
5. Right click on columns A and B/Insert
6. Name Column A **Grade** and name Column B **Comments.** The grading I use is 1 to 5, with 5 being the highest, 1 the lowest.

Again, I'll put 0 into the Columns A & B. This is because if they are blank, sometimes they won't sort correctly with the rest of the data. In the past, I would make comments about the quality on the answer and the URL links. Right now, I am using a rubrics to judge three factor for each question: quality of the answer, number of links, quality of links

If the students try to copy too much text, Google Form will have problems storing the answer.

Some students will tend to put the least amount of effort possible. The best way to let them learn not to do this is to give an appropriate grade for no effort. For the Reporters, remind them several times during class and after that they need to answer all the questions and also include all of the links. There are certain students that tend to try to "misunderstand" and will only answer one or two questions. Please remind them that you told them the instructions, that it is also in writing and on the form they fill out.

Translating a 5 to 1 score to percentage grade, I use the Excel formula =40+(score)*12

Copyright by Mahidol University

Grading Auditors

1. In Google Forms, go to Responses
2. Switch of Accepting responses
3. In to right corner, select the triple dot menu, Download responses (.cvs)
4. In Excel, Data/Sort. Sort by Name, descending then by Timestamp, ascending
5. Right click on columns A and B/Insert
6. Name Column A **Grade** and name Column B **Comments.** The grading I use is 1 to 5, with 5 being the highest, 1 the lowest.

Usually, I'll put 0 into the Columns A & B. This is because if they are blank, sometimes they won't sort correctly with the rest of the data. In grading these Auditor reports, I will usually examine each of the websites and write my own analysis. I will include this in the comments, so that the students can see what I am looking for and how I evaluate a site. Next, I will compare how I would score his website to how the student scored, give a grade. For the second part, I'll compare my analysis to students and give them a score based on this. Students will write on how they plan to improve on better quality sites next time. I they write a sentence or two, I'll give them a 1 and remind them that this is university, so I expect university-level work. For those that take the answer seriously, give positive comments and a generous grade.

Copyright by Mahidol University

BIOGRAPHY

NAME	Brian James Phillips
DATE OF BIRTH	17 April 1962
PLACE OF BIRTH	Sydney, Nebraska, USA
INSTITUTIONS ATTENDED	Colorado State University, 1984-1987 Bachelor of Science with distinction (Journalism/English Composite Major) Colorado State University, 1987-1992 Master of Business Administration (Finance) Mahidol University, 2011-2017 Doctoral of Philosophy (Science and Technology Education)
RESEARCH GRANTS	MUIC Scholarship
HOME ADDRESS	39 Moo 8, Phuttamonthon Village Taweewattana, Bangkok 10170 Thailand Tel. +66-81-645-7261 E-mail : frbjph@gmail.com
EMPLOYMENT ADDRESS	MUIC, Salaya Campus 999 Phuttamonthon 4 Road Salaya, Nakhon Pathom 73170 Tel. +66-2-441-5090 ext. 3520 E-mail : brian.phi@mahidol.ac.th

Copyright by Mahidol University

PUBLICATION / PRESENTATION

1. Phillips, B. J., Grosch, M., & Laosinchai, P. (2014). Mobile media usage by undergraduates and implications for m-learning instructional design. *International Journal of Mobile Learning and Organisation, 8*(1), 1-15. doi:10.1504/IJMLO.2014.059994

Copyright by Mahidol University