COMPUTER–BASED GAME INSTRUCTIONAL UNIT TO TEACH AGGRESSIVE AND COURTING BEHAVIORS OF FIGHTING FISH

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Thesis
entitled

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COMPUTER-BASED GAME INSTRUCTIONAL UNIT TO TEACH AGGRESSIVE AND COURTING BEHAVIORS OF FIGHTING FISH

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ABSTRACT

This study aimed to develop a computer-based game instructional unit to enhance students' understanding of animal aggression and courting behavior by using fighting fish as a model. This study started with the determination of key characteristics of fighting fish's aggression. Here in a southern Betta (*Betta imbellis*) was used in the experimental study. The results of the comparison between wild caught *B. imbellis* and bred *B. imbellis* showed that both groups displayed the same characteristics of aggression, but each group responded to a different condition. Wild *B. imbellis* had a stronger response to a mutual viewing test condition, while bred *B. imbellis* had a stronger response to a real test condition. The gained knowledge during the scientific experiment was then used to develop a computer-based game instructional unit about aggressive and courting behavior. The instructional unit consisted of four instructional games on the aggression and courtship displaying of fighting fish, and information to introduce the basic knowledge about fighting fish. It was implemented with 77 grade eleven students from a secondary school in Nakhon Pathom province, Thailand via Kolb's learning cycle (1984). Students experienced four computer games during reflective observation. They then participated in the debriefing session starting with describing their experiences, which were linked to the game playing and followed by games in real situations, and sharing their knowledge through class presentations during concrete experience and abstract conceptualization phases. Finally, they participated in discussing a new situation, sharing for implication and application, during the active experimentation phase. The results from the conceptual test, students' presentations, and interviews showed that students gained knowledge of aggression behavior and courtship behavior in animals, especially in fighting fish. Moreover, they showed positive attitudes toward the instructional unit as shown in questionnaire, interview, and classroom observation results.

KEY WORDS: COMPUTER-BASED GAME/ EXPERIENTIAL LEARNING CYCLE/ FIGHTING FISH/ AGGRESSIVE BEHAVIOR/ COURTING BEHAVIOR

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COMPUTER–BASED GAME INSTRUCTIONAL UNIT TO TEACH AGGRESSIVE AND COURTING BEHAVIORS OF FIGHTING FISH

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บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อพัฒนาบทเรียนคอมพิวเตอร์สำหรับส่งเสริมความรู้ความเข้าใจ เรื่อง พฤติกรรมก้าวร้าว และพฤติกรรมเกี้ยวพาราสีโดยใช้ปลากัดเป็นต้นแบบ การศึกษานี้เริ่มจากการหารูปแบบการแสดงพฤติกรรมก้าวร้าวของปลากัดป่าภาคใต้ (*Betta imbellis*) ซึ่งได้ทำการเปรียบเทียบระหว่างปลากัดป่า 2 กลุ่ม คือ ปลากัดป่าที่จับมาจากธรรมชาติและปลากัดป่าที่นำมาเพาะเลี้ยงโดยมนุษย์ ผลการศึกษาพบว่าปลากัดป่าทั้ง 2 กลุ่มมีรูปแบบการแสดงพฤติกรรมก้าวร้าวเหมือนกัน แต่มีลักษณะของการตอบสนองต่อวิธีการศึกษาต่างกัน ปลากัดป่าที่จับมาจากธรรมชาติจะตอบสนองต่อวิธีการ mutual viewing condition ในขณะที่ปลากัดป่าที่นำมาเพาะเลี้ยงโดยมนุษย์จะตอบสนองต่อวิธีการ real test condition ผลการการศึกษาและความรู้ที่ได้ถูกนำมาใช้ในการพัฒนาบทเรียนคอมพิวเตอร์เกี่ยวกับพฤติกรรมก้าวร้าวและพฤติกรรมเกี้ยวพาราสี บทเรียนนี้ประกอบด้วยเกมคอมพิวเตอร์ที่ออกแบบมาเพื่อใช้ในการเรียนรู้พฤติกรรมก้าวร้าวและพฤติกรรมเกี้ยวพาราสีของปลากัด จำนวน 4 เกม และข้อมูลแนะนำความรู้พื้นฐานเกี่ยวกับปลากัด บทเรียนนี้ได้ถูกนำไปใช้จัดการเรียนการสอนตามรูปแบบวัฏจักรการเรียนรู้เชิงประสบการณ์ของ Kolb โดยนำไปทดสอบกับนักเรียนระดับชั้นมัธยมศึกษาปีที่ 5 จำนวน 77 คน ในโรงเรียนมัธยมศึกษา จังหวัดนครปฐม ประเทศไทย โดยในขั้นตอนการสังเกตอย่างไตร่ตรอง (reflective observation) นักเรียนได้เรียนรู้ผ่านประสบการณ์การเล่นเกม จำนวน 4 เกม หลังจากนั้นจึงเข้าสู่ขั้นตอนการซักถาม (debrifing) โดยเริ่มจากการอธิบายว่าได้เล่นเกมอะไรบ้าง และคิดว่าเกมที่ได้เล่นเหล่านี้มีความเชื่อมโยงกับสถานการณ์จริงในเรื่องใด นอกจากนี้นักเรียนยังได้แลกเปลี่ยนความรู้ที่ได้รับกับเพื่อนร่วมชั้นเรียนผ่านการนำเสนอผลงานในระหว่างขั้นตอนประสบการณ์รูปธรรม (concrete experience) และ การคิดเชิงนามธรรม (abstract conceptualization) ด้วย ท้ายที่สุดนักเรียนเข้าร่วมการอภิปรายโดยแสดงความคิดเห็นร่วมกันในชั้นเรียนในการเชื่อมโยงความรู้ที่ได้รับไปยังสถานการณ์ใหม่ และแลกเปลี่ยนเรียนรู้ร่วมกันในการนำความรู้ที่ได้ไปประยุกต์ใช้ในระหว่างขั้นตอนการทดลองปฏิบัติจริง (active experimentation) ผลจากแบบทดสอบ การนำเสนอผลงาน และการสัมภาษณ์ พบว่าหน่วยการเรียนนี้ช่วยสร้างความรู้ความเข้าใจของนักเรียนในเนื้อหาพฤติกรรมก้าวร้าวและพฤติกรรมเกี้ยวพาราสีของสัตว์ โดยเฉพาะปลากัดได้เป็นอย่างดี นอกจากนี้ยังพบว่านักเรียนมีทัศนะคติที่ดีต่อการเรียนด้วย ดังปรากฏผลในแบบสอบถามความพึงพอใจและการสัมภาษณ์

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CHAPTER I
INTRODUCTION

Overview

This chapter provides rationale and significance of the study. The objectives and research questions are presented at the end of the chapter.

1.1 Rationale of the study

Present-day education emphasizes on how to transform students becoming lifelong learners who enable to acquire creative thinking, flexible problem solving, collaboration and innovative skills needed to be successful in work and life. Thai Education Act (1999) also emphasizes a lifelong learning and focus on an alternative way of teaching/learning called “learner-centered approach”. However traditional learning as mainly use nowadays could not provide appropriate environment for those necessary skills in students’ life. The one of successful science curriculum for student is influenced by the teaching methodology that was included by hands-on learning, interdisciplinary activities, and exploration of the natural world using the scientific method (Zemelman, Daniels, & Hyde, 1998). Leach (2002) proposed the use of secondary data in laboratory class is an alternative way for promoting students’ thinking. Many researchers used animals in the laboratory class (Daniel & Perelle, 1987; Jakob & Hodge, 2010; Pack, 2010; Smith, Scimeca & Mainous, 2011). Nevertheless the live animals have limitations, for example, the ethical issues for use in schools and difficulty for taking care. Then visual aids such as games and/or simulations can offer an alternative way of learning. A well-designed simulations and games have been recognized as an effective strategy to enhance conceptual understanding, skills, and learning attitude especially for digital-native students. Herein this study presents a computer-based game instructional unit which integrated

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technology to challenge situations or problems to engage secondary studens learn two kinds of animal behavior; aggressive and courting behaviors.

Many researchers such as Darwin, Thorpe, Tinbergen, Lorenz and von Frisch (Ord, Martins, Thakur, Mane & Borner, 2005) studied animal behaviors trying to understand about what animals do, how they do and why they do because it could link to the human behavior and society. Animal behaviors' studies revealed the mechanism and process of the animal living in group (Barnard, 2004) thus it could make us to understand about the mechanism and process of human society, especially aggressive and courting behaviors that are importantly type of animal behavior.

Aggressive behavior is a behavior or disposition that is forceful, hostile or attacking. It may occur either in retaliation or without provocation. It relates to the interaction and evolution of animal in natural environment because it has a relation with territorial, dominance, sexual, parental, parent-offspring, predatory and antipredatory. In biological advantage, aggressive behavior may help an animal secure territory, including resources such as food and water. Aggressive behavior between males often occurs to secure mating opportunities, and results in selection of the healthier/more vigorous animal. Aggression may also occur for self-protection or to protect offspring. Specially in fighting fish, the aggressive behavior is a dominance behavior, it is easily for observing in external characteristics display such as deepening of the body and fin color, fin erection, gill membrane extension, and frontal approach with an undulating movement toward the opponent. Moreover, the aggressive behavior of fighting fish has relation with the courting behavior.

Courting behavior is the period in a couple's relationship which precedes their mating and eventual reproduction. Courting behavior may be rather simple, involving a small number of chemical, visual, or auditory stimuli, or it may be a highly complex series of act by two or more individuals, using several mode of communication. Courting behavior make to ensure that the males and females of the same species recognize one another, so that mating can take place, it can be preventing inter-species breeding that does not produce viable offspring. It alsocan be used in a sexual selection allowing male or female to select the best mate. This would give an opportunity to their offsprings having more chance of survival.Fighting fish (*Betta* spp.), a native species to most countries in ASEAN is a popular species for

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studying animal behaviors in laboratory experiment. They show two noticeable behavior known as aggressive and courtship behaviors. The study of these two behaviors mostly used wildtype and domesticated Siamese fighting fish (*Betta splendens*) as a model. Only a few research used other bettas in *Betta splendens* group. Importantly, there was no research on *B. imbellis* aggression. The key characteristics of *B. imbellis* was then investigated in scientific part of this study.

With the advantages of fighting fish on easily to observe behaviors and easily to maintain in the limited space, it also has been widely used in the classroom activity in animal behavior class (Kuhn, 1970; Wersinger & Martin, 2009). Many educational researcher have used the Siamese fighting fish for enhancing students' understanding of animal behavior such as territorial behavior, and animal social behavior in biology classroom (Abante, 2005; Kowasupat, Jittam, Sriwattanarothai & Ruenwongsa, 2012; Kremer, Walker & Schluter, 2007; Monvises, Ruenwongsa, Panijpan & Sriwattanarothai, 2010). In Thai biology classroom, Siamese fighting fish has been used as a model to teach aggressive and courting behaviors. With the time limitation and animal behavior laboratory experience limitation these topics are usually taught by traditional approach. It could not engage students, less promote deep understanding, not provide inquiry skills and may let them having a negative perception toward the topics. To solve the issues, this study developed computer-based games by using a fighting fish as a model to teach aggressive and courting behaviors.

Nowadays, several active learning units employing simulations and games have been developed for educational purpose in many disciplines e.g., mathematics, science, engineering, humanities, and social sciences (Cai, Lu, Zheng & Li, 2006; Eck, 2006; Mayo, 2007). Most students prefer learning by using computer games because the latter may agree better with students' habits and interests (Gee, 2003; Prensky, 2007). Educational games serve as nearly realistic situations that allow students to interact and to gain from the learning experience. The students apply their knowledge, skills and strategies make decisions in their assigned role. As a result, students' cognitive abilities and expectations about learning are promoted.

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By the way many research works on simulation and game in biology education have been shown to enhance students' understanding in biology learning without the limitations involved in using live organisms (Parslow, 2002; Cai, Lu, Zheng & Li, 2006). Tan and Biswas (2007) have developed a simulation-based game learning environment on building and sustaining a fish tank. Their preliminary experiment showed the effectiveness of the simulation. However, there is a little research work on the effectiveness of game and simulation on students' learning on animal behavior. We found that, despite aggressive and courtship behaviors of the Siamese fighting fish being interesting topics, there was still no educational game/simulation on this topic.

Then the objective of this study work is to develop a set of four computer-based game instructional unit on fighting fish to enable students to construct their own knowledge on aggressive and courting behaviors from the results on key characteristics of fighting fish aggression in the science part. The computer game on the fighting fish consists of the introductory session of fighting fish to engage the player and four interactive games. Sound and text were put together with animated pictures to promote understanding. Four games were developed by integrating the content of the aggressive and courting behaviors of fighting fish into the framework of experiential learning theory. These fighting fish games should allow the students to refine and/or to recall the previously acquired knowledge as well as to develop relationships between concepts. The students would be expected to be in control of their actions, and be involved in the learning through Kolb's experiential learning cycle. The effectiveness of the newly developed instructional unit was investigated at the end of the study.

1.2 Significance of the study

The result on the key characteristics of southern fighting fish (*Betta imbellis*) aggression were used to develop the computer-based game instructional unit on fighting fish to teach aggressive and courting behavior. Instead of laboratory

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experiment, the computer based game instructional unit would appropriate for science classroom where have limited laboratory, time and ethical issue. Moreover this unit could suitable to engage students in animal behavior learning. This unit can be used as an alternative way of teaching the animal behavior in the classroom or can be used as a supplementary unit for self learning outside the class.

1.3 Research question and research objectives

Three research questions help frame this study:

1. What are the key characteristics of aggressive display of the fighting fish (*B. imbellis*)?

2. Can the computer game-based instructional unit of fighting fish enhance students' understanding of aggressive and courtship behaviors?

3. What are the students' perceptions toward the computer game-based instructional unit?

To optimize the research scheme, the objectives are followed:

1. To develop key characteristics of *B. imbellis* aggression by using both wild caught and inbred *B. imbellis*.

2. To develop a computer game-based instructional unit on fighting fish to enable students to construct their own knowledge on aggressive and courtship behaviors.

3.To evaluate the effectiveness of a computer game-based instructional unit with an emphasis on learning aggressive and courtship behaviors in secondary students.

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CHAPTER II
LITERATURE REVIEW

Overview

This chapter presents the literatures related to the content of the thesis. It comprises two parts, scientific review and educational review. The scientific review begins with general characteristics of the fighting fish especially bubble nest builders, followed by aggressive behavioral and courtship behavioral study in fighting fish. The educational review focuses on theoretical basis of the experiential learning approach, implications of the experiential gaming module in the classroom, and ends with using fighting fish in the classroom.

2.1 Scientific review

2.1.1 General characteristics of the fighting fish

The fighting fishes are well known in Thailand and several other countries in ASEAN. They are one of the most popular species of freshwater aquarium fish. The fighting fish is the member of family Osphronemidae of freshwater ray finned fishes (Britz, 2001), whose freshwater members are *Anabas* spp., *Trichogaster* spp., and *Trichopsis* spp., with more than sixty valid species were described (Schindler & Schmidt, 2008). *Betta* (Bleeker, 1850) is the genus of the fighting fish that belongs to a group of anabantoids whose specialized bone above the gill chamber called labyrinth organ. This fish uses the labyrinth organ as an extra organ for their breathing. The air is kept within labyrinth organ when the fighting fish comes up to the surface of water and gulps air (Linke, 1991). As the study of the molecular phylogeny of anabantoids (Ruber, Britz & Zardoya, 2006) the most recent classification of the fighting fish is show as follows:

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Kingdom Animalia
Phylum Chordata
Class Actinopterygii
Order Perciformes
Suborder Anabantoidei
Family Osphronemidae
Subfamily Macropodusinae
Genus *Betta*

The fighting fish divides into two groups depending on their mode of parental care which are mouth brooder group and bubble nest builder group (Schmidt, 1996). During breeding time, the eggs will drop out from female and the male of mouth brooders will keep their eggs within the mouth until the fly that grow enough to live by themselves whereas the male of bubble nesters will use their mouth to retrieve sinking fertilized eggs and deposit them in the bubble nest. This study focuses only on the bubble nest builders because of their convenient handling, various features and economical importance. Moreover this group represents dominant aggressive and courtship display which easy to observe.

Fighting fish has been classified into fifteen species groups (Witte & Schmidt, 1992), one of which is the *Betta splendens* group. The term of species group is used here for an assemblage of species sharing diagnostic characters. Members of the *Betta splendens* complex group are bubble nest building bettas with the following characters: small head, often brightly coloured body, body slender, iris of eye with iridescent green or blue patches, head with parallel opercles when viewed dorsally, red or brown anal and caudal fin rays contrasting with iridescent interradial membrane (especially in male) (Tan & Ng, 2005). *Betta splendens* group currently includes six species as following: *B. splendens* Regan, 1910; *B. smaragdina* Ladiges, 1972; *B. imbellis* Ladiges, 1975; *B. stiktos* Tan & Ng, 2005 and the two newly found species; *B. mahachaiensis* Kowasupat, Panijpan, Ruenwongsa & Sriwattanarothai, 2012 and *B. siamorientalis* Kowasupat, Panijpan, Ruenwongsa & Jeenthong, 2012. In Thailand there are five species of *Betta splendens* group found in native habitat while *B. stiktos*

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Tan & Ng, 2005could be only found in Cambodia. The characteristics of these wild five species are described here (see pictures in Appendix A and B):

***B. splendens* Regan, 1910** is the most well-known and the most widespread which can find every part of Thailand, e.g., province of Chiang Rai, Chiang Mai, Phayao, Phrae, Lamphun, Phitsanulok, Nakhon Sawan, Ang Thong, Pathum Thani, Nonthaburi, Bangkok, Nakhon Nayok, Chonburi, Nakhon Pathom, Kanchanaburi, Ratchaburi, Phetchaburi, Prachuap Khiri Khan, Chumphon, Ranong, Surat Thani. The maximum total length is 6.5 cm. and maximum reported age is two years. Their body and fins consist of both red and green colors. There are only short-finned and pugnacious be found in nature. The wild *B. splendens* live in small bodies of water habitat such as those in the paddy fields, ponds, lakes and marshes.

***B. smaragdina* Ladiges, 1972** is found throughout the Northeastern region around the Khorat plateau which lies on the Mae Klong river, and found in all of twenty province of the Northeastern, Thailand. The maximum total length in nature has been just six cm. long. They have a dark body with rows of metallic blue-black, blue, or green scales extending to the gill covers. Stretches of watery areas such as paddy fields, marshes, ponds and lakes are places it can be found.

***B. imbellis* Ladiges, 1975** or the peaceable nature betta is ubiquitous in the Southern regions, e.g., provinces of Phuket, Surat Thani, Nakhon Si Thammarat, Pattaluang, Satun, Phang Nga, Krabi, Trang, Songkhla, Pattani, and Narathiwat, the Malay Peninsula and Penang Island. They are the smallest bubble nest builders in Thailand. They can grow only to five cm. in total length. They have blue-black body, fins almost red containing except the caudal fin which having a black edged band to it. Shallow waters of paddy fields, marshes, ponds, lakes and acidic swamps are the habitats. However, they can also be found in areas where the water is brackish due to the ebb and flow of sea tide.

***B. mahachaiensis* Kowasupat, Panijpan, Ruenwongsa & Sriwattanarothai, 2012** the newly fighting fish species that just only found in Thailand, is a local fish distributed only in a narrow and specific area of Samut Sakhon, Samut Prakarn and western of Bangkok bordering Samut Prakarn Province (Lertpanich & Aranyavalai, 2007; Kowasupat, Panijpan, Ruenwongsa & Sriwattanarothai, 2012). They are dark blue-green, resembling *B. Smaragdina* but

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thicker or *B. imbellis* without the red marking, brown-to-black opercular membrane without red streaks or patches (vs. presence of red streaks in other species). It is found in tidal brackish waters with thick vegetation. They can build bubble nest in the axils between the leaf and crown of the nipa palm (*Nypa fruticans* Wrumb) tree that is the dominant tree in a costal swamp.

B. siamorientalis **Kowasupat, Panijpan, Ruenwongsa & Jeenthong, 2012** is currently found in only four provinces in the eastern region of Thailand; Chachoengsao, Sa Kaeo, Prachin Buri, and Chon Buri (only in areas close to Chachoengsao) and also found in Banteay Meanchey, a province of Cambodia on the eastern border of Sa Kaeo. It is distinguished from other members of the *B. splendens* group by having area belonging to the dark-brown to black body (background) greater than that of the iridescence of the scales and black opercles with two parallel reddish vertical bars (Kowasupat, Panijpan, Ruenwongsa & Jeenthong, 2012).

There is not only the wild fighting fish in Thailand, but also a spectacular ornamental fighting fish with various tail shapes and wide range of colors is examined. They are all hybrids *B. splendens* creating from many years of careful selective breeding. According to the tail shape, there are veil tail, crown tail, halfmoon tail, double tail, delta detail and short-finned fighting fish. The ornamental fighting fish can also be divided into five groups of color patterns which are single color, bicolor, butterfly color, marble color and multicolor. Newly famous the giant fighting fish and the elephant ear fighting fish (giant pectoral fin fighting fish) are developed at present.

2.1.2 Aggressive behavior study in fighting fish

Because of the animal behaviors' study reveals mechanism and process of the animal living in group (Barnard, 2004) thus it can make us to understand about the mechanism and process of human society. Aggressive behavior is a complex phenomenon with many functions and many cases relate with other animal behavior, Konrad Lorenz (1966) defined that an aggression is about "the fighting instinct in beast and man which is directed against members of the same species". He used the word instinct that points up to the one of facet of the old nature-nurture controversy having direct bearing on the behavior of human. Aggressive behavior includes many important forms of animal behavior such as territorial, dominance, sexual, parental,

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parent-offspring, predatory, and antipredatory (Wilson, 1975; Moyer, 1976). These forms of aggressive behavior have different function within and between species. Therefore the aggressive behavior has been classed by its function, such as the defense of territory, by its consequences, such as pain or injury (e.g. Dollard *et al*., 1939; Jackson, 1954; Berkowitz, 1963; Buss, 1966) and by its causes (Scott, 1966), including frustration (e.g. Buss, 1966). The studies on aggressive behavior can contribute potentially to the understanding of human social behavior (Lorenz, 1966). Thus the study on aggressive behavior is not only important as a scientific field on its own but also important as an educational conception for enhancing student knowledge about the human behavior and human social interaction.

The animal behavior study is easy to obtain results however it is difficult to explain the rationale and the meaning of each action. It is easy enough to describe and list the moves in an animal's threat or courtship behavior, and particular aspects of the display can be selected for detailed study on the basis of the ease with which they can be recorded. But it is not so easy to understand an interaction in terms of the relationships between the events during the interaction and its final outcome (Simpson, 1968). To understand what animals behave many researchers then designed the animal behavior study in the laboratory (Alder & Hogan, 1963; Clayton & Hinde, 1968: Thompson & Sturm, 1965a, Takeuchi, Hori, Myint, & Kohda, 2010). The rat is a popular animal model used in the laboratory (Miczek, Maxson, Fish, & Faccidomo, 2001). Beside rat, fishes have been recently recognized as models to study behavior, from mechanisms to functional response. They are the most diverse vertebrate and be found in vastly different environments. The variety of behaviors and adaptations found in fish reflect the diversity. To study aggressive behavior, Siamese fighting fish is one of popular model (Simpson, 1968) because their aggressive display are distinguish and easy to follow.

Aggressive behavior of fighting fish is highly stereotyped in nature and consists of the basic characters as deepening of the body and fin color, fin erection, gill membrane extension, and frontal approach with an undulating movement toward the opponent. The two confined male fighting fishes may combat until totally exhausted, or death (Lissmann, 1932). Braddock and Braddock (1955) described the

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characteristic pattern of aggressive display on two domesticated *Bettas* that are as follow:

1. Both fish, at the beginning of the encounter to be described here, were rather dull-coloured, with faint longitudinal stripes on their bodies.

2. Within two seconds of being placed in the tank, where they were to interact, one turned towards the other, spread its vertical fins, then briefly spread its opercula and extended the black brachiostegal membranes that otherwise lie behind (gill cover erection).

3. The first fish then began to approach the other, which was moving along slowly, but which checked and spread its own vertical fins when it noticed the first fish.

4. Over the next three seconds, both fish darkened so that their longitudinal stripes were almost obscured, and they closed up to within a fish-length of each other. The first fish then spread its gill covers for a second time, and it turned to face the second, withdrawing both its pelvic fins so that they lay along its belly. The second fish remained broadside to its facing neighbor, and extended the pelvic fin nearest its neighbor so that it pointed downwards. The first fish faced for a second, and then it turned broadside, lowering its gill covers and re-erecting its pelvic fins as it did so.

5. At once the second fish turned to face the first, raising its gill covers and withdrawing its pelvic fin, whereupon the first flickered the pelvic fin on the offside to and fro. In the ten seconds of the encounter that elapsed, both fishes' backs and heads had become almost jet black, and the greens and blues on their scales, eyes and fins were brighter.

6. Over the next thirty seconds the fish continued to alternate facing (and raising their gill covers as they faced) with turning broadside (when they also lowered their gill covers), and while it was broadside, each fish usually flickered its pelvic fin and beat its tail. Sometimes both were broadside at the same time, and then they usually beat their tails at each other. Often, just before one of the fish turned to face, it quickly closed and opened the rays in its tail, so that the tail was shut and opened like a fan.

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7. On two occasions when one of the fish was facing its broadside partner, the facing fish turned until the two were in a tail-to-head carousel position, and then

they held their mutual positions very rigidly as they rotated-using only their rapidly beating pectoral fins. Sometimes one of the fish moved its head nearer the other's tail, whereupon the other flashed its tail, and the first moved its head away again. Such carousels lasted ten to fifteen seconds. The second carousel ended when one of the fish broke away and went up to the surface to gulp air. During the display such simultaneous air gulping was repeated approximately every half a minute.

8. At the end of the first minute, the two paraded round the tank, side by side, each crowding and beating the other with its tail and caudal peduncle. Finally one of the fish turned to face the other, whereupon the other beat its tail even more frequently for a moment before turning to face too. Then the fish that had first turned to face turned broadside again, and beat its tail at the other which stayed facing for a few seconds. For the next seven minutes the fish continued thus, facing each other in turn, with the broadside fish usually beating its tail, and the bouts of gill cover erection lengthening, and the frequency of tail beating increasing, while the carousels shortened. Once, one of the fish faced the other twice before the other turned to face again.

9. Soon after their seventh minute of display, one of the fish, that was facing its partner's head, opened its mouth as if to bite, but did not attempt to drive the bite home until it was facing its partner's tail. As it closed in to bite, its partner beat its tail hard and accelerated round, thus evading the first fish's bite and attempting to bite its tail. The first fish, however, was moving forwards, and each flashed past the other's tail. Three more sequences of biting, tail beating, and bite evasion followed before one of the fish showed a tear in its tail. In these rapid manoeuvres the vertical fins were held less rigidly erect than they had been at the start of the display. Mutual biting attempts were well separated by the previously described mutual gill cover raising and tail beating.

10. It is seldom easy to foresee the end of such a display. One fish ceases to display before the other, its fins slacken, and it starts to swim away from its still displaying partner. At first the partner seems to moderate its own display, as if to avoid discouraging the first fish from continuing. Finally the partner stops too, and begins to chase the first, which soon pales and shows longitudinal stripes. During the chase the pursuer may direct nips towards the loser's caudal and anal fins.

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It was difficult to make generalizations about the display before it had been analyzed. In *Betta* the stages are not so clearly separate as they are in the descriptions of cichlid display, and the fish often revert to an earlier stage quite late in an encounter.

Several researchers have used the opercular display as an indicator for the aggressive display (Simpson, 1968; Evans, 1985; Gorlick, 1990). Most researcher works on the aggressive behavior of fighting fish, were done with *B. splendens* (Alder & Hogan, 1963; Clayton & Hinde, 1968: Thompson & Sturm, 1965a). There are also reports on aggressive behavior of *B. smaragdina* and *B. mahachaiensis* (Verbeek, Iwamoto & Murakami, 2007). Smith (1965) and Simpson (1968) used *B. splendens* to compare the aggressive display between wild-type and domesticated and the results showed that the domesticated from breeding for fighting had more aggression than wild-type and domesticated veil tail variety.

There is no research report on aggressive behavior of *B. imbellis*. Thus, this study observed the aggressive behavior of *B. imbellis*. The criteria of aggressive display of *B. imbellis* was investigated. The aggressive displays of wild caught *B. imbellis* from the southern Thailand were observed in comparison with those of inbred *B. imbellis*. The results obtained were used to develop the criteria for aggressive display of the fighting fish.

2.1.3 Courting behavior study in fighting fish

Courtship behavior is a part of reproduction in the animal having several functions that maximize the efficiency of the spawning act. In addition, there is a series of behavior actions performed by one or both members of a mating pair just prior to spawning. Courtship aids in species recognition (a premating species-isolating mechanism), pair bonding, orientation to the spawning site, and synchronization of gamete release. It is often necessary to overcome territorial aggression by the male, who might otherwise drive the female away from the site (Gene, Bruce & Douglas, 1997).

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Fighting fish is social animal capable of living in groups with a pecking order or in isolation (Snekser, McRobert & Clotfelter, 2006). They are very territorial, especially after isolation or during courtship behavior. The courtship behavior is

interested by many behavior researchers, usually in the bubble nest group of fighting fish (Fred & Rudolph, 1966).

Normally male fighting fish display includes the conspicuous and stereotyped signals of fin spread, gill cover erection, tail beats, and bites, used for both courtship and aggressive display (Robertson & Sale, 1974; Doutrelant, McGregor & Oliveira, 2001) but when courtship behavior will be happen the male interactions are less aggressive (*i.e.* less biting) and take longer to escalate (Matos & McGregor, 2002). However, if the female starts to exhibit a yellowish cross-striped pattern on a highly colored body and swims towards the male, this is a sign of willingness to mate. After that the male then starts building a bubble nest under or between the floating plants and usually the female will follow the male there after just a short time, in response to male continuing advances. A number of "dummy runs" may precede the actual egg laying procedure which takes place after the usual intertwining, with the eggs falling on to the anal fin of the male. Once the eggs have emerged the male disentangles themselves from the female and the eggs fall down through the water. The female will remain in the customary spawning stupor on the surface for a few seconds. During this time the male collects the falling eggs in his mouth, coats them in saliva and carefully spits them into the bubble nest. The female will have deposited all her eggs after about two hours whereupon the female will be driven away by the male who will undertake the care of the eggs alone (Linke, 1991). Thus this is a same pattern of characteristic of courtship behavior in the bubble nest group.

Many researchers were study about the courtship behavior; Doutrelant & McGregor (2000) found that female Siamese fighting fish use information gained from eavesdropping in mate choice. Male fighting fish defend territories that provide access to females (Bronstein, 1984; Doutrelant & McGregor, 2000). Jaroensutasinee and Jaroensutasinee (2001a, 2001b, 2003) study from the wild type fighting fish they found that male body size and nest size influences the female choice of mate. Larger males are better at courtship display than their smaller counterparts. Nest size also reflects the body size and during the mating season and the parental care stage, the male is more aggressive.

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2.2 Educational review

2.2.1 Theoretical basis of the experiential learning approach

Experiential education is a process through which a learner constructs knowledge, skills and values from direct experiences. The concept of experiential learning is very close to the constructivism. It is based on the concepts of "learning by doing" which aims to encourage learners to feel learning as well as to think, and to let them "try on" new behaviors and new emotional and cognitive responses (Kolb, 1984). The learning by doing is first attributed by Dewey (1938) who emphasizes the importance of experiential learning. In addition, Kolb (1984) has stated that education is becoming more accessible to all learners and there has been a corresponding need for curricula to translate abstract ideas into practical realities in human life. The experiential learning theory combines experience, perception, cognition and behavior. It revolves around any experience that can be incorporated into the curriculum or program, which is complemented by a debriefing or reflection component.

The experiential learning is emphasizing the central role that experience plays in the learning process, an emphasis that distinguishes the experiential learning from other learning theories. The term of experiential is used differently from both cognitive learning theories, which tend to emphasize cognition over affect, and behavioral learning theories that deny any role for subjective experience in the learning process. For another reason why called "experiential", because of its intellectual origins in the experiential works of Dewey, Lewin, and Piaget. Taken together, Dewey's philosophy, Lewin's social psychology, and Piaget's cognitive developmental genetic epistemology form a unique perspective on learning and development (Kolb, 1984).

The experiential learning theory defines learning as the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience (Kolb, 1984). According to the four-stage learning cycle or learning spiral (see Fig. 2-1), concrete experience, reflective observation, abstract conceptualization and active experimentation. At first, the learning spiral begins with immediate or concrete

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experiences are the basis for observations and followed by a collection of data and reflective observations of the experience. Then abstract concepts are assimilated and distilled. Finally there is active experimentation in new circumstances. In general, the experiential learning model stresses the continuous cyclical nature of learning and the appropriate feedback which provides the basis for the process of goal-directed action thus the debriefing session will be employed. This session aims to capitalize on the developed ideas and group interchange to ensure that the students will achieve the learning objectives (Steinwachs, 1992).

After that David Kolb developed the Learning Style Inventory to assess individual learning styles. The individuals tested on the Learning Style Inventory show many different patterns of scores, research on the instrument has identified four statistically prevalent learning styles, diverging, assimilating, converging, and accommodating (see Fig. 2-1).

Diverging; The diverging style's dominant learning abilities are concrete experience and reflective observation. People with this learning style are best at viewing concrete situations from many different points of view. They prefer to work in groups, listening with an open mind and receiving personalized feedback.

Assimilating; The assimilating style's dominant learning abilities are abstract conceptualization and reflective observation. People with this learning style are best at understanding a wide range of information and putting into concise, logical form. It is important for effectiveness in information and science careers. People prefer to read, lectures, exploring analytical models, and having time to think things through.

Converging; The converging style's dominant learning abilities are abstract conceptualization and active experimentation. People with this learning style are best at finding practical uses for ideas and theories. The learning skill is important for effectiveness in specialist and technology careers. People prefer to experiment with new ideas, simulations, laboratory assignments, and practical applications.

Accommodating; The accommodating styles' dominant learning abilities are concrete experience and active experimentation. People with this learning style have the ability to learn from primarily "hand-on" experience. They enjoy carrying

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out plans and involving themselves in new and challenging experiences. This learning style is important for effectiveness in action-oriented careers such as marketing or sales. People prefer to work with others to get assignment done, to set golds, to do field work, and to test out different approaches to completing a project.

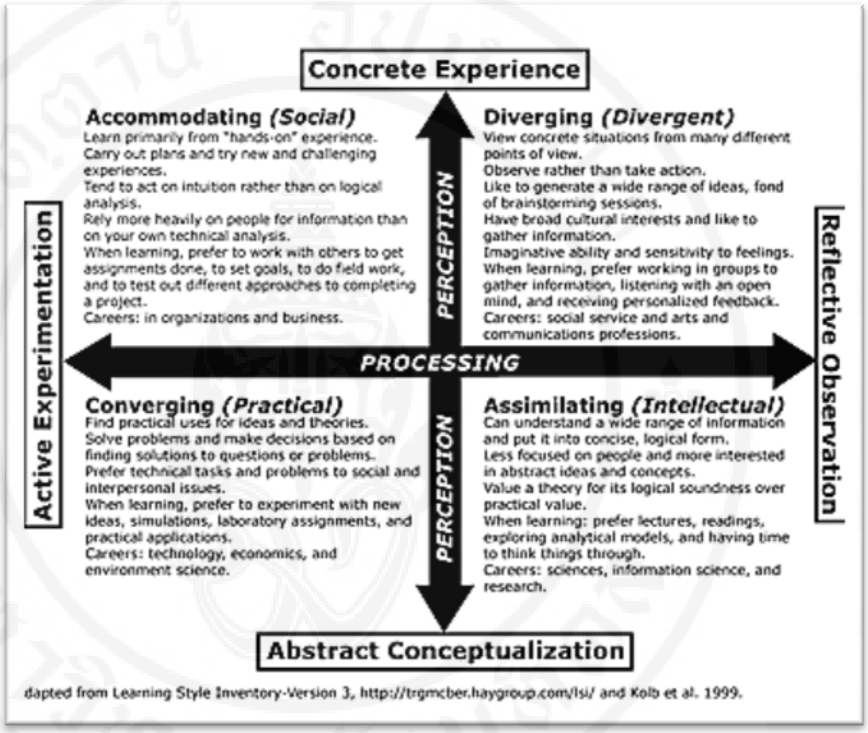

Figure 2-1 Experiential learning cycle (Kolb, 1984)

The axes in figure 2-1 represent the two dimensions of the learning task. The vertical dimension (concrete experience to abstract conceptualization) represents to the perception that means input of information either from experience or from abstractions. The horizontal dimension (reflective observation to active experimentation) refers to the processing of information by either internally reflecting on the experience or externally acting upon the conclusions which have been drawn.

Svinicki and Dixon (1987) proposed the Kolb modified model for classroom activities whichsupports each of four poles of the experiential learning cycle as shown in Figure 2-2. To produce the complete cycle of learning, the instructor would select an activity from each pole and guide the students through them in order.

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Moreover an instructor, in selecting learning activities to correspond with each of the four poles of the experiential learning model, must give greater consideration to the functional use of the activity than to the activity itself. For example, when laboratory activities precede instruction, their intent may be exploratory, such as is used in inquiry teaching. When the laboratory activities occur later in the instructional sequence, they may serve as a way to apply what is being learned, i.e., they involve active experimentation. A second variable affecting the application of this design model may be the nature of the student's role. One drawback of this actor/ receiver dimention is that, in general, activities involving students as actors require a greater amount of time.

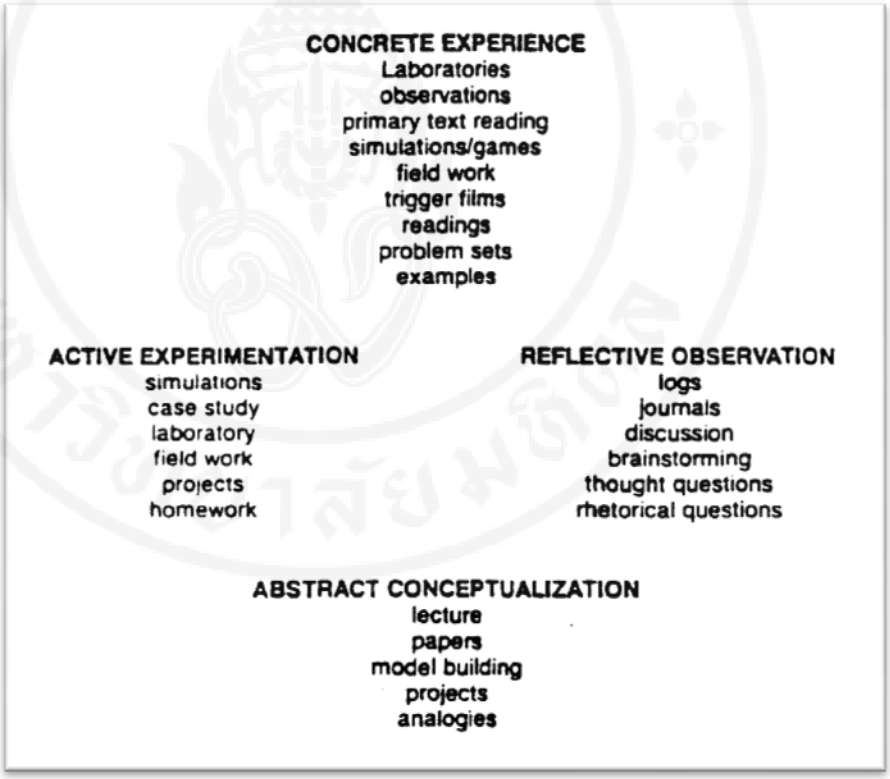

Figure 2-2 Instructional activities that may support different aspects of the experiential learning cycle (Svinicki & Dixon, 1987)

2.2.2 Implications of the experiential gaming module in the classroom

Nowadays, several active learning units employing simulations and games have been developed for educational purpose in many disciplines e.g., mathematics, science, engineering, humanities, and social sciences (Cai, Lu, Zheng & Li, 2006; Eck,

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2006; Mayo, 2007). Most students prefer learning by using computer games because the latter may agree better with students' habits and interests (Gee, 2003; Prensky, 2007). Educational games serve as nearly realistic situations that allow students to interact and to gain from the learning experience. The students apply their knowledge, skills and strategies make decisions in their assigned role. As a result, students' cognitive abilities and expectations about learning are promoted. Nevertheless, in spite of gaining scholastic content, the game may create a dissonance between in-school formal learning environment and the informal one that students experience outside school (Oblinger, 2004). Integration of games and simulations with contents help to teach concepts through the transformation of experiences (Papastergiou, 2009). Games as a learning vehicle have been used to teach factual information as well as worksheet activities in biology lessons (Spraggins & Rowsey, 1986).

Many research works on simulation and game in biology education have been shown to enhance students' understanding in biology learning without the limitations involved in using live organisms (Parslow, 2002; Cai, Lu, Zheng & Li, 2006). Tan and Biswas (2007) have developed a simulation-based game learning environment on building and sustaining a fish tank. Their preliminary experiment showed the effectiveness of the simulation. Facer, Joiner, Stanton, Reid, Hull and Kirk (2004) developed the animal behavior game for secondary students based on animals in savannah. However, there is a little research work on the effectiveness of game and simulation on students' learning on animal behavior.

To design a meaningful educational game including interactive-learning environment with problem-oriented learning, the experiential gaming model, based on experiential learning theory, flow theory and game design, has been adopted (Kiili, 2005). The learners are engaged and motivated via direct experiences by using games which should be appropriate reflective exploration, testing hypotheses, and producing objects. In addition, accompanied by Kolb's experiential learning model (Kolb, 1984; Kolb & Kolb, 2009) is integrated into the model.

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2.2.3 Using fighting fish in the classroom

The Siamese fighting fish is a popular aquatic animal for raised as a pet and also bred for commercial purpose (Monvises, Nuangsaeng, Sriwattanarothai & Panijpan, 2009). Moreover they are one of the popular animals for use in social behavior lessons in animal behavior study. This is because Siamese fighting fish is easily obtained in most pet shops around the world and also in the wild in or near the southeast Asian countries (Sriwattanarrothai, Steinke, Ruenwongsa, Hanner & Panijpan, 2010).

The Siamese fighting fish have many advantages for classroom activity (Kuhn, 1970). They have been used in physiology and behavior laboratories as a good example for observing territorial behavior in the science classroom (Abante, 2005; Lynn, Egar, Walker, Sperry & Ramenofsky, 2007). There are websites with laboratory instructions for studying animal behavior by used the fighting fish (Burke da Silva, Auburn, Hunter & Young, 2008; Foglia, 2005; Peack & Walker, 1991; Yasukawa, 2007). There are also laboratory exercises about fish schooling behavior, however there is no report on student learning (Fisher & Novak, 1984; Glase, Zimmerman & Waldvogel, 1992).

At present many educational researchers have been use the fighting fish for enhancing students' understanding in animal behavior such as social behavior, aggressive behavior and agonistic behavior. (Kowasupat, Jittam, Sriwattanarothai, Ruenwongsa & Panijpan, 2012; Kremer, Walker & Schluter, 2007; Monvises, Ruenwongsa, Panijpan & Sriwattanarothai, 2010). Their body and fin color and shape are attributes valued by fanciers as much as their two other noticeable behaviors viz., aggression and courtship.

Nevertheless there are limitations in using live specimens in behavior studies, for example, the ethical issues for use in schools. Thus visual aids such as games and/or simulations can offer an alternative way of learning about animal behavior for students.

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CHAPTER III
METHODOLOGY

Overview

This chapter presents the methodology of this study dividing into two parts which are scientific aspect and educational aspect. The development of a computer-based game instructional unit used for conducting this study and the research methodology are described. Data collection and analysis used for determining the effectiveness of the unit are presented at the end.

3.1 Determining a fighting fish behavior

3.1.1 Collection and maintenance of *B. imbellis*

Wild caught *B. imbellis*: *B. imbellis* were caught from the rice-field or natural body of water (e.g. ponds, mountain stream, freshwater marshes) in the southern part of Thailand, i.e, Satun, Pattalung, Phuket, Trang, Nakhon Si Thammarat (Fig. 3-1). The characteristics of the wild caught fighting fish carefully observed to ensure that they belong to *B imbellis*. They should have a bright red crescent on distal edge of caudal fin, no caudal transverse bars, dorsal transverse bars on distal two-thirds of dorsal fin, iridescent blue opercle scales and dark brown to black body (Tan & Ng, 2005). The male caught fish were only used in this study. Their apprearances during non-aggression and aggression were shown in Fig. 3-2.

Bred *B. imbellis*: fish were obtained from the reliable breeder. Bred fish used in this study were the first generation-bred wild fish and were around three-month olds. They were individually housed in a glass tank.

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Figure 3-1 Natural habitat of *B. imbellis*, the fighting fish from the southern part of Thailand; a) rice-field, b) mountain stream, c) pond, d) freshwater marshes

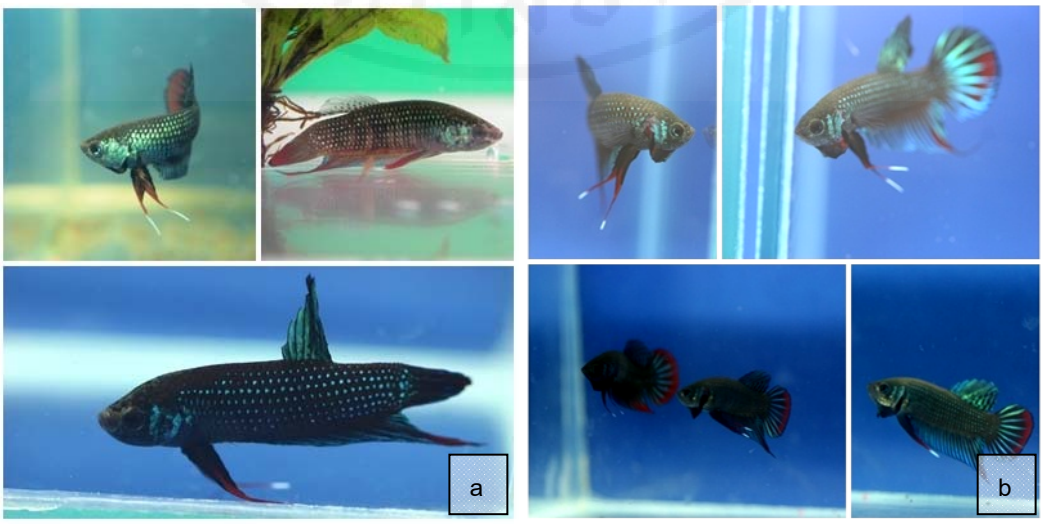

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Figure 3-2 Picture of male *B. imbellis* showing; a) non-aggressive display, b) aggressive display

Rearing and maintenance: Both wild-caught and bred *B imbellis* were individually housed in a 1-liter glass tank for 1-2 months before used in the study. Each fish tank was separated from others by opaque plastic partitions to prevent displaying of aggressive behavior before the study. However, these fish had visual access to daily activity in the laboratory. They were fed with both pellet and fresh Artemia.

3.1.2 Experimental design

The healthy male *B. imbellis* of similar size were selected for testing the aggressive display. Ten wild-caught fish with 0.46 – 0.76 g. and 26.8 – 32.7 mm. in standard length (Table 3-1) and ten F1 bred fish with 0.47 – 0.93 g. and 21.7 – 40.5 mm. in standard length (Table 3-2) were used in the experiment. The experiment was designed in such a way that each fish in each group would have chance to meet with other nine fish (see example in Table 3-3)

Table 3-1 Weight and standard length (from tip of mouth to caudal peduncle) of wild caught *B. imbellis* (IW) used in the study

Code No.	Standard length (mm.)	Weight (g)
IW1	26.8	0.46
IW2	30.2	0.69
IW3	31.1	0.66
IW4	32.7	0.76
IW5	29.7	0.71
IW6	27.5	0.67
IW7	27.8	0.69
IW8	28.5	0.71
IW9	31.2	0.73
IW10	29.7	0.68

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Table 3-2 Weight and standard length (from tip of mouth to caudal peduncle) of F1 bred *B. imbellis* (IB) used in the study

Code No.	Standard length (mm.)	Weight (g)
IB1	35.9	0.88
IB2	33.0	0.93
IB3	40.5	0.84
IB4	27.8	0.47
IB5	36.6	0.85
IB6	25.7	0.84
IB7	23.9	0.81
IB8	21.7	0.70
IB9	22.8	0.78
IB10	24.4	0.80

Table 3-3 Pair of fish (wild caught *B. imbellis*) for observing aggressive display

IW1	IW2	IW3	IW4	IW5	IW6	IW7	IW8	IW9	IW10
IW1 VS IW2	IW2 VS IW1	IW3 VS IW1	IW4 VS IW1	IW5 VS IW1	IW6 VS IW1	IW7 VS IW1	IW8 VS IW1	IW9 VS IW1	IW10 VS IW1
IW1 VS IW3	IW2 VS IW3	IW3 VS IW2	IW4 VS IW2	IW5 VS IW2	IW6 VS IW2	IW7 VS IW2	IW8 VS IW2	IW9 VS IW2	IW10 VS IW2
IW1 VS IW4	IW2 VS IW4	IW3 VS IW4	IW4 VS IW3	IW5 VS IW3	IW6 VS IW3	IW7 VS IW3	IW8 VS IW3	IW9 VS IW3	IW10 VS IW3
IW1 VS IW5	IW2 VS IW5	IW3 VS IW5	IW4 VS IW5	IW5 VS IW4	IW6 VS IW4	IW7 VS IW4	IW8 VS IW4	IW9 VS IW4	IW10 VS IW4
IW1 VS IW6	IW2 VS IW6	IW3 VS IW6	IW4 VS IW6	IW5 VS IW6	IW6 VS IW5	IW7 VS IW5	IW8 VS IW5	IW9 VS IW5	IW10 VS IW5
IW1 VS IW7	IW2 VS IW7	IW3 VS IW7	IW4 VS IW7	IW5 VS IW7	IW6 VS IW7	IW7 VS IW6	IW8 VS IW6	IW9 VS IW6	IW10 VS IW6
IW1 VS IW8	IW2 VS IW8	IW3 VS IW8	IW4 VS IW8	IW5 VS IW8	IW6 VS IW8	IW7 VS IW8	IW8 VS IW7	IW9 VS IW7	IW10 VS IW7
IW1 VS IW9	IW2 VS IW9	IW3 VS IW9	IW4 VS IW9	IW5 VS IW9	IW6 VS IW9	IW7 VS IW9	IW8 VS IW9	IW9 VS IW8	IW10 VS IW8
IW1 VS IW10	IW2 VS IW10	IW3 VS IW10	IW4 VS IW10	IW5 VS IW10	IW6 VS IW10	IW7 VS IW10	IW8 VS IW10	IW9 VS IW10	IW10 VS IW9

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3.1.3 Conditions for testing aggressive display

Two methods modified from Verbeek, Iwamoto and Murakami (2007) were employed in this study:

1) **Mutual viewing test:** the fighting fish in a separate tank was used to stimulate each other. The fighting fish in each separated tank was brought to meet each other. To start the experiment, the opaque plastic sheet between the two adjacent walls of glass tank was removed (Fig. 3-3).

Figure 3-3 Mutual viewing test condition; the fighting fish in a separate tank was used to stimulate each other

2) **Real test condition:** Two tested fighting fish were put in the same tank but separated with a partition in the middle of the tank. The size of glass tank was twice that of the first condition, and a plastic sheet was used to partition the tank into two compartments. Before the test, each fish was put into each compartment of the tank. The partition was then removed upon starting the experiment. During the experiment, if the fish were going to fight each other, the partition was immediately inserted to separate the two fish (Fig. 3-4).

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Figure 3-4 Real test condition; two tested fighting fish were put in the same tank

3.1.4 Data recording /analysis

For data recording, both video recorder and direct observation were used to collect data on the characteristics of aggressive display i.e., time before showing full repertoire, fin display, opercular display, attempted bites (Verbeek, Iwamoto & Murakami, 2007). Other characteristics, such as air gulping, movements, fin flickering, etc. were also being observed. The video recording time of mutual viewing test condition was 10 minutes while the recording time of real test condition was stopped when the fighting started. If the fish in real test condition did not fight within 30 minutes the experiment was then terminated. The video tape was analyzed and data were reported as times of showing each characteristics. Here are the definition of aggressive characteristics collecting from the video and direct observation;

Time before showing full repertoire:

Time was counted in a minute since the removal of opaque cardboard between the tanks until the full aggression appears

Fin display time:

The total amount of time was counted in minute since fish starting to perform fin display. As for mutual viewing test, time was counted within the first 10 minutes while in real test condition, it was counted no longer than 30 minutes in real test condition.

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Opercular display time:

The total amount of time was counted in minute since the fish starting to flare their gill covers. As for mutual viewing test, time was counted within the first 10 minutes while in real test condition, it was counted no longer than 30 minutes

Air gulping:

The total number of fish performed air gulping.

Attempted bites:

The total number of fish attempted to bite the tank as in mutual viewing test and as in real test condition.

Mouth drags:

The total number of dragging mouth from left to right as performed by fish in mutual viewing test.

Approach:

The total number of approaching as performed by fish in real test condition.

Caudal fin flickering:

The total number of caudal fin flickering either as performed by the fish in mutual viewing test or as in real test condition.

Pelvic fin flickering:

The total number of fish performed the pelvic fin flickering or moving the pelvic fin around, guitar similar acting as playing a guitar.

The average times were then used to compare between the same type of fish within the same testing condition. To identify patterns in aggressive characteristics of *B. imbellis*, principal component analysis (PCA) was used. Herein this study PCA was carried out from the PAST program. The program is spreadsheet interface which is easy to use. The input data is a matrix of multivariate data and no separate centering of groups before analysis. The correlation (normalized variance-covariance) matrix was used to calculate the eigenvalues and eigenvectors in this study. The components of given eigenvalues more than one were used to determine the key characteristics of *B. imbellis* aggressive display.

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3.2 Developing and implementing a fighting fish computer-based game instructional unit

The secondary data and local information from scientific part were used to develop a fighting fish computer -based game instructional unit on aggressive behavior and courting behavior. The researcher adopted and adapted Kolb's experiential learning cycle (Kolb, 1984) to outline the instructional unit with an emphasis on student' s achievement.

3.2.1 Participants

The participants in this study were 77 grade eleven students, aged 15-17 years, from secondary school in Nakhon Pathom province, Thailand, who had already been taught the basic biology and general animal behavior.

3.2.2 Development of computer games on aggressive and courting behavior of fighting fish

We developed the computer-based games on the fighting fish from the contents of the standard biology curriculum on animal behavior. The theory of experiential learning model (Kolb, 1984) was used as a framework in devising the games. There are four stages in the experiential learning process. Concrete experience is followed by reflection on the experience on the personal basis. The next step on abstract conceptualization is derivation of the general rules describing the experience, or application of known theories to it. The final step, active experimentation, is to construct ways of modifying the next occurrence of the experience. This may lead in turn to the first step of the cycle on concrete experience. There may be a "wheels within wheels" process at the same time.

In the computer-based games, we first designed the introductory session of Siamese fighting fish to engage the player (Fig. 3-5). Sound and text were put together with animated pictures to promote understanding and interest.

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Figure 3-5 Introductory page of fighting fish computer-based games

The content consists of four components:

1. Introduction of the fighting fish

We developed the content of the biology of fighting fish which are divided into four sections (Fig. 3-6);

1.1 What is the fighting fish?

This section introduces the fish well known in Thailand and ASEAN.

1.2 What are the characteristics of the fighting fish?

This section shows the important organs of the fish together with the names and functions.

1.3 How can we classify the fighting fish?

The classification of the fish is shown in this section.

1.4 What species of the fighting fish are there?

The section shows other fishes in the *Betta splendens* group.

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Figure 3-6 Components of introduction part of the fighting fish.

2. Home of fighting fish

This topic shows the habitats of the wild type fighting fish in Thailand with pictures and key characteristics in the text (Fig. 3-7).

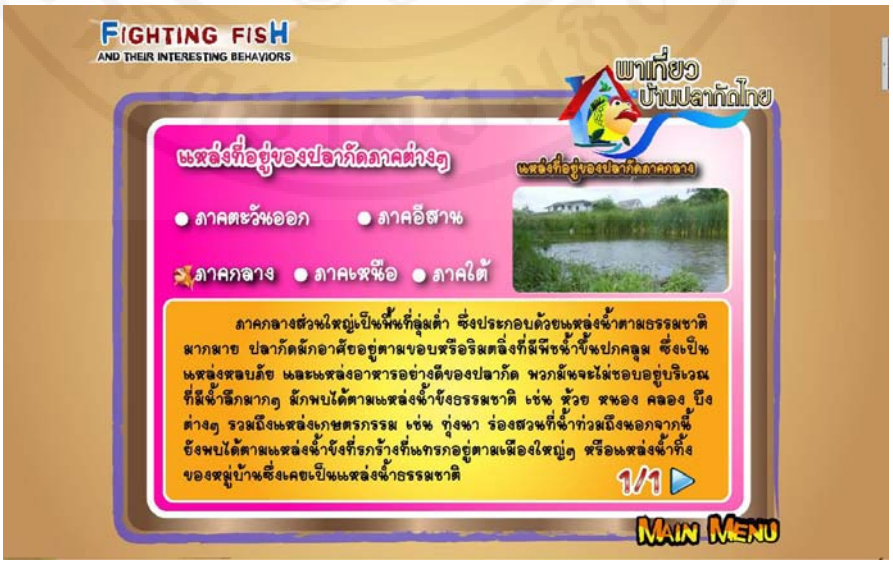

Figure 3-7 Habitats of fighting fish in nature

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3. Fighting fish behavior

The students learn about the aggressive and courting behaviors of fighting fish by using video (Fig. 3-8). Key statements were used to motivate players to pay attention to the video.

Figure 3-8 Behavior of fighting fish consisted of two dominant behavior; aggressive behavior and courting behavior.

4. Games on fighting fish

We developed the games by integrating the content of the aggressive and courting behaviors of fighting fish into the framework of experiential learning theory. At the end of each game, there are feedbacks and explanations for the right or wrong choices. There are four games as follows:

4.1 The fighting fish in the glass bowl

The fighting fish are aggressive, thus we cannot put them in the same tank or glass container because one fish may fight another. In this game, the player should put the fighting fish and other types of fish into the right glass tanks within thirty seconds. If a player puts a fighting fish in the same glass tank with another fighting fish the player loses the point (Fig. 3-9).

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Figure 3-9 The fighting fish in glass bowl game

4.2 Aggressive behavior game

We developed this game from the actual aggressive display of fighting fish. When the fish shows aggression, the basic characteristics such as deepening of the body and fin color, fin erection, gill membrane extension can be seen. The player should select the fin of a fish showing aggressive display at a level and then compare the level of aggression with the other three fishes in the game. If the player selected the level of aggression higher than the other three fish, he/she is the winner (Fig. 3-10).

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Figure 3-10 Aggressive behavior game

4.3 Betta reaction game

We developed this game from the communication of the animals. The fighting fish can change their behavior upon visual contact. When a fish sees another fish, it reacts. However, a fish can also respond to its mirror image and a video of other aggressive fighting fish when exposed to it the first time. However the fish can learn and stop the response. The player should select three pictures to which the fish would respond. If the player collects the wrong pictures, the game is over (Fig. 3-11).

Figure 3-11 Betta reaction game

4.4 Betta breeding game

We developed this game from the courting behavior and breeding of fighting fish in the bubble nester group. When the fish pair is spawning the male must build the bubble nest and stimulate the female by expanding their fins and gill covers. The female lays the eggs which are then fertilized outside the body. The male must put the fertilized egg in the bubble nest and take care of them until the fry hatch. The player has to put the eggs into the bubble nest and protect the egg from the female and other fish. The scores are reduced if he/she cannot protect the eggs. If a player gets a minus five scores, the game is over. But if he/she reaches to twenty points the player is the winner (Fig. 3-12).

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Figure 3-12 Betta breeding game

3.2.3 Implementation of the computer-based game instructional unit

The computer-based game instructional unit was implemented to the students as shown in Table 3-4. The students took a ten-minute pretest, and then learned and played the games of fighting fish for two hours (introduction phase and concrete experience phase). The researchers followed the three debriefing phases of Steinwachs (1992) and Leualami and Panijpan (2010). We tried to capitalize on the developed ideas and group interchange to ensure that the students achieved the learning objectives before they took the posttest. A combination of small-group (4-5 persons) and large-group (whole class) discussion was used throughout the debriefing session. Details of the three phases are as follows:

1. Description phase: The researchers examined and analyzed the individual knowledge experienced during game playing. We encouraged the students to recount their experiences in the computer-based game learning unit by describing in their own words about experience and impression. For example, what happened in the fighting fish games? What are the similarities and differences between the aggressive and courting display? Students in groups of four-five identified what occurred during displaying of these behaviors. The students were also asked to reflect their feeling about the games, and on the aspects that were most challenging. After five to ten minutes discussion in group, representative of each group reported to the class.

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Students were encouraged to add some key points that might be missing. The researchers might add more points and then led the students to the next analysis phase.

2. Analysis/analogy phase: The emphasis was for the students to explore the computer-based game on the fighting fish and compare with real world situation. We first led the students into this phase by encouraging them to mention some of the major issues/ situations raised in the first phase. Then each of the small groups was given focal topic(s). For example, have you ever had experience with fish fighting? What does the game experience suggest about what to do when you see the two fighting fish in the same tank? Are there some important aspects of the Siamese fighting fish missing from this game? Are there any simulated situations in the game that you do not find in your real life? After the students from small group shared idea, they briefly reported to the class by presenting a group poster linking between their experiences to the theoretical basis.

3. Application phase: This phase emphasized that the students understand what are relevant to them and what further action they would do. In this phase, the students should be able to generalize and identify pattern as well as to discuss implication and application. Each group of students was asked what they had learned and how they were going to exploit. For example, has your experience in playing the computer-based game learning unit helped you in any special way? What can you do to increase the probability of having such experience? Can you compare the aggressive behavior and/or the courting behavior of the fighting fish with other animals? What is the most important principle you learned from this game? After extensively sharing in the class, the researchers provided closure and evaluation to ensure that all students have a clear understanding of facts, concepts or principles.

Then the students took the ten-minute posttest and responded to the questionnaire about their perceptions of the computer-based games instructional unit for another ten minutes. Finally the researcher interviewed five volunteer students individually (ten minutes each) for their perception of the games.

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Table 3-4 Kolb's experiential learning sequence in the computer game-based instructional unit on fighting fish aggressive and courting behaviors

Phase	Objectives	Student Activities	Assessment Tools
Prior knowledge (10 min)	1. To assess prior understanding of fighting fish aggressive and courting behaviors	- Students took a pretest of fighting fish conceptual test	-Pre conceptual test
Introduction (30 min)	2. To introduce game playing and general information of fighting fish	- Introductory session of games on fighting fish	-Classroom observation
Concrete experience (90 min)	3. To implement and experience with computer-based games	- The fighting fish in the glass bowl game - Aggressive behavior game - Betta reaction game - Betta breeding game	-Classroom observation
Reflective observation (10 min)	4. To examine the meaning of gathered experiences	- Debriefing session (description phase)	-Classroom observation
Abstract conceptualization (35 min)	5. To draw a logical conclusion on theoretical basis	- Debriefing session (analysis/analogy phase)	-Classroom observation -Poster presentation

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Table 3-4 Kolb's experiential learning sequence in the computer game-based instructional unit on fighting fish aggressive and courting behaviors **(cont.)**

Phase	Objectives	Student Activities	Assessment Tools
Active experimentation (15 min)	6. To apply the gained concept to new experiences	- Debriefing session (application phase)	-Classroom observation
Evaluation (30 min)	7. To assess the knowledge gain after participation 8. To assess the attitude toward computer-based game learning unit	- Students took posttest of fighting fish conceptual test - Perception questionnaire - Semi-structured interview	-Post conceptual test - Perception questionnaire -Semi-structured interview

3.2.4 Data collection and analysis

The students were assessed for their understanding of fighting fish aggressive and courting behavior and for the perception of the game learning unit by using these assessment tools, i.e., the fighting fish conceptual test (pretest/posttest), student group poster presentation, questionnaire on perception, semi-structured interview and classroom observation.

3.2.4.1 The fighting fish conceptual test

The conceptual test was developed based on concepts of animal behavior in general including aggressive and courting behavior according to the science curriculum for secondary school. The multiple choice test items were divided into three categories: characteristics of fighting fish, aggressive behavior, and courting behavior. The ten-minute pretest was administered to the students before

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participating in the unit. The same conceptual test was used as posttest administered after the debriefing session.

The fighting fish conceptual test was analyzed by using the SPSS program to obtain gained scores, means and standard deviations. T-test was used to determine the significant differences of the descriptive values.

Furthermore normalized gain in each concept of animal behavior was used to determine the conceptual dimension between pretest and posttest. The normalized gain (<g>) score, developed by Hake (1998), is 0-1. It is divided into 3 levels, the high gain is $\langle g \rangle \geq 0.7$, the medium gain is $0.7 \leq \langle g \rangle \geq 0.3$ and the low gain is $0.0 \leq \langle g \rangle > 0.3$.

3.2.4.2 Student's group poster presentation

At the end of abstract conceptualization phase (Table 3-4) each group of seven students prepared their poster and presented to the class. Teachers assessed students' understanding on three criteria (Table 4) using a 5-point Likert scale where 5=excellent, 4=exemplary, 3=accomplished, 2=developing, 1=beginning. Then teacher used this step for discussing with the whole class about their observed results and animal social behavior concepts.

The score from group presentation was analyzed by using the SPSS program to obtain means and standard deviations.

3.2.4.3 Questionnaire on perception of the instructional unit

The questionnaire was developed to assess the students' perception toward the instructional unit. The questionnaire consists of three criteria: perception of thirst of knowledge, perception of enjoyment, and perception of time duration. Each item consists of five responses on the Likert scales: strongly agree (5), agree (4), have no opinion (3), disagree (2), and strongly disagree (1). The questionnaire was administered to the students after completion of the unit.

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The questionnaire was analyzed by using the SPSS program to obtain means and standard deviations.

3.2.4.4 Semi-structured interview

Ten-minute semi-structured interview was carried out with five volunteer students. The interview questions focused on the understanding on aggressive and courting behavior of the fighting fish and the perception of the computer-based game instructional unit. The interview was conducted one-on-one outside of the classroom by a researcher. The data from interview were audio-taped and fully transcribed.

The qualitative analysis approach was employed to interpret the transcription gathered from semi-structured interview. These data were used for triangulation to corroborate those from other sources.

3.2.4.5 Classroom observation

Both of a video-camera and an audio-recorder were used to record in classroom observation as a supplementary tool to the student's behavior in the activity class. We mainly observed the interactions between student-student in both within group and within a whole class during the activity.

These data provided for more information to be eventually triangulated with other assessment tools.

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CHAPTER IV
RESULTS

Overview

This chapter reports the findings of scientific study and educational study. The first part describes results collected from an aggressive behavior study of southern fighting fish (*B. imbellis*) while the second part describes the findings obtained from the effectiveness of a newly developed instructional unit. Results of students' conceptual test, group poster presentation, questionnaire, interviews and classroom observation are included in the second part.

4.1 Scientific aspect

The healthy male *B. imbellis* with similar size were selected for testing the aggressive display. Wild caught and bred *B. imbellis* were experienced with two conditions including in the experiment which are the mutual viewing test and the real test condition. Results here represent time or frequency of each aggressive characteristics display.

4.1.1 Results of mutual viewing test from wild caught (IW) and bred *B. imbellis* (IB)

4.1.1.1 Time before showing full repertoire

The mean scores of time before showing full repertoire of each wild caught and bred *B. imbellis* was shown in Fig. 4-1. The time spent by ten wild caught *B. imbellis* were 0.26, 0.37, 2.55, 0.46, 0.41, 0.26, 0.26, 2.55, 0.46, and 0.41 min., while by those of ten bred fish were 0.31, 2.44, 1.16, 1.32, 2.38, 0.31, 0.26, 2.11, 2.38, and 1.13 min. The results showed that three wild caught fighting fish (IW1, IW6 and IW7) and one bred fighting fish (IB7) showed full repertoire within the shortest time period(0.26 min.). It should be noticed that wild caught fish, (IW3 and IW8)

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took the longest time for showing full repertoire, when compared to the other wild caught fish. For bred fish, IB1, IB6 and IB7took less than one minute for showing full repertoire, while IB2 and IB5 spent more than two min.

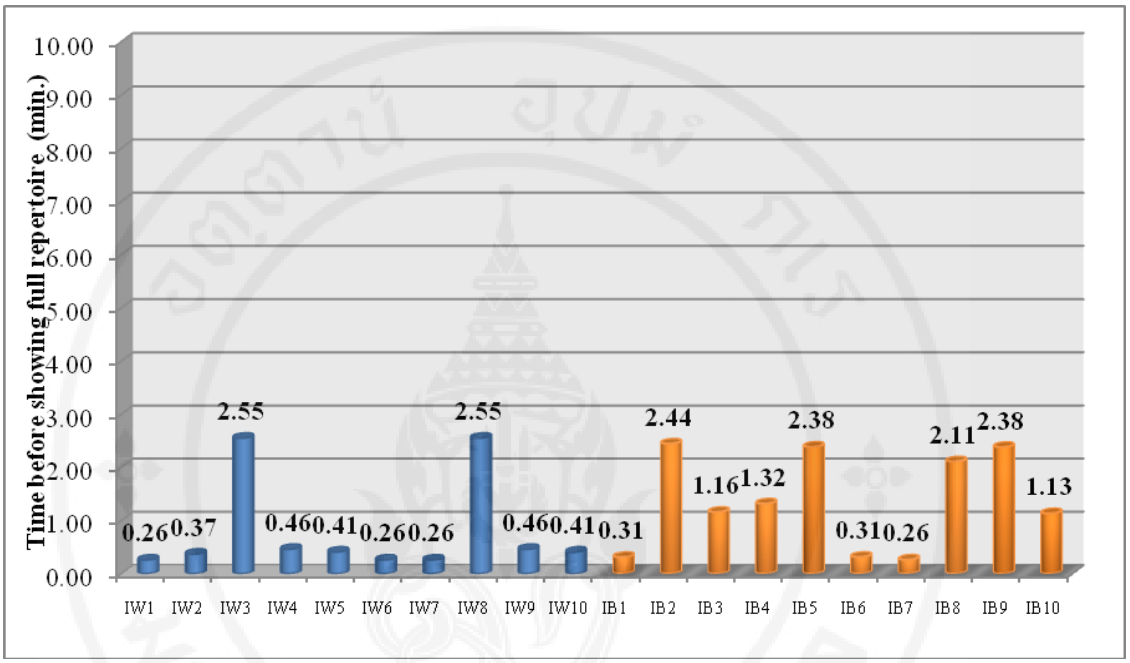

Figure 4-1 Mean displaying time before showing full repertoire of wild caught (IW) (n=10) and bred *B. imbellis* (IB) (n=10) as observed in mutual viewing test condition

4.1.1.2 Total times for fin display and opercular display

Results in Fig. 4-2 showed total display times for fin and opercular display. The total display times of fin and opercular of both wild caught and bred *B. imbellis* were similar. The results suggested that both characteristics occurred together, more or less at the same time. The comparison between wild caught and bred *B. imbellis* found that bred *B. imbellis* spent longer total display times of fin and opercular than the wild caught (9.38 min.). Opercular display times (in a total of 10 min) ranged from 6.42 to 9.36 min. in wild caught and from 1.48 to 9.38 min. in bred fish. Fin display times ranged from 7.24 to 9.36 min. in wild caught and from 1.27 to 9.38 min. in bred *B.imbellis.*

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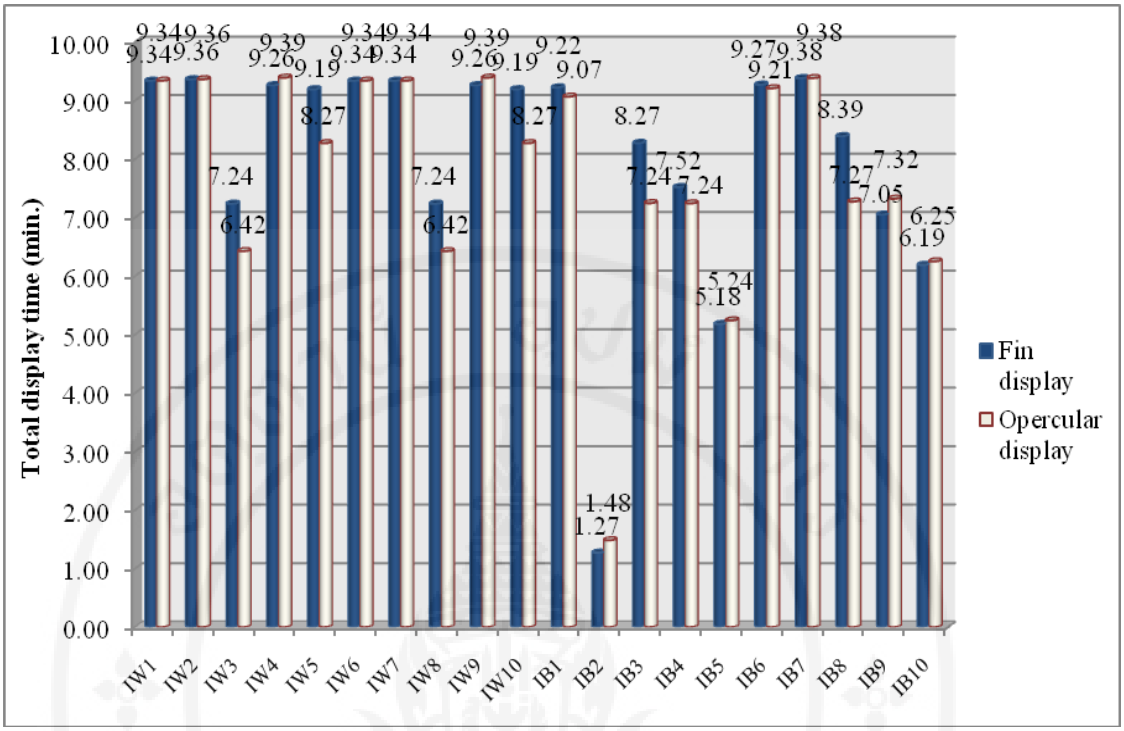

Figure 4-2 Mean times for fin display and opercular display of wild caught (IW) (n=10) and bred *B. imbellis* (IB) (n=10) as observed by mutual viewing test condition

4.1.1.3 Other criteria for aggression from mutual viewing test

Besides fin and opercular displays, there were air gulping, attempted bites, mouth drag, caudal fin flickering and pelvic fin flickering together showing during aggression. Results on other criteria for aggressive behavior of wild caught and bred *B. imbellis* were shown in Table 4-1 and Table 4-2.

Results showed that wild caught *B. imbellis* (0.22-4.11) has wider frequency range of air gulping than bred one (0.44-2.78). Wild caught fish (0.22-4.44) also seemed to show higher number of attempted bites than those of the bred (0.00-3.56). Moreover, wild caught fish showed a higher number of caudal fin and pelvic fin flickering than those of bred fish. However, both type of fish seemed to show the similar amount of mouth dragging. The results in Table 4-1 and Table 4-2 could be summarized that IW3, IW5, IB2, IB5 and IB10 showed less aggressive display.

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Table 4-1 Mean scores on aggressive display criteria of wild caught *B. imbellis* observed by the mutual viewing test condition (n=10)

Criteria	Mean score of IW									
	IW1	IW2	IW3	IW4	IW5	IW6	IW7	IW8	IW9	IW10
1. Time before showing full repertoire (min.)	0.26	0.37	2.55	0.46	0.41	0.26	0.26	2.55	0.46	0.41
2. Total display time (min.)										
- Fin display time (min.)	9.34	9.36	7.24	9.36	9.19	9.34	9.34	7.24	9.26	9.19
- Opercular display (min.)	9.34	9.36	6.42	9.39	8.27	9.34	9.34	6.42	9.39	8.27
3.Air gulping (number)	4.11	0.67	0.22	1.22	0.78	4.11	4.11	0.22	1.22	0.78
4.Attempted bites (number)	0.22	4.44	0.44	0.44	0.67	0.22	0.22	0.44	0.44	0.67
5.Movement										
- Mouth drag (left-right) (number)	1.67	4.67	1.56	0.89	1.56	1.67	1.67	1.56	0.89	1.56
6.Body attack glass										
- Caudal fin flickering (number)	12.44	8.44	2.11	13.22	4.56	12.44	12.44	2.11	13.22	4.56
7.Pelvic fin flickering (number)	6.89	9.78	3.22	8.11	13.33	6.89	6.89	3.22	8.11	13.33

Table 4-2 Mean scores on aggressive display criteria of bred *B. imbellis* observed by the mutual viewing test condition (n=10)

Criteria	Mean score of IB									
	IB1	IB2	IB3	IB4	IB5	IB6	IB7	IB8	IB9	IB10
1. Time before showing full repertoire (min.)	0.31	2.44	1.16	1.32	2.38	0.31	0.26	2.11	2.38	1.13
2. Total display time (min.)										
- Fin display time (min.)	9.22	1.27	8.27	7.52	5.18	9.27	9.38	8.39	7.05	6.19
- Opercular display (min.)	9.07	1.48	7.24	7.24	5.24	9.21	9.38	7.27	7.32	6.25
3.Air gulping (number)	1.89	1.00	0.44	1.89	1.78	2.78	2.00	0.44	0.89	2.78
4.Attempted bites (number)	3.56	0.00	3.11	0.00	0.00	0.33	3.11	0.44	0.78	0.11
5.Movement										
- Mouth drag (left-right) (number)	3.56	0.78	2.00	1.11	0.67	1.22	2.89	1.56	1.78	1.11
6.Body attack glass										
- Caudal fin flickering (number)	7.44	1.44	3.11	4.67	1.67	11.56	9.56	3.22	4.33	7.44
7.Pelvic fin flickering (number)	7.44	0.44	3.33	3.44	1.33	7.89	8.00	7.78	4.33	4.33

4.1.2 Results of real test condition from wild caught (IW) and bred *B. imbellis* (IB)

4.1.2.1 Time before showing full repertoire

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In this condition, each pair was put together in the same tank. The time before showing full repertoire was recorded right after removing the partition between the two compartments in a tank. The results in Fig. 4-3 showed that wild

caught fish had shorter time before showing full repertoire, when compared to the bred fish. Two wild caught fish that showed the shortest time of 1.42 min. and all of them show the full repertoire even before ten minutes. Time before showing full repertoire of the bred fish in the two conditions seemed to be similar ranged from 2.32 to 6.03 min., also all fish showed display in 10 min time.

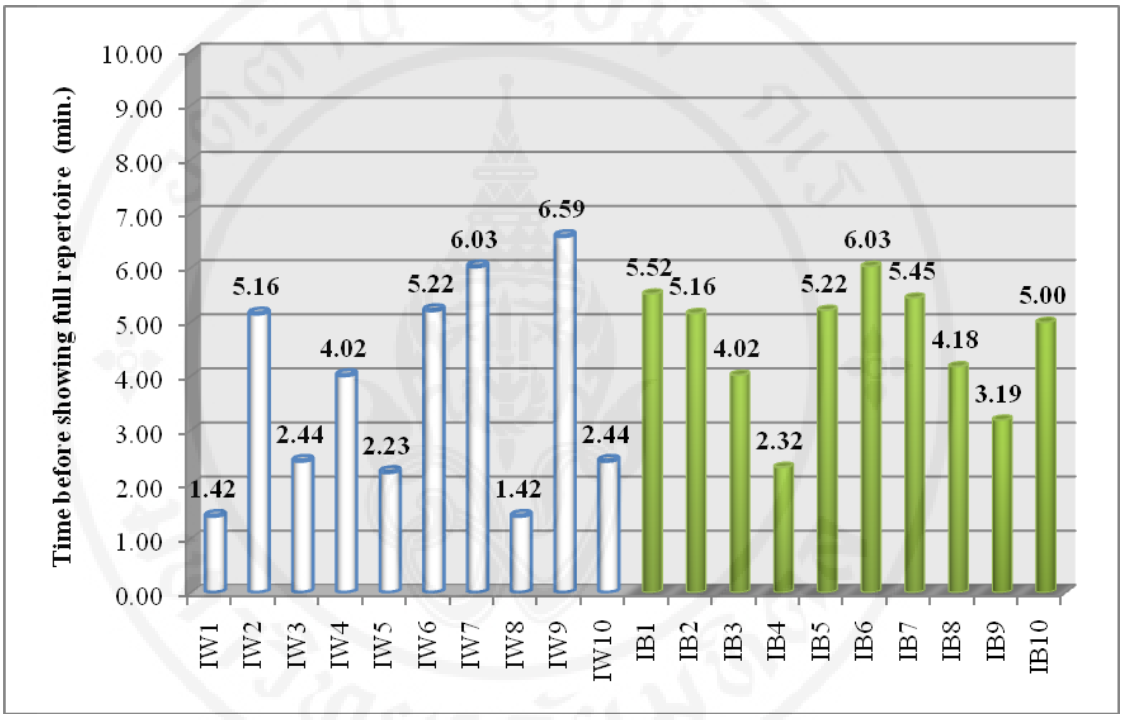

Figure 4-3 Mean displaying time before showing full repertoire of wild caught (IW) (n=10) and bred *B. imbellis* (IB) (n=10) as observed in real test condition

4.1.2.2 Total times for fin display and opercular display before the fighting start

Results from Fig.4-4 show the display times for fin and opercular before wild caught and bred *B. imbellis* start to fight. One wild caught fish (IW5) and one bred fish (IB4) displayed both fin and opercular less than 1 min. Two of the wild (IW3 and IW10) showed displaying time more than 4 min.

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It should be noticed that the results obtained from the real test condition (two fish encountered in the same tank) was different to what observed by using the mutual viewing test.

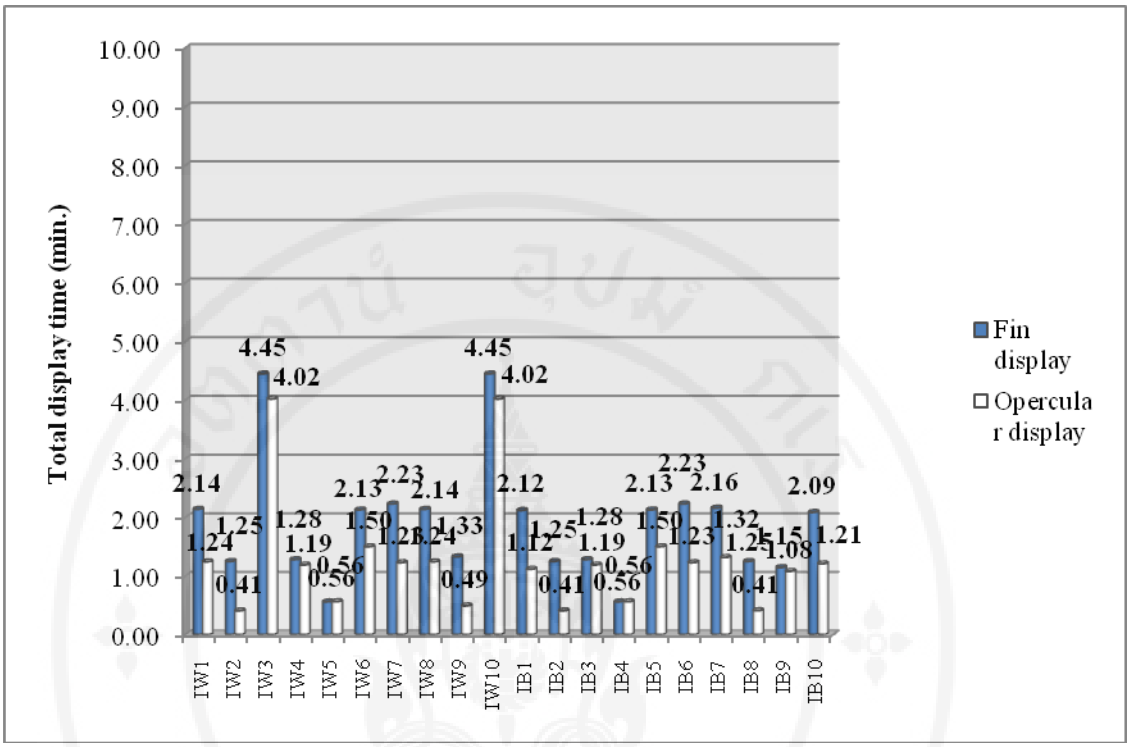

Figure 4-4 Mean time for fin display and opercular display of wild caught (IW) (n=10) and bred *B. imbellis* (IB) (n=10) as observed by real test condition

4.1.2.3 Other criteria for aggression display from real test condition

Results in Table 4-3 and Table 4-4 show other criteria of wild caught and bred *B. imbellis*. Both type of fish showed similar numbers of air gulping ranged from 2.11 to 5.89 in the wild caught, and from 4.33 to 5.33 in the bred. It should be noticed that these numbers were rather high when compared to the results obtained by using a mutual viewing test. However, the numbers of attempted bites were rather low in both types of fish, when compared to results from the mutual viewing test. The number of approaches in the wild caught was equal to the bred fish (0.67-6.22). For the number of caudal fin flickering, the wild-type fish showed as same as of flickering number when compared to the bred fish (2.78-11.56) and this result as same as in number of pelvic fin flickering.

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Table 4-3 Mean scores on aggressive display criteria of wild caught *B. imbellis* observed by the real test condition (n=10)

Criteria	Mean score of IW									
	IW1	**IW2**	**IW3**	**IW4**	**IW5**	**IW6**	**IW7**	**IW8**	**IW9**	**IW10**
1. Time before showing full repertoire (min.)	1.42	5.16	2.44	4.02	2.23	5.22	6.03	1.42	6.59	2.44
2. Total display time (min.)										
- Fin display time (min.)	2.14	1.25	4.45	1.28	0.56	2.13	2.23	2.14	1.33	4.45
- Opercular display (min.)	1.24	0.41	4.02	1.19	0.56	1.50	1.23	1.24	0.49	4.02
3.Air gulping (number)	3.78	5.22	2.11	4.89	4.33	4.56	5.11	3.78	5.89	2.11
4.Attempted bites (number)	0.67	2.56	0.89	0.11	0.33	0.56	2.78	0.67	0.56	0.89
5.Movement										
- Approach (number)	2.22	5.89	2.44	3.00	0.67	2.44	6.22	2.22	5.67	2.44
6.Body attack glass										
- Caudal fin flickering (number)	3.78	4.89	2.78	4.11	6.11	11.56	8.44	3.78	5.56	2.78
7.Pelvic fin flickering (number)	5.11	4.67	5.00	4.22	2.56	5.78	6.67	5.11	6.00	5.00

Table 4-4 Mean scores on aggressive display criteria of bred *B. imbellis* observed by the real test condition (n=10)

Criteria	Mean score of IB									
	IB1	**IB2**	**IB3**	**IB4**	**IB5**	**IB6**	**IB7**	**IB8**	**IB9**	**IB10**
1. Time before showing full repertoire (min.)	5.52	5.16	4.02	2.32	5.22	6.03	5.45	4.18	3.19	5.00
2. Total display time (min.)										
- Fin display time (min.)	2.12	1.25	1.28	0.56	2.13	2.23	2.16	1.25	1.15	2.09
- Opercular display (min.)	1.12	0.41	1.19	0.56	1.50	1.23	1.32	0.41	1.08	1.21
3.Air gulping (number)	4.67	5.22	4.89	4.33	4.56	5.11	5.22	5.33	4.44	4.67
4.Attempted bites (number)	3.00	2.56	0.11	0.33	0.56	2.78	2.78	2.56	0.11	2.44
5.Movement										
- Approach (number)	6.11	5.89	3.00	0.67	2.44	6.22	6.11	5.56	1.78	6.00
6.Body attack glass										
- Caudal fin flickering (number)	11.33	4.89	4.11	6.11	11.56	8.44	8.00	3.67	2.78	4.56
7.Pelvic fin flickering (number)	5.67	4.67	4.22	2.56	5.78	6.67	7.33	4.22	2.89	4.33

4.1.3 Comparison of the results from mutual viewing test and real test condition

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The results suggested that eight *B. imbellis* preferred mutual viewing test condition while two of them preferred real test condition to display aggression. This was support from time before showing full repertoire, fin and opercular display time

evidences (Table 4.5) In contrast the results in Table 4-6 suggested that the fish in real test condition took longer time for showing full repertoire than the mutual viewing test condition.

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Table 4-5 Comparison of mean score (n=10) on aggressive display criteria of wild caught *B. imbellis* in "mutual viewing test" and "real condition test" condition

Criteria	Mean score (n=10)																			
	Mutual viewing test * *(display times in total of 10 min)*										**Real test condition * *(display time before start fighting)***									
	IW1	**IW2**	**IW3**	**IW4**	**IW5**	**IW6**	**IW7**	**IW8**	**IW9**	**IW10**	**IW1**	**IW2**	**IW3**	**IW4**	**IW5**	**IW6**	**IW7**	**IW8**	**IW9**	**IW10**
1. Time before showing full repertoire (min.)	0.26	0.37	2.55	0.46	0.41	0.26	0.26	2.55	0.46	0.41	1.42	5.16	2.44	4.02	2.23	5.22	6.03	1.42	6.59	2.44
2. Total display time (min.)																				
-Fin display time (min.)	9.34	9.36	7.24	9.36	9.19	9.34	9.34	7.24	9.26	9.19	2.14	1.25	4.45	1.28	0.56	2.13	2.23	2.14	1.33	4.45
-Opercular display (min.)	9.34	9.36	6.42	9.39	8.27	9.34	9.34	6.42	9.39	8.27	1.24	0.41	4.02	1.19	0.56	1.50	1.23	1.24	0.49	4.02
3.Air gulping (number)	4.11	0.67	0.22	1.22	0.78	4.11	4.11	0.22	1.22	0.78	3.78	5.22	2.11	4.89	4.33	4.56	5.11	3.78	5.89	2.11
4.Attempted bites (number)	0.22	4.44	0.44	0.44	0.67	0.22	0.22	0.44	0.44	0.67	0.67	2.56	0.89	0.11	0.33	0.56	2.78	0.67	0.56	0.89
5.Movement																				
-Mouth drag (left-right) (number)	1.67	4.67	1.56	0.89	1.56	1.67	1.67	1.56	0.89	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Approach (number)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.22	5.89	2.44	3.00	0.67	2.44	6.22	2.22	5.67	2.44
6.Body attack glass																				
-Caudal fin flickering (number)	12.44	8.44	2.11	13.22	4.56	12.44	12.44	2.11	13.22	4.56	3.78	4.89	2.78	4.11	6.11	11.56	8.44	3.78	5.56	2.78
7.Pelvic fin flickering (number)	6.89	9.78	3.22	8.11	13.33	6.89	6.89	3.22	8.11	13.33	5.11	4.67	5.00	4.22	2.56	5.78	6.67	5.11	6.00	5.00

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Table 4-6 Comparison of mean score (n=10) on aggressive display criteria of bred *B. imbellis* in "mutual viewing test" and "real condition test" condition

Criteria	Mean score (n=10)																			
	Mutual viewing test * *(display times in total of 10 min)*										Real test condition * *(display time before start fighting)*									
	IB1	**IB2**	**IB3**	**IB4**	**IB5**	**IB6**	**IB7**	**IB8**	**IB9**	**IB10**	**IB1**	**IB2**	**IB3**	**IB4**	**IB5**	**IB6**	**IB7**	**IB8**	**IB9**	**IB10**
1. Time before showing full repertoire (min.)	0.31	2.44	1.16	1.32	2.38	0.31	0.26	2.11	2.38	1.13	5.52	5.16	4.02	2.32	5.22	6.03	5.45	4.18	3.19	5.00
2. Total display time (min.)																				
-Fin display time (min.)	9.22	1.27	8.27	7.52	5.18	9.27	9.38	8.39	7.05	6.19	2.12	1.25	1.28	0.56	2.13	2.23	2.16	1.25	1.15	2.09
-Opercular display (min.)	9.07	1.48	7.24	7.24	5.24	9.21	9.38	7.27	7.32	6.25	1.12	0.41	1.19	0.56	1.50	1.23	1.32	0.41	1.08	1.21
3.Air gulping (number)	1.89	1.00	0.44	1.89	1.78	2.78	2.00	0.44	0.89	2.78	4.67	5.22	4.89	4.33	4.56	5.11	5.22	5.33	4.44	4.67
4.Attempted bites (number)	3.56	0.00	3.11	0.00	0.00	0.33	3.11	0.44	0.78	0.11	3.00	2.56	0.11	0.33	0.56	2.78	2.78	2.56	0.11	2.44
5.Movement																				
-Mouth drag (left-right) (number)	3.56	0.78	2.00	1.11	0.67	1.22	2.89	1.56	1.78	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Approach (number)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.11	5.89	3.00	0.67	2.44	6.22	6.11	5.56	1.78	6.00
6.Body attack glass																				
-Caudal fin flickering (number)	7.44	1.44	3.11	4.67	1.67	11.56	9.56	3.22	4.33	7.44	11.33	4.89	4.11	6.11	11.56	8.44	8.00	3.67	2.78	4.56
7.Pelvic fin flickering (number)	0.31	2.44	1.16	1.32	2.38	0.31	0.26	2.11	2.38	1.13	5.52	5.16	4.02	2.32	5.22	6.03	5.45	4.18	3.19	5.00

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4.1.4 Aggressive display patterns from mutual viewing test condition

We used principal component analysis (PCA) to identify aggressive display patterns from nine characteristics of ten wild caught and ten bred *B. imbellis*. which are (1) time before showing full repertoire, (2) fin display time, (3) opercular display time, (4) air gulping, (5) attempted bites, (6) mouth drag, (7) approach, (8) caudal fin flickering, and (9) pelvic fin flickering in mutual viewing test condition. The principal component (PC) scores of which eigenvalue higher than one are shown in Table 4-7 including four components or four groups of pattern, the first principal component (PC1; eigenvalue =28.30) showed dominant characteristics of caudal fin flickering, pelvic fin flickering, opercular display time, fin display time, and air gulping. The second principal component (PC2; eigenvalue= 14.49) comprised dominant chracteristics of pelvic fin flickering. The third principal component (PC3; eigenvalue= 4.52), dominant characteristics consisted of attempted bites, fin display time, opercular display time, and mouth drag. And the fourth principal component (PC4; eigenvalue= 1.50) comprised dominant attempted bites, mouth drag, caudal fin flickering, and pelvic fin flickering.

Table 4-7 Principal component scores on the aggressive behavioral characteristics of *B. imbellis* in the mutual viewing test condition

Criteria	PC 1	PC 2	PC 3	PC 4
M-Time before repertoire	-0.1522	0.03673	-0.07562	-0.1135
M-Fin_display_time	0.2947	-0.05286	0.5102	-0.5127
M-Opercular_display_time	0.3163	-0.1096	0.4077	-0.3332
M-Air_gulping	0.1195	-0.168	-0.2482	-0.03708
M-Attempted_bites	0.01997	-0.04151	0.5196	0.6199
M-Mouth_drag	0.03537	-0.01602	0.3519	0.4043
M-Caudal_fin_flickering	0.7252	-0.4782	-0.3174	0.2354
M-Pelvic_fin_flickering	0.4981	0.8514	-0.1079	0.09288

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From the result on four components, we generated biplot of scores and loading on PCA from the dataset of the mutual viewing test condition. Biplot is a type of combined scatter plot and variable vector plot and the loading are presented as

vectors. The vectors are as the projection of the four-dimensional, orthogonal variable axes down to the two-dimensional plane. Their absolute lengths are not important, they can be scaled to produce a diagram, but their relative lengths and directions indicate very well how the two principal components in the scatter plot should be interpreted.

Bipolt of scores and loading on component 1 (PC1) and component 2 (PC2) in mutual viewing test condition are shown in figure 4-5. The most seven variables tilt toward the right, and opposite direction is only a time before showing full repertoire. The highest score is pelvic fin flickering therefore the one variable increase in value as go toward higher scores on PC1 and PC2 (the line show in plus quarter). For the fighting fish which had the highest scores of pelvic fin flickering are only wild caught fighting fish that are number IW2, IW5, and IW10.

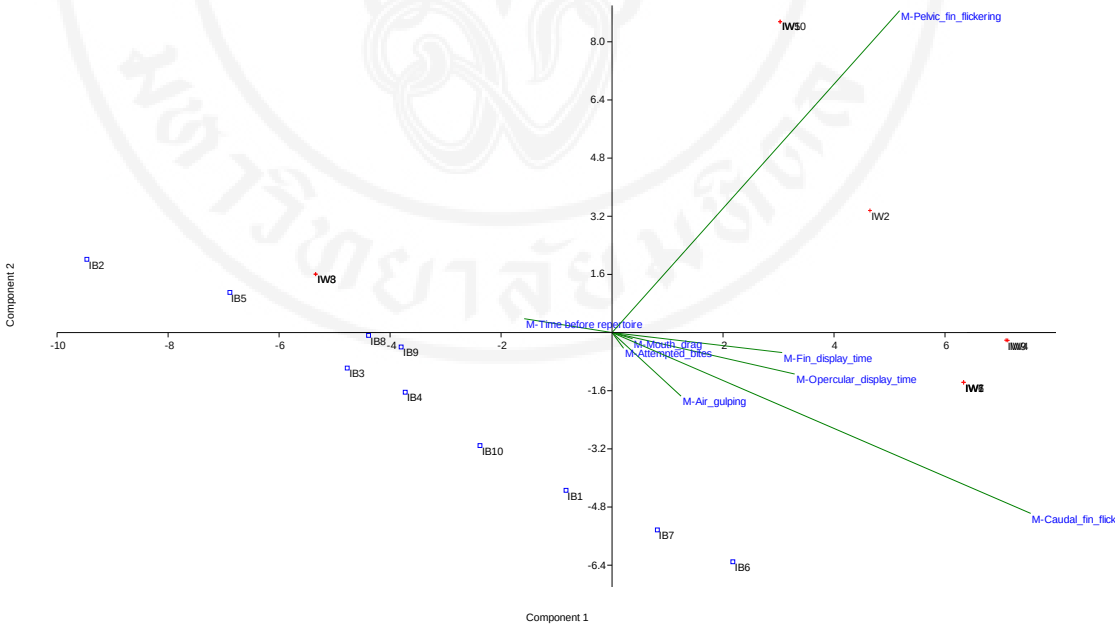

Figure 4-5 Bipolt of scores and loading on component 1 (PC1) and component 2 (PC2) of aggressive display characterisstics in mutual viewing test condition. The *x* axis is scores from component 1 (PC1) whereas a *y* axis is scores from component 2 (PC2). Crosses (+) in figure means wild caught *B. imbellis* (IW); and squares (☐) means bred *B. imbellis* (IB).

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The bipolt of scores and loading on component 1 (PC1) and component 3 (PC3) of aggressive display characteristics in mutual viewing test condition showed seven variables tilt toward the right and only one opposite tilt toward the left (Figure 4-6). There are four variables including in the higher scores as went toward plus quarter which are attempted bites, mouth drag, fin display time, and opercular display. For the fighting fish which had the highest scores of four variables are IW2, IW5, IW10 and IB7.

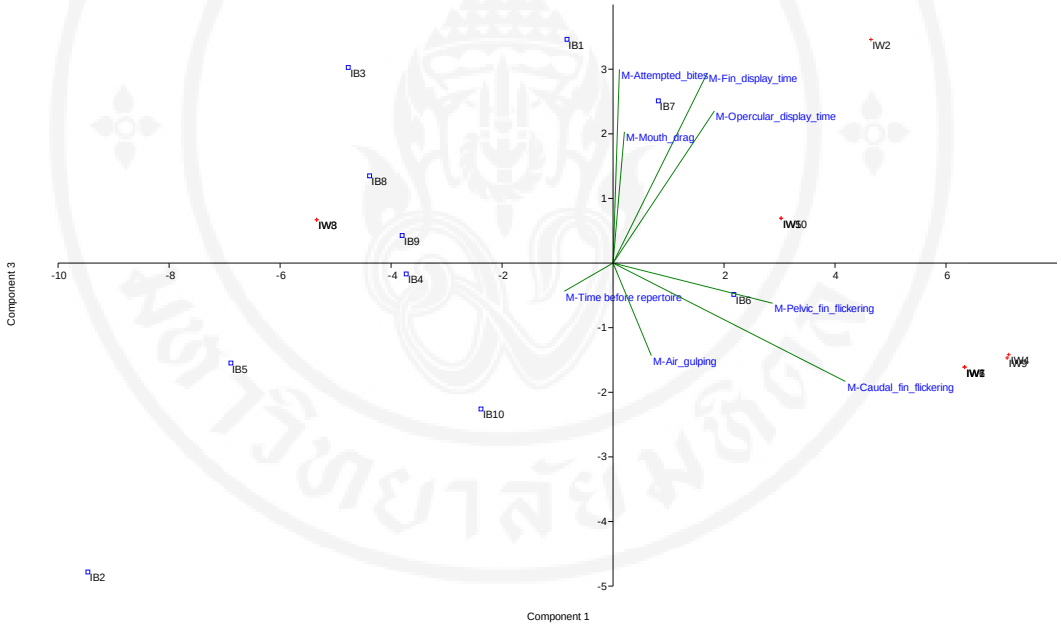

Figure 4-6 Bipolt of scores and loading on component 1 (PC1) and component 3 (PC3) of aggressive display characteristics in mutual viewing test condition.

The *x* axis is scores from component 1 (PC1) whereas a *y* axis is scores from component 3 (PC3). Crosses (+) in figure means wild caught *B. imbellis* (IW); and squares (☐) means bred *B. imbellis* (IB).

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The bipolt of scores and loading on component 1 (PC1) and component 4 (PC4) of aggressive display characteristics in mutual viewing test condition showed

seven variables tilt toward the right and only one variable opposite tilt toward the left (Figure 4-7). There are four variables including in the higher scores as went toward plus quarter which are attempted bites, mouth drag, caudal fin flickering, and pelvic fin flickering. For the fighting fish which had the highest scores of four variables are IW2, IW9 and IB7.

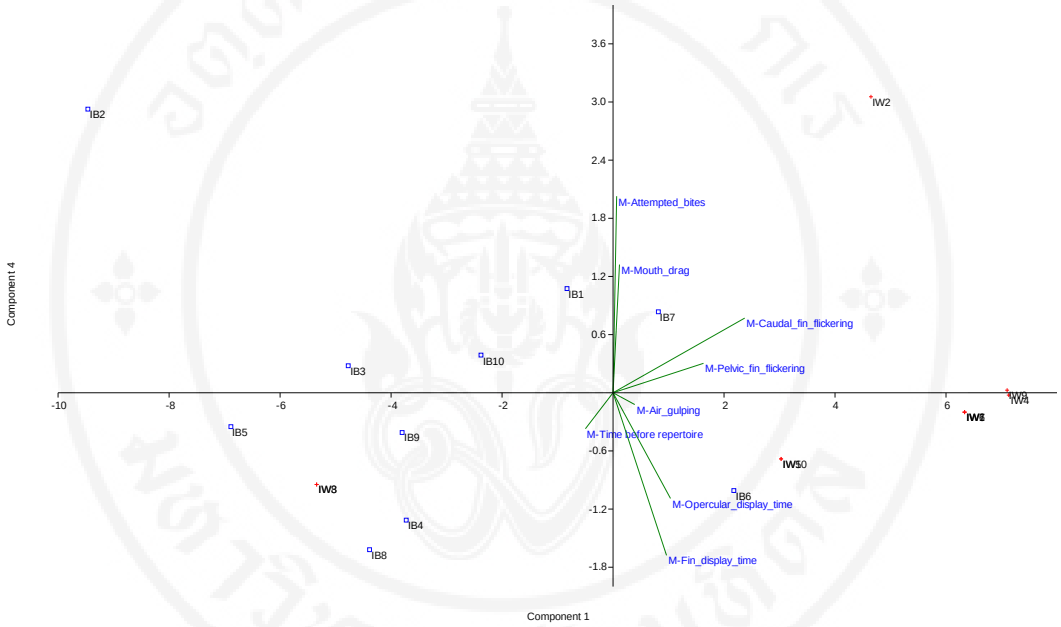

Figure 4-7 Bipolt of scores and loading on component 1 (PC1) and component 4 (PC4) of aggressive display characteristics in mutual viewing test condition.
The *x* axis is scores from component 1 (PC1) whereas a *y* axis is scores from component 4 (PC4). Crosses (+) in figure means wild caught *B. imbellis* (IW); and squares (☐) means bred *B. imbellis* (IB).

The bipolt of scores and loading on component 2 (PC2) and component 3 (PC3) of aggressive display characteristics in mutual viewing test condition showed two variables tilt toward the right and six variables opposite tilt toward the left (Figure 4-8). However there is no variable including in the higher scores as went toward plus quarter.

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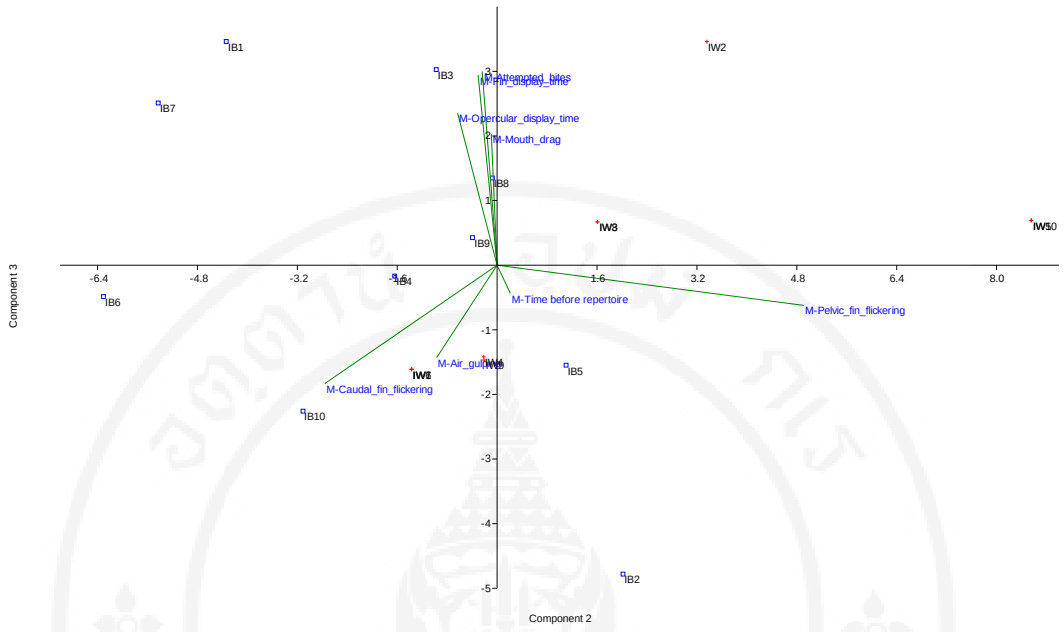

Figure 4-8 Bipolt of scores and loading on component 2 (PC2) and component 3 (PC3) of aggressive display characteristics in mutual viewing test condition. The *x* axis is scores from component 2 (PC2) whereas a *y* axis is scores from component 3 (PC3). Crosses (+) in figure means wild caught *B. imbellis* (IW); and squares (☐) means bred *B. imbellis* (IB).

Bipolt of scores and loading on component 2 (PC2) and component 4 (PC4) in mutual viewing test condition are shown in figure 4-9. Two variables; pelvic fin flickering, and time before showing full repertoire, tilt toward the right, and opposite direction is seven variables. The highest score is only pelvic fin flickering therefore the one variable increase in value as go toward higher scores on PC2 and PC4 (the line show in plus quarter). For the fighting fish which had the highest scores of pelvic fin flickering are only IW2, and IB2.

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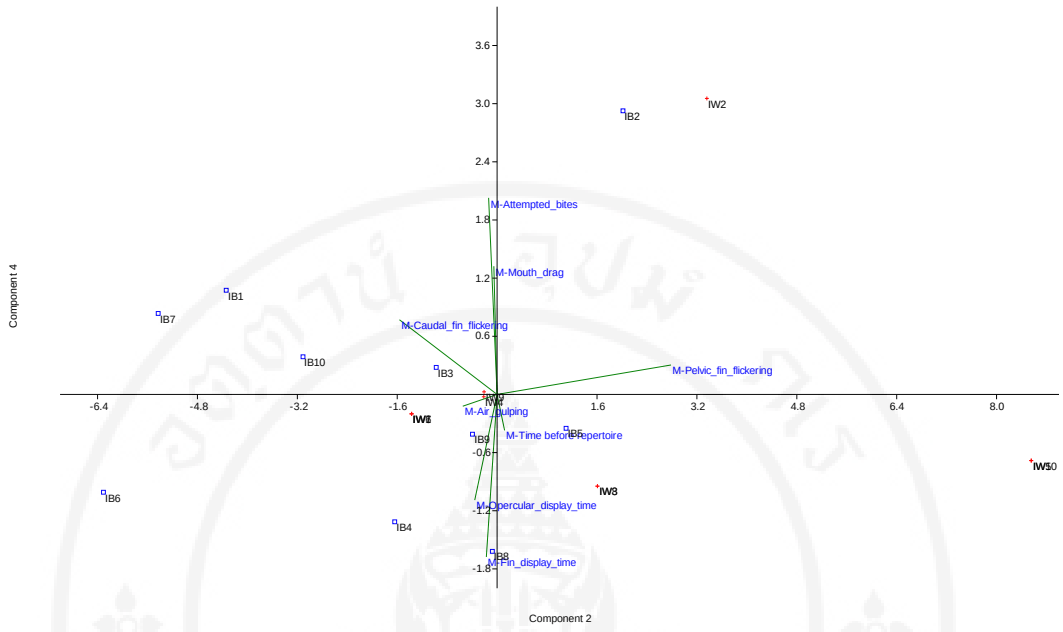

Figure 4-9 Bipolt of scores and loading on component 2 (PC2) and component 4 (PC4) of aggressive display characteristics in mutual viewing test condition. The *x* axis is scores from component 2 (PC2) whereas a *y* axis is scores from component 4 (PC4). Crosses (+) in figure means wild caught *B. imbellis* (IW); and squares (☐) means bred *B. imbellis* (IB).

The bipolt of scores and loading on component 3 (PC3) and component 4 (PC4) of aggressive display characteristics in mutual viewing test condition showed four variables tilt toward the right and four variables opposite tilt toward the left (Figure 4-10). There are two variables including in the higher scores as went toward plus quarter which are attempted bites, and mouth drag. For the fighting fish which had the highest scores of attempted bite and mouth drag are IW2, IB1, IB3, and IB7.

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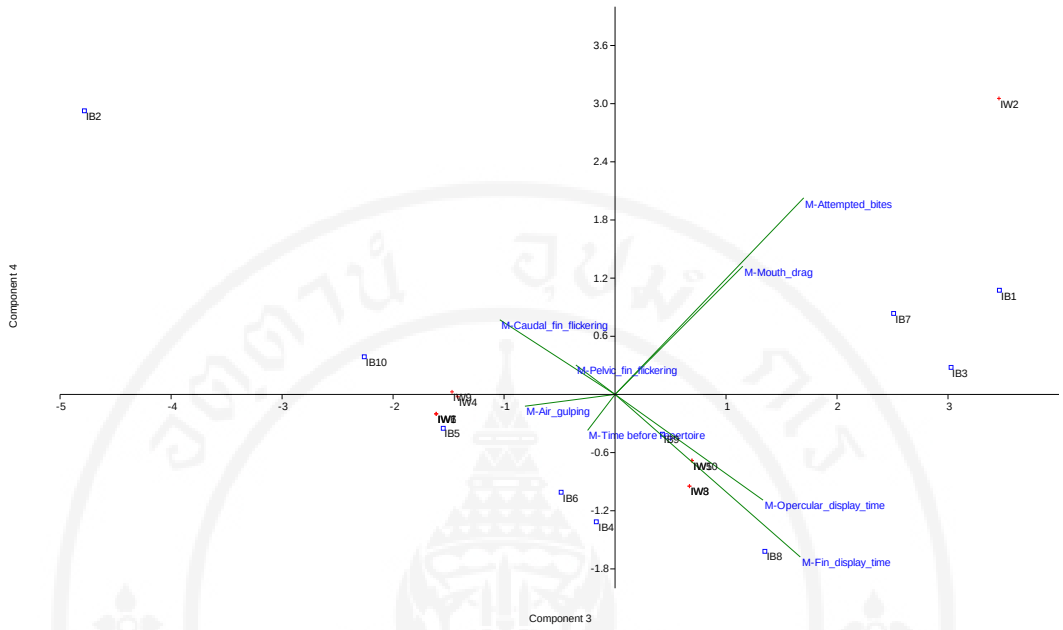

Figure 4-10 Bipolt of scores and loading on component 3 (PC3) and component 4 (PC4) of aggressive display characteristics in mutual viewing test condition. The *x* axis is scores from component 3 (PC3) whereas a *y* axis is scores from component 4 (PC4). Crosses (+) in figure means wild caught *B. imbellis* (IW); and squares (☐) means bred *B. imbellis* (IB).

The result of running PCA on the complete dataset showed that a staggering 56.86 % of the total variance was explained by the first principal component (PC1). It is obvious that PC1 could identify with pelvic fin flickering (Fig. 4-5), thus key index of *B. imbellis* aggressive behavior in the mutual viewing test condition is a pelvic fin flickering. However secondary variance explained by the next principal components, PC2 (29.12 % of total variance), PC3 (9.08 % of total variance), and PC4 (3.01 % of total variance) are also considered. Therefore the sub-key indexs of *B. imbellis* aggressive behavior in the mutual viewing test condition are attempted bite, mouth drag, fin display time, opercular display time, and caudal fin flickering. Moreover wild caught fighting fish IW2 seem to show the most aggressive display.

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4.1.5 Aggressive display patterns from real test condition

We used principal component analysis (PCA) to identify aggressive display patterns from nine characteristics of ten wild caught and ten bred *B. imbellis*. which are the same as in mutual viewing test condition. The result on Table 4-8 show the PC scores of which eigenvalue higher than one including three components or three groups of pattern. The first principal component (PC1; eigenvalue=11.85) showed dominant characteristics of caudal fin flickering, time before showing full repertoire, approach, pelvic fin flickering, attempted bites, and air gulping. The second principal component (PC2; eigenvalue= 5.29) comprised dominant characteristics of approach, attempted bites, time before showing full repertoire, pelvic fin flickering, and air gulping. And the third principal component (PC3; eigenvalue= 2.79) comprised dominant characteristics of fin display time, opercular display time, and pelvic fin flickering.

Table 4-8 Principal component scores on the aggressive behavioral charateristics of *B. imbellis* in real test condition

Criteria	PC 1	PC2	PC 3
R-Time_before_repertoire	0.4122	0.2278	-0.07977
R-Fin_display_time	-0.02974	0.02093	0.61
R-Opercular_display_time	-0.09379	-0.05135	0.5419
R-Air_gulping	0.1708	0.123	-0.4104
R-Attempted_bites	0.2024	0.2842	0.09897
R-Approach	0.3985	0.6561	0.06554
R-Caudal_fin_flickering	0.7416	-0.6305	0.06655
R-Pelvic_fin_flickering	0.2036	0.1452	0.3755

Results on biplot of scores and loading on four PCA components from real test condition are shown in Figure 4-11, Figure 4-12, and Figure 4-13. Bipolt of scores and loading on component 1 (PC1) and component 2 (PC2) in real test condition are shown in figure 4-11. Six variables tilt toward the right, and opposite direction is only two variables. The highest score is approach, attempted bites, time before showing fully repertoire, pelvic fin flickering, and air gulping therefore five

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variables increase in value as go toward higher scores on PC1 and PC2 (the line show in plus quarter). For the fighting fish which had the highest scores of pelvic fin flickering are IW2, IW7, IW9, IB2, IB6, IB7, IB8 and IB10.

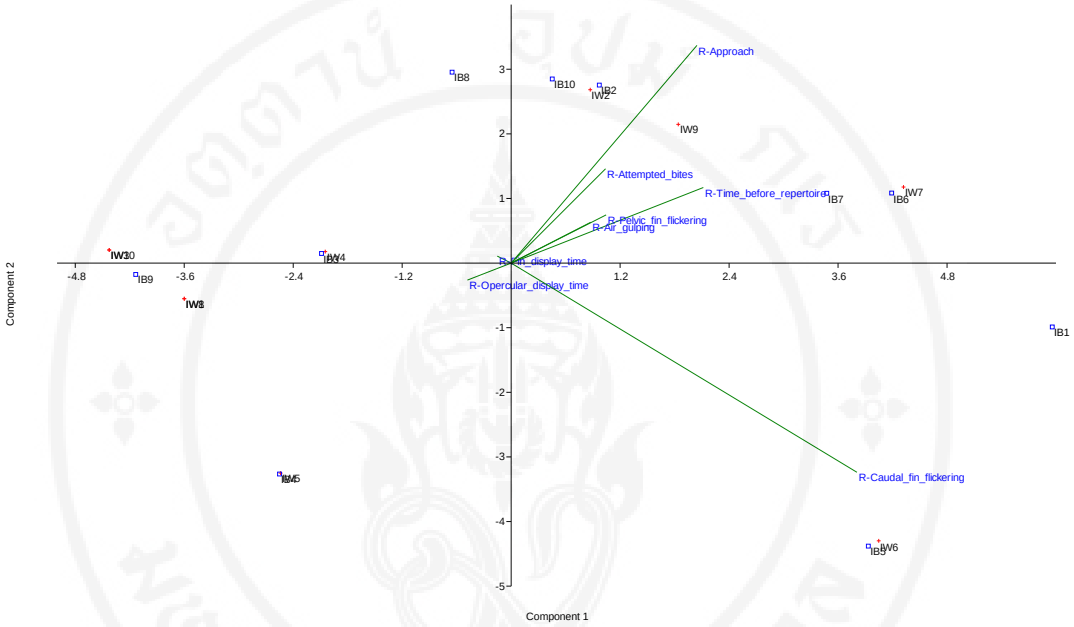

Figure 4-11 Bipolt of scores and loading on component 1 (PC1) and component 2 (PC2) of aggressive display characteristics in real test condition. The *x* axis is scores from component 1 (PC1) whereas a *y* axis is scores from component 2 (PC2). Crosses (+) in figure means wild caught *B. imbellis* (IW); and squares (☐) means bred *B. imbellis* (IB).

The bipolt of scores and loading on component 1 (PC1) and component 3 (PC3) of aggressive display characteristics in real test condition showed six variables tilt toward the right and two variables opposite tilt toward the left (Figure 4-12). There are four variables including in the higher scores as went toward plus quarter which are pelvic fin flickering, attempted bites, approaches, and caudal fin flickering. For the fighting fish which had the highest scores are IW6, IW7, IB1, IB5, IB6, IB7, and IB10.

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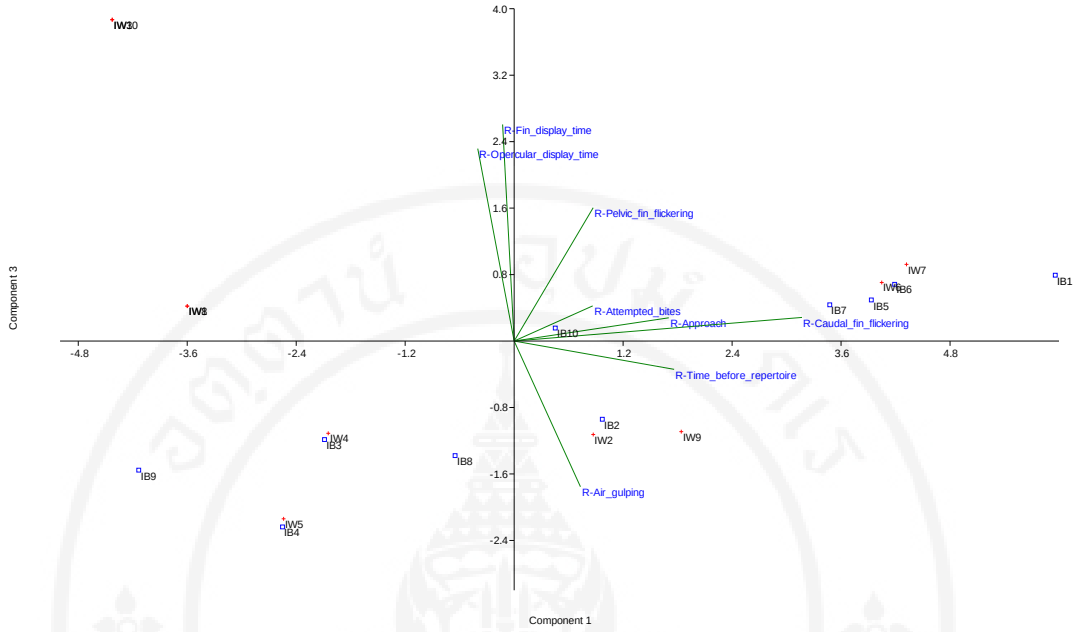

Figure 4-12 Bipolt of scores and loading on component 1 (PC1) and component 3 (PC3) of aggressive display characteristics in real test condition. The *x* axis is scores from component 1 (PC1) whereas a *y* axis is scores from component 3 (PC3). Crosses (+) in figure means wild caught *B. imbellis* (IW); and squares (☐) means bred *B. imbellis* (IB).

Bipolt of scores and loading on component 2 (PC2) and component 3 (PC3) in real test condition are shown in figure 4-13. Six variables tilt toward the right, and opposite direction is two variables. The highest score is four variables which are approaches, attempted bites, pelvic fin flickering, and fin display time increase in value as go toward higher scores on PC2 and PC3 (the line show in plus quarter). For the fighting fish which had the highest scores are only IW3, IW7, IW10, IB6, IB7, and IB10.

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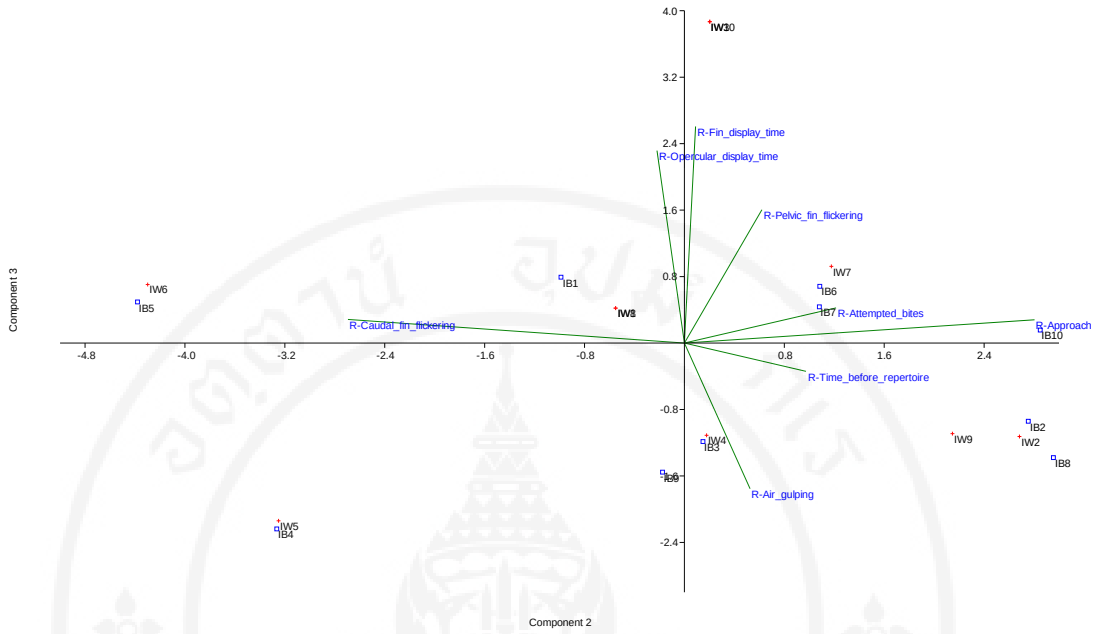

Figure 4-13 Bipolt of scores and loading on component 2 (PC2) and component 3 (PC3) of aggressive display characteristics in real test condition. The *x* axis is scores from component 2 (PC2) whereas a *y* axis is scores from component 3 (PC3). Crosses (+) in figure means wild caught *B. imbellis* (IW); and squares (☐) means bred *B. imbellis* (IB).

The result of running PCA on the complete dataset showed that a staggering 56.25 % of the total variance was explained by the first principal component (PC1). It is obvious that PC1 could identify with pelvic fin flickering, approaches, and attempted bites (Fig. 4-11), thus the key index of *B. imbellis* aggressive behavior in the real test condition are pelvic fin flickering, approaches, and attempted bites. However we also consider the secondary variance explained by other principal components, PC2 (25.14 % of total variance), and PC3 (13.26 % of total variance). Therefore the sub-key indexes of *B. imbellis* aggressive behavior in the real test condition are air gulping, time before showing full repertoire, and caudal fin flickering. Moreover wild caught fighting fish IW7 and bred fighting fish IB7 and IB10 seem to show more aggressive display than others.

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4.2 Educational aspect

Triangulation had been used to evaluate the effectiveness of a computer–based game instructional unit on students' achievement. Students' conceptual test, poster presentation and semi-structured interview was used to assess the students' understanding. Students' perception toward a newly develop instructional unit was evaluated through questionnaires, semi-structured interview and classroom observation. The results are as follows:

4.2.1 Effectiveness of a computer-based game instructional unit on aggressive and courting behavior understanding

The secondary students in this study had been taught animal behavior concept through a traditional approach for a few years ago. However they had little understanding of fighting fish, aggressive behavior and courtship behavior as shown in the pre-test scores (Table 4-9). The students enjoyed games in this unit as they expressed their emotion during playing game, made sound for cheering their friends, or expresses their idea to win those games. Moreover, some students who had experienced about fighting fish shared their ideas to peer during game playing, small group and a whole class discussion and presentation. After they had gone through the active learning module consisting of four games, students took the post - test and interviewed. The post-test results from 77 students showed that they significantly gained better understanding of three subtopics (Table 4-9, Figure 4-14). Five months later, students took the retention-test to confirm whether they understood these concepts or remembered them. The results showed that the retention-test mean scores of three sub topics and total points are slightly declining to 2.13 ± 0.73, 2.04 ± 0.78, 3.18 ± 0.72 and 7.35 ± 1.29. However the difference between pre-test and retention-test mean scores in each concept are statistically different. Therefore the students' understanding of aggressive behavior and courtship behavior of animal are improving after participating in this learning unit. Furthermore the result of the normalized gain shows that the students had a high level of those conceptual dimension in animal behavior (Table 4-9, Figure 4-14).

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Table 4-9 Mean scores of pretest, posttest, retention test, and normalized gain scores on the fighting fish conceptual test

Sub topic	Average score (Mean ± SD)			Normalized Gain
	Pre-test	Post-test	Retention-test	
1. Introduction of fighting fish (three points)	1.79 ± 0.61	2.97 ± 0.16*	2.13 ± 0.73	0.98
2. Aggressive behavior (three points)	1.61 ± 0.81	2.99 ± 0.11*	2.04 ± 0.78	0.99
3. Courtship behavior (four points)	2.32 ± 0.83	3.97 ± 0.16*	3.18 ± 0.72	0.98
Total (ten points)	5.73 ± 1.43	9.94 ± 0.25*	7.35 ± 1.29	0.98

* Significant difference at $p < 0.05$

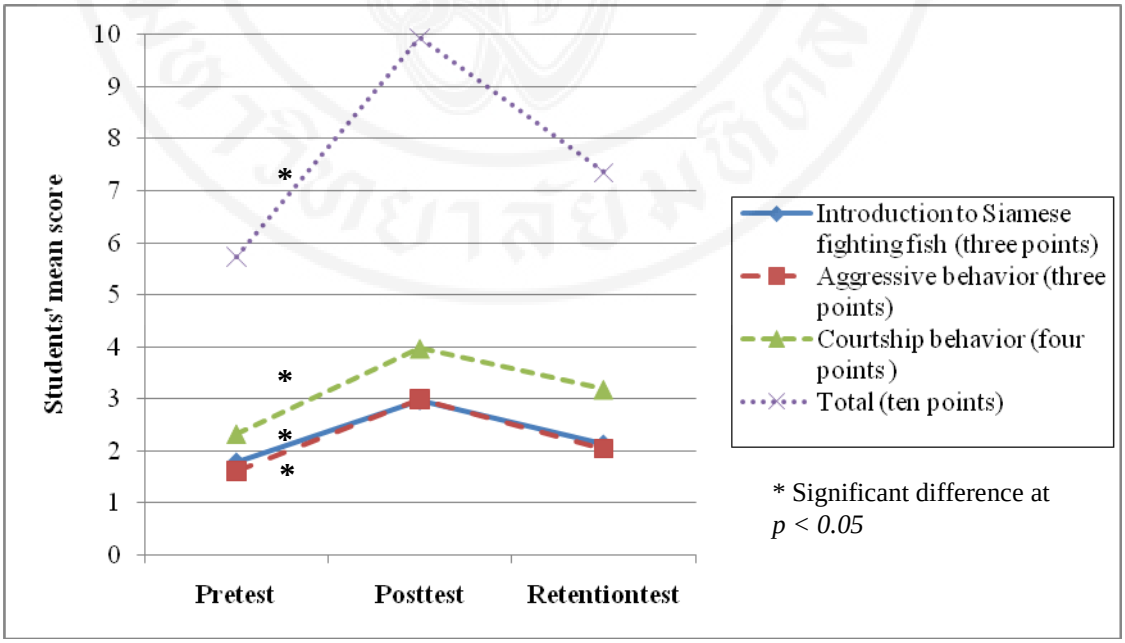

Figure 4-14 The comparison of pre-test, post-test and retention-test of students' mean scores in the Siamese are fighting fish conceptual test before and after the computer game-based instructional unit implementation

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After students participated in game playing, they divided into a group of 3-4 for discussion in reflective observation phase and for constructing a poster in abstract conceptualization phase (see more details in Table 3-4). Their poster results (see Table 4-10) showed that they had got high average score of three criteria (4.00 ± 0.55). Moreover the highest average scores are in the criteria of result and discussion on behavior of fighting fish. It seems that students gained a better understanding after participated in game playing and discussion.

Table 4-10 The average scores of students' group poster presentation

Criteria	**Average (Mean ± S.D.)**
1. Result and discussion on behavior of fighting fish (5 points)	4.27 ± 0.62
2. Poster presentation (5 points)	3.91 ± 0.67
3. Answering question (5 points)	3.82 ± 0.57
Average (5 points)	4.00 ± 0.55

Results from semi-structured interview also supported the results of conceptual test and poster presentation. Five students were voluntarily participated in interview after this learning unit implementation. They stated about animal behavior that:

> "The game made me understand the Siamese fighting fish and their behavior better, because by playing the game I learned by doing and this should help me to retain my knowledge"
>
> (Source: Students' Interview)

All of them said about characteristics of aggressive display of the fighting fish as this example statement:

> "When the fish saw the other fish, the fish usually show aggressive display by expanding the opercular

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and all fins, then change the body in dark color before the fighting will happen."

(Source: Students' Interview)

In addition, some students gained more knowledge about the courting behavior of the fighting fish as this example statement:

"I do not know about the fighting fish courting behavior before but after I had learned in this unit I know that if I saw the bubble nest that means the reproduction will follow."

(Source: Students' Interview)

In summary, an analysis of conceptual test, students' poster presentation and data from semi-structured interview found that the students had a better understanding after participated in the computer game-based instructional unit. It can conclude that a newly develop instructional unit could promote students' understanding of fighting fish and its behaviors.

4.2.2 Effectiveness of a computer-based game instructional unit on students' perception

Students took the questionnaire on perception when an intervention finished. The results showed that students had a positive perception toward a computer game-based instructional unit (Table 4-11). The highest average scores were on perception of knowledge (4.27±0.06), followed by the perception on enjoyment and on time duration.

Table 4-11 Average scores and standard deviations of responses to the questionnaire.

Criteria	Average score (Mean ± SD)
1. Perception of knowledge	4.27 ± 0.06
2. Perception of enjoyment	4.10 ± 0.09
3. Perception of time duration	3.97 ± 0.09

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The interview results also support the questionnaire findings. Most students satisfied with a computer game-based instructional unit. They agreed that the games helped them to build up their knowledge. Excerpts from the interview are as follows:

> "I would rather learn by using games than listening to lectures or even doing the laboratory experiment because it is much easier to understand by visualization and simulation."
>
> (Source: Students' Interview)

> "I gained knowledge from playing the games of the Siamese fighting fish. The clear objectives of the games helped me finding answers to my curiosity and thereby constructing the knowledge accordingly."
>
> (Source: Students' Interview)

Debriefing after participating in games helped the students understand better. An excerpt from the interview is as follows:

> "After debriefing, I learned with a better understanding about the Siamese fighting fish and their behavior"
>
> (Source: Students' Interview)

> "I caught link the knowledge from the Siamese fighting fish behavior to animal behavior content by debriefing phase."
>
> (Source: Students' Interview)

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Most of the participants had the positive attitude toward the unit, for example:

> "I enjoyed learning through the games. The fantasy pictures and scenes in the games aroused my interest and motivated me to learn."
>
> (Source: Students' Interview)

However, some students said that the allocated time for each game was too short, more time should be given. The games should be improved to be more complex, if they were to use at high school or university level. More attractive games should be added, with an up to date technology.

Not only the results from the questionnaire and semi-structured interview confirmed the positive perception of students toward an instructional unit, data from classroom observation was also. Most students seem active during playing game. They involved in the activities even they were not a player by shouting, cheering, observing, pointing the screen, or suggesting their peers. It was a noisy classroom during game session. However there were few students not much participates in the activities. They looked at the game with no response showing. Some students chat with friends or walked around the room. During debriefing session (small group and a whole class discussion), students tried to answer posed questions by teacher and peers. Moreover they listened to the class with interesting faces, especially when their friends shared their actual experience about fighting fish. There were still silent students but they seem interest what the class discussing.

All together with these findings, the results could be summarized that a newly develop instructional unit has a positive impact on students' perception in this study.

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CHAPTER V
DISCUSSION

Overview

This chapter presents the interpretation and discussion of this study. The first session discussed about an aggressive behavior in southern fighting fish (*B. imbellis*). The others explain how a computer-based game instructional unit promotes students' understanding and perception toward the unit.

5.1 Scientific aspect

By using mutual viewing test condition, the obtained results could be used to discriminate the aggressive display from non aggressive display, and could also demonstrate different aggressive display among fish of the same type and different type.

Upon comparing the aggressive display of the ten wild caught *B. imbellis*, the results suggested that fish number IW2 seemed to be more aggression than others. This was judged from the PC scores of mutual viewing test condition which pelvic fin flickering is a key index criteria and the sub-key index criteria are attempted bite, mouth drag, fin display time, opercular display time, and caudal fin flickering (Table 4-7). By using the PCA, it also can be suggested that ten bred *B. imbellis* were different in their aggressiveness. The fish number IB2,and IB5 seemed to be less aggressive than the other three fishes. However, for reliability of the results, the experiment should be repeated with higher numbers of fish samples and repeated with the numbers of the experiment.

The results from PCA on mutual viewing test condition also suggested that the wild caught *B. imbellis* seemed to be more aggressive than those of bred *B. imbellis*. This is evidenced from the results on PC scores of pelvic fin flickering, attempted bites, opercular display time, fin display time and caudal fin flickering

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(Table 4-7). Verbeek, Iwamoto and Murakami (2007) used the mutual viewing test condition in studying the aggressive behavior of the so called wild-type fish in comparison to the domesticated fish. However, their wild-type was not the wild-caught, but it was the bred one. The domesticated fish was the hybrid of the selected fighter. Several reports from the other studies (Smith, 1965; Simpson, 1968; Evans, 1985; Gorlick, 1990) were also from either the hybrid or the bred one. Up to our knowledge the results reported here is the first time for comparing the aggressive behavior of wild-type fish between the wild caught and bred one. The results suggested that they behaved differently in degree of aggressiveness, although they showed a similar pattern of aggressive display. This might be due to the different way that they were brought up. The wild caught fishes were raised naturally in a larger space of the water basin. They have more freedom to move around. They were just housed individually for about 1-3 months before the experiment. The bred fishes were raised in a fish tank with much smaller space. They have more chance to meet with their bred relatives, due to limited space. It is rather difficult to compare the finding in this study to the results of others researchers. This is because the condition used for raising the fish and the experiment seem to be different. The aggressive display of the fighting fish seemed to be sensitive to the environment. Moreover, this study used a rather small number of samples, more conclusive data could be drawn upon using a higher number of fish samples.

The results from the real test condition seemed to be different from those of the mutual viewing test condition. The fish took longer time before showing full repertoire than the mutual viewing test condition. The fin and opercular display time in this experiment was the time from showing full repertoire to the time just before they started to fight.

Result from PCA was difficult to compare aggressiveness of wild caught and bred *B. imbellis*. One of the wild caught fish (IW7) seem to show more aggressive display in this case and also two bred fish (IB7 and IB10). When compared to the number of pelvic fin flickering, approaches, and attempted bites of the fish that use for the key index, it could show aggressive display. Time used in five wild caught fish was shorter than nine bred fish. However, the results on fin and opercular display, along with the number of attempted bites and number of caudal fin flickering and

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number of pelvic fin flickering led to a suggestion that the bred fish seem to show more aggressive display, when compared to those of the wild caught fish. We could not really explain for this phenomenon. It might be partly due to their habitat before being caught or collected. Bred fish might be used to live together in limited space and fight more often while the wild used to live in a larger space and had less chance to meet and fight.

Results on PC scores from mutual viewing test condition found that six criteria seem to behave together which are pelvic fin flickering, attempted bites, mouth drag, fin display time, opercular display time, and caudal fin flickering while from real test condition found that fighting fish also behave six criteria; pelvic fin flickering, approaches, attempted bites, air gulping, time before showing full repertoire, and caudal fin flickering. Moreover the highest score on both condition was pelvic fin flickering. Therefore it could be concluded that pelvic fin flickering should be used as a key index of aggressive display of southern fighting fish (*B. imbellis*).

5.2 Educational aspect

The improvement of students' understanding and perception in this study is used as the indicators for the effectiveness of a computer-based game instructional unit. The results clearly showed that a newly developed instructional unit help students to construct their own understanding of the aggressive and courting behaviors of the fighting fish. This is evidenced by the significantly higher scores of the post-test when compared to those of the pre-test and poster presentation average scores. The results implied that studying about animal behavior in school by listening or reading from textbooks, without any hands-on activity or visual-aids such as the multimedia, resulted in poor understanding and memorization leading to poor retention as judged from lower pre-test scores. From the interview, most participants had little knowledge as well as harbored misconceptions about behaviors of the fighting fish, both the aggressive and courtship ones. They stated that after playing the interactive games on fighting fish they could build up their own understanding and correct the alternative conceptions. Here, even without the hands-on activity on live fighting fish, they could just as well gain experience by repeatedly playing the games

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until they found the right answers. Moreover learning by gaming aroused their interest and motivated them to learn. Regarding games on animal behavior, Facer, Joiner, Stanton, Reid, Hull and Kirk (2004) developed a mobile gaming experience to encourage students to build up their understanding of animal behavior. They suggested that mobile gaming might be employed as a tool to support learning. The result is in agreement with several other research works that educational games have a positive impact on student learning and motivation (Leach & Sugarman, 2005). As same as the result of Liu, Cheng and Huang (2011) showed that games enable students to further develop their curiosities for their learning resulting in better concept building and problem solving abilities. For example an immersive protein gaming for bio-edutainment which focused on the learning Biomolecular structure by virtual reality gaming has been shown to facilitate high school student learning (Leach & Sugarman, 2005; Cai, Lu, Zheng & Li, 2006).

For students, the computer-based game instructional unit had provided an engaging and motivating environment which was entirely different from the experience in the traditional lecture or laboratory. Motivation is an important factor to extend learning capacity. Motivation is a significant characteristic of educational video games (Dickey, 2005; Fisch, 2005). Because of the limitation of working memory, apart from motivating, learning games lessen the mental load by providing an extra dimension. Squire, Barnett, Grant and Higginbotham (2004) and other studies (Leach & Sugarman, 2005) found better mastery of abstract and conceptual knowledge through game play.

Additionally the success of the computer-based game instructional unit in promoting students to construct their own knowledge of fish behavior is due to the incorporation of the experiential learning theory (Kolb, 1984) into the selected content. In such an instructional unit, the framework of experiential learning provided the student with concrete experience about the fish behavior. The participants observed and collected data as well as reflected on what they had observed about the aggressive and courtship behaviors. In the next step on abstract conceptualization, the participant drew conclusions and hypothesized from the experience gained. Lastly the participants tested their hypothesis in a new situation, i.e., levels of aggression, responses to various induction circumstances including video and mirror image of

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other fish. Results from interview indicated the participants felt that each step of the games that incorporated the experiential learning theory helped gradually to construct their knowledge. In the fighting fish games in this study, there was an introduction providing interesting background about the fighting fish to arouse student interest. In all four games, there were clear goals and immediate feedback to help student learning. The first game on putting the right fish in the right bowl was used to challenge students into the general behavior of the fighting fish. In all the games experiential learning facilitated student conceptualization. An experiential gaming model that facilitates flow experience has been reported by Kiili (2005), however, there was no report of their learner achievement.

It is well recognized that games can make learning more interesting, however the concepts of science can be taught not only by playing games but by designing games (Jong, Shang, Lee & Lee, 2008; Crookall, 2010). The educational games in this study not only incorporated the experiential learning but also included motivational and socio-cultural perspectives. Fortunately the fighting fish is well known among the ASEAN people, the fantasy scenes close to their real-life and culture were provided to arouse their curiosity and thereby interest. This was done according to the intrinsic motivation theory of Malone (1980) that challenge, fantasy, control, curiosity, cooperation, recognition and competition are the significant elements that cause fun and engage and sustain motives of the players. From the results of perception questionnaire that the participants had a positive attitude to the games is not surprising. The results corroborate several other reports that the motive power of games makes learning fun, and learning through doing in games is a powerful practice. The results from this study offer an alternative way in teaching biology through educational games based on the experiential learning theory.

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CHAPTER VI
CONCLUSIONS

Overview

This chapter summarizes the findings from both scientific and educational aspects in the study. Implication of the study and limitations are also described.

6.1 Scientific aspect

6.1.1 By using the mutual viewing test condition, the obtained results can discriminate aggressive display from non-aggressive display.

6.1.2 Result of PC scores on pelvic fin flickering from mutual viewing test condition suggested that wild caught *B. imbellis* seem to be more aggressive than those of bred *B. imbellis*.

6.1.3 Results from real test condition seem to be different from those of the mutual viewing test condition. There was no direct answer of which types could show more aggression. Two bred fighting fish seem to be more aggressive than wild caught when focus on number of approach, attempted bites, and pelvic fin flickering. However wild caught *B. imbellis* seem more aggression when used fin and opercular display, along with the number of attempted bites and the number of caudal fin flickering and number of pelvic fin flickering as indicators.

6.1.4 For the key characteristic of aggressive display, the results from the mutual viewing test condition found that six criteria seem to behave together which are pelvic fin flickering, attempted bites, mouth drag, fin display time, opercular display time, and caudal fin flickering. Furthermore results from real test condition found that fighting fish also behave six criteria; pelvic fin flickering, approaches,

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attempted bites, air gulping, time before showing full repertoire, and caudal fin flickering together during aggression.

6.1.5 PC scores gathered from both mutual viewing test condition and real test condition could be summarized that key index of southern fighting fish aggression should be pelvic fin flickering.

6.2 Educational aspect

6.2.1 A newly developed computer game-based instructional unit on fighting fish could enhances students' conceptual understanding of animal behavior of secondary students

6.2.2 The students had a positive perception of the computer game-based instructional unit.

6.2.3 The computer game-based instructional unit may be used as an integral part of biology education.

6.3 Implication of the study

Results of the study suggested that the computer game-based instructional unit may help students understand concepts involved in animal behavior. Teacher can use this learning unit for promoting students' understanding in animal behavior contents, moreover some part of game can apply for use in the teaching approach that will be created by own teacher. Moreover teacher can apply this unit to engage and motivate student to interest in depth content and enjoyment when they learn in biology class. Moreover the games could be applied into mobile device for support mobile learning.

6.4 Limitations

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The computer-based game instructional unit should be improved to be more complexes, because of the study result came from limited numbers of students in

only one school. More extended studies with a larger population of students and teachers should adapted the result in suitable for each classroom. In addition, more attractive and complicate games should be added, with an up to date technology.

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APPENDICES

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APPENDIX A

Photographs of the wild-type bubble nest builder bettas (*Betta splendens* group)

***Betta splendens* Regan, 1910**

***Betta imbellis* Ladiges, 1975**

***Betta siamorientalis* Kowasupat, Panijpan, Ruenwongsa & Jeenthong, 2012**

***Betta smaragdina* Ladiges, 1972**

***Betta mahachaiensis* Kowasupat, Panijpan, Ruenwongsa & Sriwattanarothai, 2012**

***Betta stiktos* Tan & Ng, 2005**

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APPENDIX B

Photographs of the bred bubble nest builder bettas (domesticated fighting fish)

Betta splendens **(blue half moon)**

Betta splendens **(opaque half moon)**

Betta splendens **(multicolored crown tail)**

Betta splendens **(short fin crown tail)**

Betta splendens **(red double tail)**

Betta splendens **(maeble short fin)**

Copyright by Mahidol University

APPENDIX C

Fighting fish conceptual test for high school students (grade 10-12)

Instruction:

This multiple-choice-question test aims to assess basic knowledge, understanding and opinion of high school students toward fighting fish and its aggressive and courtship behaviors. Obtaining data will be used to develop the learning path within a computer game-based instructional unit for enhancing understanding of fighting fish as well as its distinguished behaviors. All data will be restricted and reserved for research purpose mainly. The identification code number is applied for, in case of respondents' data dissemination. Thus, please carefully select the answer to represent your knowledge.

The fighting fish conceptual test comprises two parts, which are:

Part 1: Basic information

Part 2: Ten multiple-choice questions regarding the understanding and opinion toward fighting fish and its aggressive and courtship behaviors. There is ten minutes to complete the pretest.

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Fighting fish conceptual test

Part 1: Basic Information

Instruction: Please tick the appropriate box or complete the answer

1. Identification code number ……

2. Gender: ( ) Male ( ) Female

3. Age……

4. Grade/Class…… School's name…….……...….

Province ……

5. Place of Birth:

( ) Bangkok ( ) Others, (please specify)…….……

Part 2: Ten multiple-choice questions regarding the understanding and opinion toward fighting fish and its aggressive and courtship behaviors.

Instruction: The following are ten multiple-choice questions. Please carefully read and select an appropriate answer.

No.	Question	Data processing (Researcher only)
1.	Which characteristic is used to categorized fighting fish into two groups? A. Egg shape B. Feeding young C. Courtship display D. Bubble nest size	
2.	What is the distinguish characteristics of fighting fish? A. Fast swimming and moving around B. Always deepening in color and fins slacken C. Attempted bite without spreading their fins or	

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No.	Question	Data processing (Researcher only)
	darkening D. Enlarge the body size, flare the gill covers, spread the fins and deepening in color during encounter	
3.	Is it possible to keep adult fighting fish from different locations in the same tank? Give reason. A. Yes, because they can share their territory B. Yes, because the tank will look even more beautiful when they are putting together C. No, because they will fight until death D. No, because they will compete for food	
4.	Which one is **incorrect** for the fighting fish aggressive display? A. Deepening of the body and fin color B. Only male fighting fish can display aggression C. Gill cover flaring for threaten each others D. Pelvic fins flickering and broadside turning	
5.	Which one is **not** the function of aggressive behavior in fighting fish? A. To defend territory B. To select a mating choice C. To protect fertilized eggs D. To attract the opposite	
6.	What kind of communication when fighting fish display	

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No.	Question	Data processing (Researcher only)
	aggressively? A. Sound communication B. Visual communication C. Chemical communication D. Sign communication	
7.	From the following statement, what could be an appropriate behavior referring those actions: When a male fighting fish meets with a female one, he spreads his fins and darker his color and then try to wrap his body around the female. A. Aggressive behavior B. Courtship behavior C. Territorial defensive behavior D. Teasing	
8.	What is the sign of willingness to mate in male fighting fish? A. Build a bubble nest B. Build a nest from the rocks C. Build a nest from the aquatic plants D. Do nothing	
9.	What is the relationship between aggressive and courtship behaviors in fighting fish? A. There is no relation with each other B. Aggression is a part of courtship behavior C. A male will not act aggressively to a female	

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No.	Question	Data processing (Researcher only)
	during courtship display D. A female will not act aggressively to a male if she is not ready to breed	
10.	What a male fighting fish has to do after breeding? A. Consuming the fertilized eggs B. Looking for another female to breed with C. Leaving a female to take care the fertilized eggs alone D. Keeping and guarding the fertilized eggs until larvae hatching	

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APPENDIX D

MAHIDOL UNIVERSITY
Wisdom of the Land

Questionnaire for student's perception toward a computer-game based instructional unit of fighting fish and its distinguished behaviors

Objective:

The questionnaire aims to investigate students' perception after they received the remedial learning. Your answers will be kept in secret. It will be used in research that does not have any effects on an individual or school.

Instruction:

Please consider each statement and mark ✓ your opinion in the table of each response according to your perception. The criterion of each level of agreement is following:

5 means strongly agree

4 means agree

3 means neutral

2 mean disagree

1 means strongly disagree

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Part 1: Personal Data

Gender ☐ Male ☐ Female

Student's ID…… Age……..……..……..……..

Grade/Class…….. School……..……..……..……...

Cumulative Grade Point Average

☐ < 1.00 ☐ 1.00 – 1.99 ☐ 2.00 – 2.99 ☐ 3.00 – 4.00

Part 2: Students' perception of the computer-game based instructional unit and media

Issue	**Level of agreement**				
	5	**4**	**3**	**2**	**1**
1. Media is suitable to arouse student interest					
2. Media could enhance the understanding of fighting fish biology					
3. Media could improve the understanding of fighting fish behavior					
4. Game is suitable to arouse student interest					
5. Game make me enjoy					
6. Fighting fish in the glass bowl game could make me understand how to maintain the fighting fish appropriately					
7. Aggressive behavior game could make me understand the fighting fish aggression					
8. Betta breeding game could make me understand courtship and reproductive behavior in fighting fish					
9. Betta reaction game could make me understand how fighting fish reacts to the stimulus					

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Issue	Level of agreement				
	5	4	3	2	1
10. Game could make me improve the understanding and also connect the media to the content knowledge					
11. Duration time for game playing is suitable					
12. Duration time for media usage is appropriate					

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2. Kowasupat, C., Panijpan, B., Ruenwongsa, P., & Jeenthong, T. (2012). Betta siamorientalis, a new species of bubble-nest building fighting fish (Teleostei: Osphronemidae) from eastern Thailand. *Vertebrate Zoology, 62*(3), 387-397.

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