PROMOTING PRIMARY AND SECONDARY STUDENTS LEARNING OUTCOMES THROUGH INQUIRY-BASED AND HANDS-ON INSTRUCTION ON SIAMESE FIGHTING FISH BIODIVERSITY

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PROMOTING PRIMARY AND SECONDARY STUDENTS LEARNING OUTCOMES THROUGH INQUIRY-BASED AND HANDS-ON INSTRUCTION ON SIAMESE FIGHTING FISH BIODIVERSITY

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ABSTRACT

This study focused on developing two instructional learning units for primary and secondary students. In the first unit on cooperative learning, a learning center on fighting fish was established in the school. Groups of four students worked together on each topic which differed from those of the other groups. Following extensive discussion, all students were expected to gain knowledge from both their own in-group activity and the activities of other groups. The results showed improvement in the level of knowledge of the students from the first week to the third week. Almost all students were able to conceptualize various aspects of the life of the fighting fish. This can be explained by the self-accountability of individual students as well as their responsibility for the achievements of their friends.

The second one was a hands-on learning unit on genetics and biodiversity with an emphasis on guided-inquiry. Students from the experimental group learned in a hands-on class while these in the control group learned in a traditional lecture class. The experimental group used colored clips to represent traits (phenotype) of genes (genotype) in the topic on genetics. Regarding biodiversity, the students were given plastic models of diverse animals and asked to classify them according to morphological criteria. The results clearly showed an increase in the conceptual understanding of the students on both topics as compared to the control group taught by traditional lecture.

In both learning units, the teacher had some standard objectives in mind while guiding the students who were engaged enough to pursue the activity to the end. Additionally, the students from both learning units stated that they enjoyed being active and challenged in the unit.

KEY WORDS: COOPERATIVE LEARNING / HANDS-ON LEARNING / GUIDED-INQUIRY / FIGHTING FISH / MENDELIAN GENETICS / BIODIVERSITY

137 pages

การส่งเสริมผลการเรียนรู้ของนักเรียนระดับประถมศึกษาและมัธยมศึกษาโดยใช้วิธีการสอนแบบสืบเสาะหาความรู้และการลงมือปฏิบัติการ เรื่อง ความหลากหลายของปลากัดไทย

PROMOTING PRIMARY AND SECONDARY STUDENTS LEARNING OUTCOMES THROUGH INQUIRY-BASED AND HANDS-ON INSTRUCTION ON SIAMESE FIGHTING FISH BIODIVERSITY

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บทคัดย่อ

งานวิจัยครั้งนี้เป็นการพัฒนาหน่วยการเรียนรู้จำนวน 2 หน่วย สำหรับนักเรียนระดับประถมศึกษาและมัธยมศึกษา หน่วยการเรียนรู้ที่ 1 ใช้วิธีการเรียนรู้แบบร่วมมือกัน ผู้วิจัยได้ร่วมกับโรงเรียนจัดสร้างศูนย์การเรียนรู้ภูมิปัญญาท้องถิ่น เรื่อง ปลากัดไทย ขึ้นภายในห้องเรียน นักเรียนที่เข้าร่วมงานวิจัยจะทำงานร่วมกันเป็นกลุ่ม กลุ่มละ 4 คน แต่ละกลุ่มจะได้รับหัวข้อความรู้และใบกิจกรรมที่แตกต่างกัน เกี่ยวกับเรื่อง ปลากัดไทย หลังจากนั้นนักเรียนแต่ละกลุ่มจะมาร่วมกันอภิปรายผลที่ได้จากการทำกิจกรรม โดยผู้วิจัยคาดหวังว่านักเรียนจะได้รับความรู้เพิ่มขึ้นจากการทำกิจกรรมภายในกลุ่มและระหว่างกลุ่ม ผลการศึกษาพบว่าระดับความรู้ของนักเรียนที่ได้จากการเรียนรู้ภายในศูนย์การเรียนนับตั้งแต่สัปดาห์ที่ 1 ถึงสัปดาห์ที่ 3 เพิ่มมากขึ้นและมีมโนคติที่หลากหลายในด้านต่างๆเกี่ยวกับกระบวนการดำรงชีวิตของปลากัด ซึ่งสามารถวัดผลได้จากงานของนักเรียนแต่ละคนและงานแต่ละกลุ่ม

หน่วยการเรียนรู้ที่ 2 เป็นการพัฒนาหน่วยการเรียนรู้ที่ใช้สอนเรื่อง ลักษณะทางพันธุกรรมของเมนเดล และความหลากหลายทางชีวภาพโดยเน้นวิธีการเรียนการสอนแบบให้นักเรียนสืบเสาะหาความรู้ด้วยตนเอง โดยการสร้างชุดการเรียนการสอนจากอุปกรณ์ที่หาได้ง่ายในท้องถิ่น 2 ชนิด คือ 1.ไม้หนีบผ้าสีต่างๆ สำหรับใช้ในการสอน เรื่อง การถ่ายทอดพันธุกรรมของเมนเดล และ 2.ใช้ตุ๊กตายางรูปสัตว์ในการสอนเกี่ยวกับการจัดหมวดหมู่ของสิ่งมีชีวิตใน เรื่อง ความหลากหลายทางชีวภาพ และเปรียบเทียบผลการวิจัยระหว่างกลุ่มทดลองและกลุ่มควบคุมที่จัดการเรียนการสอนแบบดั้งเดิม ซึ่งผลการวิจัยปรากฏชัดเจนว่ากลุ่มทดลองมีความเข้าใจในเรื่องดังกล่าวเพิ่มมากขึ้นกว่ากลุ่มควบคุม

จากหน่วยการเรียนรู้ทั้งสองหน่วยดังกล่าวข้างต้น ครูผู้สอนต้องกำหนดวัตถุประสงค์ที่เป็นมาตรฐานอยู่แล้วและพร้อมที่จะชี้แนะแนวทางในการเรียนให้กับนักเรียนเพื่อสร้างแรงจูงใจในการทำกิจกรรมให้บรรลุถึงเป้าหมายในที่สุด และยิ่งไปกว่านั้นยังพบว่านักเรียนที่เข้าร่วมกิจกรรมให้การยอมรับและสนุกกับการเรียนการสอนด้วยหน่วยการเรียนดังกล่าวอีกด้วย

137 หน้า

CONTENTS

CONTENTS (cont.)

CONTENTS (cont.)

CONTENTS (cont.)

LIST OF TABLES

LIST OF FIGURES

CHAPTER I
INTRODUCTION

Overview

This chapter introduces the background of the research study on the development of instructional units on cooperative learning and inquiry-based learning. The rationale and significance of the study are described. The objectives and research questions of the two instructional units are presented here.

1.1 Background of the study

It is likely that students' achievement in science is influenced by the teaching methodology. Teachers should try new practice and examine the effects on their students' outcomes. The students should have fewer difficulties in understanding what they are being taught. They should be more engaged in the learning activities and are learning more purposefully. The students should also demonstrate enhanced learning outcomes, at least in knowledge, skills, attitude and teamwork. For a better achievement of student, teacher should have knowledge in both content and learning strategies appropriate to the content they taught (Koehler & Mishra, 2005). Teacher should be able to develop an appropriate teaching strategy that can be transmitted effectively to student.

It has been wildly recommended that the learning approach should be changed from teacher centered to student centered one, but, with a balance of knowledge skill and attitude (NRC, 2000). Several teaching strategies have been proved to be effective in enhancing student achievement (Marzano, Gaddy & Dean, 2000). Nevertheless, the developed teaching methodology should be challenging and engaging and appropriate to classroom context.

This study aimed at developing two teaching strategies for effective learning of students in biology: cooperative learning and inquiry-based learning.

1.1.1 Cooperative learning unit

Several articles in the literature have favored students' learning cooperatively under the guidance of the teacher (Slavin, 1996; Antil, Jenkins, Wayne & Vadasy, 1998; Watter & Ginns, 2000). In such a learning environment each student in a group actively learns by finding information on certain aspects of the learning unit, conceptualizing from what each has learned and discusses with friends. In addition, if members of each group have the opportunity to learn from other groups' presentations from working on different aspects, the whole class could benefit by forming an integrated picture of the learning unit designed for them. Cooperative learning has been shown to have several benefits, namely, academic, social, psychological as suggested by several research studies (Johnson & Johnson, 1989; Panitz, 1996).

Cooperative learning has been implemented in all levels, especially, primary and secondary school. Grade-4 students have been shown to improve their problem solving in environmental studies through cooperative learning (Ross, 1988). The advantages of using cooperative learning in biology courses have been reported both at school and college levels (Lord, 1998; Marbach-Ad & Sokolove, 2000; Lord, 2001; Armstrong, Chang & Brickman, 2007). Additionally, several studies have investigated the effects of cooperative learning on secondary and tertiary students in various disciplines. The results indicated the benefits of structured group interaction in achieving the learning outcomes as well as social responsibility (Mueller & Fleming, 2001; Kramarski & Mevarech, 2003; Gillies, 2004; Moni, Depaz & Lluka, 2008).

The skills of working in groups, especially for school students should be developed early. However, according to Nelson-Le Gall (1992), not many children go to schools that encourage peer interaction as a major means of learning. We, therefore introduced this cooperative learning unit about the living process for primary students in a provincial school so that they should be working in such a cooperative learning environment before going on to secondary school. Needless to say, their teachers benefit the experience as well.

The organism used in this learning unit, the Siamese fighting fish (*Betta splendens*), is indigenous to the localities where the students live. The fighting fish has long been known to have many advantages for classroom activities (Kuhn, 1970). It can be kept individually and easily maintained. The fish is raised as pets and also bred for commercial purposes. It can thus be easily found in pet shops. The fish is attractive because of their finnage and pigment pattern. Its aggressive display and courtship display, especially during spawning, an easily observed process, can also be studied without any special aid. The fighting fish has already been used in teaching/learning at both school and university levels. An inquiry-based science course on fish behavior based on fighting fish was developed for students training to become primary school teachers (Kremer, Walker & Schlüter, 2007). The fighting fish has been used to set a simple and low cost physiology laboratory for undergraduate students to investigate the mechanism of aggressive behavior (Lynn, Egar, Walker, Sperry & Ramenofsky, 2007).

1.1.2 Inquiry-based learning unit

The National Science Education Standards (National Research Council (or NRC), 1996) and also the 2061 project (The American Association for the Advancement of Science (or AAAS), 1990) reaffirm the conviction that inquiry in general and in the context of practical works is central to achievement in science education. There are reform documents which state that science should be taught in a manner that all students learn best by conducting hands-on engaging investigations based on simple everyday materials (Lederman, 1998). Students are thus expected to have a broad understanding of science concepts and a positive attitude towards science. Hands-on laboratory activities are also expected to be an integral component of the good science class (Stohr-Hunt, 1996; Edwards, 1997) and to play an important part in influencing such student attitudes (Freedman, 1977; Osborne, 2003). Students engaged in a hands-on instructional program have been shown to outperform those in one based on lecture from textbook materials. McCarthy (2005) and Ornstein (2006) found that students had more positive attitudes toward science when the teacher regularly emphasized hands-on laboratory activities and when students more frequently experienced high levels of experimentation or inquiry.

Glasson (2006) found that students in hands-on laboratory class acquired better procedural knowledge than did students exposed only to teacher demonstration. Additionally, the research work of Wallace (2004) suggested that the students were able to integrate firsthand observations from hands-on activities with lecture content and blended them into detailed explanations for biological phenomena. Hands-on activities allow students to undergo certain scientific processes. Hofstein and Lunetta (1982) defined hands-on science lab activities as “contrived learning experience” in which students interact with materials to observe phenomena.

Genetics and biodiversity are among the most difficult topics for biology students (Weelie & Wals, 2002). Several studies have attempted to come up with more effective pedagogy to promote student understanding of biology (Johnson & Stewart, 1990; Banet & Ayuso, 2000; Weelie & Wals, 2002; Randler, 2008). There are many reports about biodiversity education and student knowledge about biodiversity (Summers et al., 2001; Lindemann-Matthies et al., 2009; Menzel & Bögeholz, 2009), however, incomplete concept and misconceptions about diversity have been reported. Inquiry-based learning was used to enhance student understanding of molecular biology and biology concepts (Regassa & Morrison-Shelter, 2009). A problem-solving methodology was employed in a teaching unit on genetics and human inheritance for secondary students (Aznar & Orcajo, 2005). Better understanding in genetics concept has been shown in students who learned by both the prediction/discussion-based learning cycle and conceptual change text (Yilmaz, Tekkaya & Sungur, 2010). Several hands-on activities have been shown to be effective for deeper understanding of genetics concepts (McKean & Gibson, 1989; Omoto, 1998; Haws & Bauer, 2001; Grumbine, 2006).

1.2 Rational of the study

1.2.1 A cooperative learning unit

This study aimed at developing a cooperative learning unit on the living process of Siamese fighting fish for primary students. The cooperative learning unit involved group activities, knowledge sharing and class discussion with assistance of the teacher. The learning unit encompassed five topics or aspects of the life of the fighting fish, which the students are familiar with, but not generally have derived biologically relevant concepts about them. As each student was expected to have something to say about the fish and it was expected that as each of them learned, he or she should become more active as a learner and giver of knowledge. Students' outcomes in both knowledge and perception were assessed both individually and as a group.

1.2.2 A hands-on learning unit with an emphasis on guided inquiry

Hands-on experiments have been shown to be capable of producing "conceptual changes necessary for intellectual development and understanding, as well as higher cognitive skill development". However, recently researchers, who reviewed popular high school biology textbooks, revealed that the written lab activities of these textbooks are not capable of meeting the laboratory goals of problem solving and higher level inquiry (Lumpe & Scharmann, 1991). Many textbooks provide instructions on hands-on laboratories; however, only a few textbooks emphasized inquiry as advocated by the NRC. It is believed that an inquiry-type laboratory has the potential to develop students' abilities and skills (Hofstein et al., 2005). Therefore the study aimed to develop inquiry-based hands-on activities for secondary students on two topics that have proved difficult for students to understand, namely, Mendelian inheritance and biodiversity.

1.3 Objectives and research questions

1.3.1 A cooperative learning unit

This research study has two principal objectives:

1. To develop a cooperative learning unit on Siamese fighting fish for primary students,

2. To evaluate the effectiveness of a cooperative learning unit on Siamese fighting fish on primary students.

Two research questions help frame this study:

1. Does the cooperative learning unit help primary students achieve the learning outcomes in the topic of the living process of the fighting fish?

2. What are the primary students attitudes toward the cooperative learning unit?

1.3.2 A hands-on learning unit with an emphasis on guided-inquiry

This research study has two principal objectives:

1. To develop a hands-on learning unit with an emphasis on guided-inquiry for secondary students,

2. To evaluate the effectiveness of a hands-on learning unit with an emphasis on guided-inquiry on genetic and biodiversity for secondary students.

Two research questions help frame of this study:

1. Does the inquiry-based and hands-on learning unit help the students to construct their own concepts on genetics and biodiversity?

2. What are the students attitudes toward the hands-on activity with an emphasis on guided inquiry-based?

1.4 Significance of the study

The local materials, Siamese fighting fish, plastic models of animal and plant and colored clippers, were used to develop the learning units, a cooperative learning unit on Siamese fighting fish for primary students and a hands-on learning unit with an emphasis on guided-inquiry on genetic and biodiversity for secondary students. Both learning units are used as alternative learning units to effectively promote primary and secondary students outcomes.

CHAPTER II
LITERATURE REVIEW

Overview

This chapter summarizes the literatures related to the content of the thesis. It begins with a description of cooperative learning approach, followed by an inquiry-based approach and hands-on learning. In all these teaching approach, definition, elements and their uses in science classroom are described. Additionally, integrating of inquiry approach to cooperative learning and to hands-on activity.

2.1 Cooperative learning approach

Cooperative learning is a teaching/learning approach stemming from constructivism theory in which students work in teams and is appropriate for variety of learning activities to improve achievement. Cooperative learning exists when students work together to accomplish shared learning goals (Johnson & Johnson, 1999). In the past three decades, modern cooperative learning has become a widely used instructional process from school through college levels, in all subject areas. The popularity of cooperative learning is due to its firm base on theory, validated by research, and operationalized into clear procedures. Cooperative learning has its roots in social interdependence, cognitive-developmental (Johnson & Johnson, 1979) and behavioral learning theories (Bandura, 1977). There are over 1000 research studies over the last 100 years validating the effectiveness of cooperative over competitive and individualistic efforts. This body of research has considerable generalizability because the research has been conducted by many different researchers with markedly different orientations working in different settings and countries.

2.1.1 Definitions of cooperative learning

Cooperative learning is a generic term referring to numerous methods of group-based activity that encourage students to work together in small groups to achieve learning outcome, but not for competition (Armstrong, Chang & Brickman, 2007). Many educators give the definitions of cooperative learning as follows:

> *"Cooperative learning is an instructional program in which students work in small groups to help one another master academic content."* (Slavin, 1995)

> *"Cooperative learning involves students working together in pairs or groups, and they share information. They are a team whose players must work together in order to achieve goals successfully."* (Brown, 1994)

According to Johnson (2005), cooperation is not assigning a job to a group of students where one student does all the work and the others put their names on the paper. It is not having students sit side by side at the same table to talk with each other as they do their individual assignments as well. It is not having students do a task individually with instructions that the ones who finish first are to help the slower students. On the contrary, cooperative learning is a teaching strategy in which small teams, each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject. Each member of a team is responsible not only for learning what is being taught but also for helping teammates learn, thus creating an atmosphere of achievement. Students work through the assignment until all group members successfully understand and complete it.

2.1.2 Elements of the cooperative learning

Cooperative efforts are expected to be more productive under certain conditions. The followings are the five basic elements of cooperative learning.

2.1.2.1. Positive interdependence

The first requirement for an effectively structured cooperative learning environment is that students believe they "sink" or swim together. (Johnson, Johnson & Stanne, 2000) That is, cooperation occurs only when students perceive that the success of one depends on the success of the other. Whatever task students are given to perform, each group member must feel that his or her contribution is necessary for the group's success. Students have to learn to work together in order to accomplish tasks. This is why learning task must be designed in a way that makes them believe, "they sink or swim together." Through the assigned material, students learn to achieve the goal. Therefore, a number of ways of structuring positive interdependence are carried out such as reward, resources, or task responsibilities to supplement goal interdependence. Each group member has a unique contribution to make to the joint effort because of his or her resources or role or task responsibilities.

2.1.2.2 Face-to-face interaction

The second element of cooperative learning requires face-to-face interaction among students within which they promote each other's learning and success. Johnson (2005) suggests that it is necessary to maximize the opportunities for them to help, support, encourage, and praise each other. Such promotive interaction helps to promote the following:

- orally explaining how to solve problems
- teaching one's knowledge to other
- checking for understanding
- discussing concepts being learned
- connecting present with past learning

2.1.2.3. Individual and group accountability

The third element leads to the belief "What students can do together today, they can do alone tomorrow." The purpose of cooperative learning groups is to make each member a stronger individual. Individual accountability exists when the performance of each individual student is assessed, and the results are given back to the groups. Therefore, the group knows who needs more assistance, support, and encouragement in completing the job. Johnson & Johnson (1991) suggest some common ways to structure individual accountability. These include giving an individual test to each student, randomly selecting one student to represent the entire group, or having students teach what they have learned to someone else.

2.1.2.4. Interpersonal & small – group skills

Students must be taught the social skills and be motivated to use them. Social skills which are needed for both teamwork and task work include leadership, decision–making, trust–building, communication, and conflict–management skills. (Johnson, Johnson, & Holubec, 1993)

2.1.2.5. Group processing

Group members should think about how well they have cooperated as a team and how to enhance their future cooperation. Some of the keys to successful processing are allowing sufficient time for it to take place, emphasizing positive feedback, maintaining student involvement in processing etc. To be cooperative, group members must promote each other's learning and success face-to-face, hold each other personally and individually accountable to do a fair share of the work, use the interpersonal and small group skills needed for cooperative efforts to be successful, and process as a group how effectively members are working together.

These five essential components must be present for small group learning to be truly cooperative. There needs to be an accepted common goal on which the group will be rewarded for their efforts. (Johnson & Johnson, 1991)

2.1.3 Cooperative learning in science

Cooperative learning is not a new concept. It has endured as an important way of learning in some cultures for generations (Haynes & Gebreyesus, 1992; Jagers, 1992; Swisher, 1990). Socrates, engaging his disciples in group questioning and argument to develop their philosophical ideas, used a form of cooperative learning.

Early in this century when American students were schooled in a system based on authoritarian teaching and rote learning, educator John Dewey espoused a teaching philosophy that contained elements of cooperative learning. Dewey realized the importance of learning by doing and urged establishing laboratory and workshop courses to foster creativity and cooperation among students (Dewey, 1916).

During the past decade evidence has accumulated on the effectiveness of cooperative learning in classrooms from preschool to college and beyond, in a wide variety of disciplines. Cooperative learning methods have been applied in the physical sciences (Smith, Hinckley, & Volk, 1991), mathematics (Dees, 1991; Duren & Cherrington, 1992), and biology (Lazarowitz, Hertz, Baird, & Bowlden, 1988, Okebukola 1986a & b), as well as in the social sciences (Lambiotte, Dansereau, Rocklin, Fletcher, Hythecker, Larson, & O'Donnell, 1987) and humanities (Barratt, 1992).

The value of cooperative learning as an educational tool lies in both its effective and cognitive impacts. For many students, the feelings of self-confidence and self-esteem they gain from learning cooperatively with their fellow students may be as important to their education as the specific knowledge they attain.

Among the many studies that measure the effects of cooperative learning in biology, there is wide variation in quality, with some succumbing to the pitfalls of research involving human subjects, including small sample size, lack of random distribution and assignment to test conditions of students and teachers, and built-in bias in training teachers and teaching the material. However, several good studies have shown that cooperative learning methods are effective for learning certain types of biological concepts. Lazarowitz et al., (1988) found that high school students in a cooperative classroom spend more time focusing on their assignment and achieved at a higher level in a cellular biology unit that demanded inquiry and high-level thinking than did students in a traditional competitive

2.1.4 Integrating cooperative learning with science inquiry learning

Stevens and Slavin (1995) argued that when cooperative learning is the primary mode of instruction and when it is integrated with effective instruction in reading, language, arts, and mathematics and with changes in school organization and with peer coaching, it is effective in producing higher student achievement.

Relatively speaking, group work was used more often in general studies than in other subjects because of the topics or activities in general studies that lent themselves to be more effectively carried out in the form of group work than other forms of organizational strategies such as whole class work, pair work and individual work (Chan & Galton, 1999). Nevertheless, inquiry-oriented teaching and learning activities are the most difficult to master (Fullan & Watson, 2000). Teachers rarely involve students in activities that require them to express or demonstrate their understanding of key concepts and procedures. Group tasks will determine how students interact together (Gillies, 2007), for open and discovery-based group tasks require students to interact if they are to resolve the problem at hand.

2.2 Inquiry-based learning approach

Recent educational reforms usually expect students to develop their intellect, knowledge, morality, and skills in order to live well in the age of globalization (Australia Capital Territory Parliamentary Counsel, 2004; Office of the National Education Commission [ONEC], 1999; National Research Council [NRC], 2000). Lifelong learning has become one of the policy discourses of many countries to enable students to continuously use what they learn in science and related skills for their daily and professional life (Dehmel, 2006; Wang, Song, & Kang, 2006). It has been widely recommended that the learning approach should be changed from teacher-centered to student-centered one with a balance of knowledge, skills, and attitudes. These educational reforms recommend incorporating inquiry to classroom. It is believed that through inquiry one can construct the interrelated knowledge and understanding (NRC, 2000).

2.2.1 Definitions of inquiry-based learning

Inquiry-based learning refers to the pedagogical strategy that uses the general processes of scientific inquiry as its teaching and learning methodology. This approach emphasizes student questioning, investigating, and problem solving similar to the process scientists use to conduct their inquiries and investigations in the laboratory, at field sites, in the library, and in discussion with colleagues in such activities (Bybee, 2004; DeBore, 2004). The National Science Education Standard (NRC, 2000) identifies five necessary components of inquiry based teaching and learning: student engages in scientifically oriented questions, student gives priority to evidence in responding to questions, student formulates explanations from evidence, student connects explanations to scientific knowledge, and student communicates and justifies explanations.

Bell, Smetana, and Binns (2005) illustrated and named each of Herron' ideas (Herron, 1971) of level of inquiry. Level one is confirmation; students confirm a principle through activities in which the results are known. Level two is structured inquiry; students investigate questions using the procedure provided by the teacher. Level three is guided inquiry; students investigate teacher's questions by designing their own procedure. Finally, level four is open inquiry; students investigate questions related to learning topics by selecting questions and designing procedures by themselves. In addition, inquiry based learning approach can be an active learning approach (or dynamic of learning) that ranges from more structured, teacher-guided inquiry to more open ended, student-centered inquiry (Hammerman, 2006).

2.2.2 Scientific inquiry and inquiry-Based teaching and learning

The term inquiry can be used and described in two main parts: scientific inquiry (SI) and inquiry-based teaching and learning (IBL). Scientific inquiry is a way of explaining the natural world and it is the fundamental concept of science and second, inquiry is a teaching and learning strategy (Bybee, 2004). In addition, the term scientific inquiry will be used to refer to the general process of investigation that scientists use as they attempt to answer questions about the natural world (DeBore, 2004). Similarly, Schwartz, Lederman, and Crawford (2004) have described the scientific inquiry. It has the characteristics of the scientific enterprise and processes through which scientific knowledge is acquired, including the conventions and ethics involved in the development, acceptance, and utility of scientific knowledge. On the other hand, the term inquiry-based teaching and learning will refer to pedagogical approach that model aspects of scientific inquiry. Inquiry-based teaching and learning approach mirrors scientific inquiry by emphasizing student questioning, investigation, and problem solving similar to the process scientists use to conduct their inquiries and investigations in laboratory, at field sites, in the library, and in discussion with colleagues in similar activities (DeBore, 2004).

Science as inquiry widely recognized in the 1960S. Schwab introduced two terms of inquiry, stable inquiry and fluid inquiry, into science education and he identified science as a product of fluid inquiry. The function of stable inquiry is to accumulate what a doctrinal education teaches as the whole of scientific knowledge.

Each stable inquiry is concerned to fill a particular blank space in a growing body of knowledge. However, fluid inquiry, the mode of investigation, proceeds to the invention of new conceptions and tests them for adequacy and feasibility. Its immediate goal is not added knowledge of the subject matter, but development of new principles which will redefine the subject matter and guide a new course of effective, stable inquiries (Schwab, 1964).

At the beginning of the twenty-first century, inquiry, which is categorized as science as inquiry, in other words scientific inquiry, teaching through inquiry, and learning through inquiry, has been a central style advocated for science learning and teaching. The standards also state that scientific inquiry is a fundamental of science education at all levels and suggest mechanisms to promote inquiry-based education. One often-cited definition of scientific inquiry, science as inquiry, is draws from the National Science Education Standards (in short, NSES):

> *Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in the light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.* (National Research Council [NRC], 2000, p.13)

In addition, Schwartz, Lederman, and Crawford (2004) stated that scientific inquiry refers to methods and activities that lead to the development of scientific knowledge. Science as inquiry as composed of three main elements: skills of scientific inquiry, knowledge about scientific inquiry, and a pedagogical approach for teaching content in science. In other words, it concerns with what students should do and understand about nature of scientific inquiry, as well as what teacher should do.

In laboratory class, inquiry-based teaching and learning was introduced by Schwab in 1964. He proposed three different levels of openness and permissiveness of laboratory inquiry. At the simplest level, the laboratory manual can pose problems and describe ways and means by which the students can discover relationships that student does not already know from text books or lecture materials. At a second level, problems are posed by the laboratory manual, but methods as well as answers are left open. At a third level, problem, method, and answer are left open. In 1971, Herron adapted Schwab's ideas (1962) about the levels of inquiry arranged by the degree of openness and the demand for inquiry skills in four levels: In level zero, problem, procedure and conclusions are all given and the only task remaining for student is to collect data. In level one, problem and procedure are given and the students have to collect data and draw the conclusion. In level two, only the problem is given and the students have to design the procedure, collect data and draw conclusions. Finally, in level three, the highest level of inquiry which is simulate scientific inquiry, the students have to investigate everything by themselves, beginning with problem formulation, and ending with drawing conclusions. In addition, Bell, Smetana, and Binns (2005) illustrated and named each of Herron's ideas of level of inquiry. Level one is confirmation; students confirm a principle through activities in which the results are known. Level two is structured inquiry; students investigate questions using the procedure provided by the teacher. Level three is guided inquiry; students investigate teacher's questions by designing their own procedure. Finally, level four is open inquiry; students investigate questions related to learning topics by selecting questions and designing procedures by themselves.

Inquiry-based teaching and learning uses the general processes of scientific inquiry as its teaching and learning methodology. Moreover, students in inquiry classrooms try to advance their understanding of the principles and methods of science, just as scientists seek to understand the natural world through their investigations (DeBore, 2004). Thus, inquiry simultaneously represents processes that scientists routinely employ in their research, and also a way for students to learn science content and skills. Above all, inquiry in the classroom is student-centred, providing learners with opportunities to formulate and conduct their own scientific investigations (Krystyniak & Heikkinen, 2007). It is important to note that inquiry-based teaching does not require students to behave exactly as scientists do (DeBore, 2004).

Inquiry-based teaching in the classroom is simply a metaphoric scientific inquiry for teaching what science involves (DeBore, 2004). Teaching science through inquiry requires some knowledge of the ways that scientists develop questions, engage in research, and create their frames of thought. The dimensions of classroom inquiry will be rich with opportunities for students to experience and explore the world, offer time and opportunity for students to wonder and ask questions, permit authentic investigations wherein students develop questions; make observations; collect, record, graph, and analyze data; make sense of data, and ask new questions related to their own experiences or phenomena that affect their lives; and allow students to synthesize information, describe or create patterns and apply their understanding to new contexts (Hammerman, 2006). Some teachers resist constructivist pedagogy (e.g. inquiry-based teaching and learning approach) because of at least one of three reasons: commitment to their present instructional approach, concern about student learning, or concern about classroom and time control including control (Bell, 1998; Brooks & Brooks, 1993; Brown & Melear, 2006). However, there are many methods used to persuade teacher to use this approach in their classroom. For example, some professional development programs provide knowledge and explicit experiences about inquiry-based teaching (Bell, 1998; Wee, Shepardson, Fast, & Harbor, 2007; Supovitz & Turner, 2000).

Learning science is a dynamic process of shaping and reshaping thoughts based on new knowledge and experiences (Hammerman, 2006). Inquiry-based learning which is compatible with the constructivist approach emphasizes the idea that knowledge is not transmitted directly from one person to another, but it is actively developed by the student (Zion et al., 2004). There are many benefits that can come from an inquiry teaching and learning approach. The relationship between inquiry-based teaching and improved learning has been well documented (Bransford et al., 1999). Zion and his colleagues (2004) investigated the use of the Biomind curriculum which was designed to emphasizing the students acting as self-directed learners by searching for knowledge through inquiry, and recognizing the importance of learning both in the laboratory and in the field. The results have shown learning as a process emphasizes continuous thinking throughout the inquiry process.

Inquiry-based teaching and learning is an effective teaching and learning strategy which provides activities for student-centred learning. When students engage in inquiry-based activity, they need to use science process skills to solve problems, to formulate questions, and/or to interpret data (Basaga, Geban, & Tekkaya, 1994). Inquiry-based teaching and learning approach could provide insight into enhancing students' conceptual understanding of science topic as well as improving their science process skills (Krystyniak & Heikkinen, 2007).

2.3 Hands-on learning

Hands-on learning gives learners real work to perform. The learner completes a task outside the lesson, such as performing a calculation with an on-screen calculator, designing something on paper, operating a piece of machinery or conducting some laboratory experiment. The hands-on activity guides learners through the real-life task, provides feedback on their success, and may test what they have learned.

2.3.1 Definition of hands-on learning

Hands-on learning has become a common phrase in science education. Like many other highly used terms and phrases, there are various interpretations of what is meant by "hands-on learning." Rather than attempt to offer a definitive operational definition, we present in this section a variety of viewpoints on what is meant by hands-on learning in science. Then we address the issues of whether hands-on learning is a new phenomenon and whether hands-on approaches will continue to have a continual impact on science teaching and learning in schools.

Hands-on activities mean students have objects (both living and inanimate) directly available for investigation (Meinhard, 1992). James Rutherford director of the science reform initiative, Project 2061, describes his view of hands-on science. "Hands-on quite literally means having students 'manipulate' the things they are studying - plants, rocks, insects, water, magnetic fields - and 'handle' scientific instruments - rulers, balances, test tubes, thermometers, microscopes, telescopes, cameras, meters, calculators. In a more general sense, it seems to mean learning by experience (Rutherford, 1993).

There are two ways that we find the term hands-on science in common use today. The first uses hands-on science to refer to a general approach to instruction. Hands-on science can be thought of as a philosophy guiding when and how to use the broad range of teaching strategies needed to address diversity in contemporary classrooms. The second way hands-on science is commonly used is in terms of a specific instructional strategy where students are actively engaged in manipulating materials, using called a hands-on science activity (Flick, 1993). Other terms for hands-on activities are materials-centered activities, manipulative activities, and practical activities (Doran, 1990). According to Hein (1987), materials-centered science is synonymous with hands-on science and activity-centered science. Elementary school mathematics teachers have long been interested in the use of manipulatives to provide concrete learning experiences (Ross & Kurtz, 1993).

The concept of hands-on science is predicated on the belief that a science program for elementary children should be based on the method children instinctively employ to make sense of the world around them. Science must be experienced to be understood. These experiences should allow students to be actively engaged in the manipulation of everyday objects and materials from the real world. Children are by nature observers and explorers, and the most effective approach to learning should capitalize on these intrinsic abilities (Shaply & Luttrell, 1993).

Hands-on science is defined as any science lab activity that allows the student to handle, manipulate or observe a scientific process. Hands-on teaching can be differentiated from lectures and demonstrations by the central criterion that students interact with materials to make observations, but the approach involves more than mere activity. The assumption is that direct experiences with natural phenomena will provoke curiosity and thinking, so, recently, a new twist has been added, and the topic is called Hands-on/Minds-on science. Hands-on learning can be thought of as comprising three different dimensions: the inquiry dimension, the structure dimension, and the experimental dimension. In inquiry learning, the student uses activities to make discoveries. The structure dimension refers to the amount of guidance given to the student. If each step is detailed, this is known as a cookbook style lab. These types of activities do not increase a student's problem-solving abilities. The third dimension is the experimental dimension which involves the aspect of proving a discovery, usually through the use of a controlled experiment (Lumpe & Oliver, 1991).

2.3.2 The historical development of hands-on learning

Science education in elementary schools first existed as selections contained in the eighteenth and nineteenth century children's didactic literature (Craig, 1957; Underhill, 1941). By the middle of the nineteenth century, approximately 20 percents of the pages of the most popular introductory reading textbooks were devoted to science selections (Rillero & Rudolph, 1992). For many students, this was the only science education they received. Nineteenth century American schools had bleak learning conditions. Teaching was by rote and drill. Encouragement was by the rod. Obedience (to God, parent and teacher) was the foundation rock for the mansion of learning" (Withers, 1963). Pestalozzi extended Enlightenment ideas into education by having students learn from experiences and observation rather than from the authority of the textbook and the teacher (Elkind, 1987; Rillero, 1993). After the experts in getting knowledge discovered that it was far more profitable to examine real things and observe how they did work than merely to speculate and argue about them, and that it was unsafe to trust the authority of any man's opinion without testing it by its accordance with facts in nature, the experts in education also began to advocate teaching by direct study of things and experimental verification of opinions (Thorndike, 1920). Pestalozzi's ideas of using objects for teaching were spread in America in the 1860s. The object teaching revolution occurred as a direct result of teacher education. This movement challenged the dominance of the textbook in education and promoted active learning by students. The evolution of methodologies used in science education including science activities, field trips, and school science collections were influenced by object teaching (Rillero, 1993). The Committee of Ten (National Education Association, 1893) was instrumental in securing a permanent place for science in the American school curriculum. The science committees repeatedly stressed the importance of object manipulation by students. The Physics, Chemistry and Astronomy Committee recommended that the study of simple natural phenomena be introduced into the elementary schools and that this study, so far as practicable, be pursued by means of experiments carried on by the pupil. They added, the study of books is well enough and undoubtedly important, but the study of things and of phenomena by direct contact must not be neglected" (National Education Association, 1893).

John Dewey emphasized the same ideas about learning through activity and child-centered instruction advocated during the eighteenth and nineteenth century by Pestalozzi and Froebel. The most representative feature of Dewey's philosophy of education was his recommendation of the project method of learning described by various followers as a purposive, problem-solving activity carried on in its natural setting (Smith, 1979).

In more recent times, almost all the major science curriculum developments of the 1960s and early 1970s promoted hands-on practical work as an enjoyable and effective form of learning" (Hodson, 1990). Since the curricula innovations of the 1960s, the emphasis in laboratory activities has been providing students with hands-on experiences (Tobin, 1990).

The term hands-on is so widely used that it is hard to believe that it is something of a newcomer. It first surfaced in the late 1960s meaning to learn how to use a computer by actually using one - hands-on the keyboard, as it were. Although the computer people coined the term, the idea of learning by doing is an ancient one in the arts and crafts, and it has become a mark of good teaching in science and math" (Rutherford, 1993). Hands-on learning is an important aspect of the current constructivist epistemologies that suggest that people construct their own understandings of the world. Exemplary science learning is promoted by both hands-on and minds-on instructional techniques - the foundations of constructivist learning" (Loucks-Horsley et al. 1990).

After a quarter of a century, the familiar phrase hands-on science is now a part of the everyday discussion of elementary science. Teachers, administrators, publishers, and trade books all refer to the importance of hands-on activities in science instruction. This is nothing short of a revolution. Descriptions of science education at all precollege levels have shifted from vocabulary and text material to activities, inventions, and even project-based Olympics (Flick, 1993).

There are a variety of ideas about what constitutes hands-on learning. We have compiled views from teachers, curriculum developers, and other writers to arrive at a general notion of hands-on learning in science which encompasses its use in school classrooms, museums, and other learning environments. From the collected responses and writings, we have come to consider hands-on learning in science to be any educational experience that actively involves people in manipulating objects to gain knowledge or understanding.

2.3.3 Using hands-on activity along with textbook in science teaching and learning.

Many schools and advocates of hands-on learning seek to do away with textbooks or downplay their value, particularly in the elementary grades. The forces for keeping textbooks are undoubtedly strong; the dominance of the textbook in defining the curriculum has marked American education since its inception. Some schools have decided to keep textbooks and use hands-on science activities to supplement a text-based approach to teaching science. A textbook-centered program can be augmented with a hands-on component to integrate right brain and left brain functioning in improving achievement and attitude (Hider & Rice, 1986). Lack of time to teach hands-on science is a frequently mentioned obstacle (Morey, 1990; Tilgner, 1990). This is compounded by the tendency for teachers to want to cover the textbook. According to a district science supervisor, in all elementary schools, once you buy a text, it doesn't matter what the state or the district says about what is actually required, teachers try to cover the entire book (Martens, 1992). To create time for hands-on instruction it is important for teachers to decide the major concepts to be taught and use hands-on activities to help achieve these goals.

In an analysis of science textbooks for junior high/middle school students, Shepardson (1993) found the activities tended to stress lower level skills such as information gathering, remembering, and organizing rather than higher level skills such as classifying, inferring, theorizing, generalizing, hypothesizing, and predicting. A hands-on methodology elicits a 'minds-on' response from students. The relevance of the topics, the students' understanding of and interest in science, and reading skills can all be increased with the introduction of tradebooks. Tradebooks are commercially available publications that can be used as supplements to classroom text (Kralina, 1993). Charron and De Onis (1993) described the approach of two elementary school teachers in combining reading and science in four steps: 1) students brainstorm and record what the already know about a topic. 2) students list what they want to learn. 3) students investigate the topic by reading about it. 4) students summarize what was learned. Hands-on activities were added to the reading activity in third step**.**

Although, the textbook has withstood the test of time in conveying basic information, a large percentage of teachers have combined hands-on learning to the text-based instruction. Nevertheless, hands-on learning and science textbooks need not be incompatible. Textbooks can provide springboards to discussion or instruction, serve as references for students, provide background information, or supply examples and applications of key ideas in science.

2.3.4 Extending hands-on activities to be inquiry-based

Providing students with an opportunity to do hands-on science does not necessarily mean they are doing inquiry. Many science activities are very structured providing step by step procedures and to be followed as a linear path to a solution. These students are told what questions to answer, what materials to use, and how to go about solving questions and problems. Charts or tables are even provided for recording the observations, or data. Although most inquiry activities are hands-on, not all hands-on activities are inquiry oriented.

Many popular hands-on science activities, as traditionally implemented, fail to support inquiry-based science instruction, because the activities direct teachers to terminate lessons prematurely. Huber and Moore (2010) presented a model describing one approach for extending seemingly limited hands-on activities into full-inquiry science lessons. The strategy involves (a) discrepant events to engage students in direct inquiry; (b) teacher-supported brainstorming activities to facilitate students in planning investigations; (c) effective written job performance aids to provide structure and support; (d) requirements that students provide a product of their research, which usually includes a class presentation and a graph; and (e) class discussion and writing activities to facilitate students in reflecting on their activities and learning. This model facilitates science teachers implementing the type of powerful, effective, and manageable inquiry-based science instruction called for in the National Science Education Standards.

The model addresses several needs at this stage in the standards-based reform initiative. First, the need for inquiry-based instruction is too pressing for teachers to wait for new curriculum materials to be developed and promulgated. Teachers need strategies that would allow them to move toward the realization of the standards' vision. Existing textbooks and corpus of noninquiry lesson plans may prove a significant resource in implementing the standards. Second, for many traditionally oriented teachers, the first step toward inquiry-based instruction may be the most difficult. Stepping into inquiry-based instruction can make these teachers feel like they are first-year teachers all over again (Science Media Group, 1995). The inquiry-based lesson plans may well be an ideal resource for helping these teachers understand the differences between what they were doing and what they could be doing through the inquiry-based instruction. Such a benefit is consistent with the National Science Education Standards' strategy and goal of using inquiry-based approaches to support teachers as agents of educational reform.

2.4 Fighting fish as a model for studying living process

2.4.1 General characteristics of fighting fish

Fighting fish belongs to a group of anabantoids whose specialized bone above the gill chamber called labyrinth. Ordinarily fish has gills for exchanging the air, but this fish uses the labyrinth as an extra organ for their breathing. When the fish comes up to the surface of water and gulps air, the air is kept within labyrinth.

In 2006, Ruber et al. studied the molecular phylogeny of anabantoids, the most recent classification of the fighting fish is shown as follows:

Kingdom Animalia
  Phylum Chordata
    Class Actinopterygii
      Order Perciformes
        Suborder Anabantoidei

Family Osphronemidae

Subfamily Macropodusinae

Genus *Betta*

The fighting fish is now placed in the Osphronemidae family or Gouramies family, whose freshwater members are *Anabas* spp., *Trichogaster* spp. and *Trichopsis* spp., Macropodusinae subfamily and genus *Betta*. They can be divided into two groups depending on parental care which are mouth brooder and bubble nest builder.

The most recent classification of bettas from phylogenetic evidence places them in the Osphronemidae family (whose freshwater members are *Anabas* spp., *Trichogaster* spp., and *Trichopsis* spp.), Macropodusinae subfamily and genus *Betta*. (Britz, 2001; Ruber & et.al, 2004; Ruber, Britz, & Zardoya, 2006)**.** This study focuses only on the bubble nest builders because of their convenient handling, various features and economical importance.

There are two main types of bubble nest builders, wild and ornamental. Goldstein (2004) and Linke (1991) reported the four species of wild type bubble nest builders in Thailand (see the fighting fish figures in Figure 2-1) as follows:

The *B. splendens* Regan, 1910 is the most well-known and the most widespread which can find every part of Thailand. The wild *B. splendens* live in small bodies of water habitat such as those in the paddy fields, ponds, lakes and marshes.

The *B. smaragdina* Ladiges, 1972 is found throughout the Northeastern region around Khorat plateau which lies on Mae Klong river, e.g., provinces of Nong Khai, Udon Thani, Khon Kaen, Loei and Ubon Ratchathani

The *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 and Songkhla, the Malay Peninsula and Penang Island.

The *B.* sp. Mahachai is a local fish distributed only in a narrow and specific area of Samut Sakhon, Samut Songkhram and Samut Prakarn. It is found in tidal brackish waters with thick vegetation. No other wild *Betta* species have been found in the area. There is no consensus, for lack of good evidence, whether it is a new species or a hybrid (Monvises, 2008).

Betta splendens **Regan, 1910 (wild type)**

Betta smaragdina **Ladiges, 1972 (wild type)**

Betta **sp. Mahachai (wild type)**

Betta imbellis **Ladiges, 1975 (wild type)**

Figure 2-1 Photographs of the wild type bubble nest builder bettas in Thailand

To our knowledge, there are spectacular ornamental bubble nesters with various tail shapes and wide range of colors (see the fighting fish figures in Figure 2-2). 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 tail 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.

***Betta splendens* (muticoloured crown tail)**

***Betta splendens* (red double tail)**

***Betta splendens* (opaque white halfmoon)**

***Betta splendens* (pineapple short tail)**

Figure 2-2 Photographs of ornamental bubble nesters with various tail shapes and wide range of colors

2.4.2 Classical genetics study in Thai fighting fish

The classical genetic basis for the pigments of *B. splendens* was first published by Goodrich and Mercer (1934). Wallbrunn (1957) using statistical analysis of Betta scale pigments found that the body, fin and scale colors of *B. splendens* were regulated by genes for melanin and iridescence pigments as well as the genes for pigment density. The gene for iridescence completely dominates gene for melanin.

Khoo et al. (1997) studied sacroplasmic protein patterns of *B. splendens* by isoelectric focusing and found little differences probably arising from little genetic diversity. After comparing hatchery stocks of *B. splendens* in Nakorn Pathom province by studying their allozymes, Meejui et al. (2005) concluded that the genetic diversity of hatchery populations of Siamese fighting fish in Thailand was marked with a slight decline in allele diversity and proportion of polymorphic loci while heterozygosity increased. However sufficient genetic diversity existed among populations and would greatly benefit genetic improvement programs of this species.

They recommended keeping genetic integrity of each population by minimizing stock translocation between genetically distinct populations.

Moreover, karyotyping of *B. splendens* has been done and there is a good agreement on the number of chromosomes (2n = 42) but less on the types of chromosome (Ratanatham & Patinawin, 1979; Magtoon et al., 2007). The sex chromosomes are also not easily distinguishable from autosomes (Bennington, 2005).

2.4.3 Molecular genetics study in fighting fish

Taxonomy and related phylogenetic tree positions of the fighting fish have been worked out using mitochondrial and nuclear DNA sequences and some minor changes to fighting fish evolutionary position were made recently. The studies are the ones that showed fighting fish to be in the Osphronemidae family (Ruber et al., 2006). It was also found that the *B. splendens* nesters are genetically more closely related to *B. imbellis* than others whereas the *B. pi* brooders are genetically close to *B. simplex* (Ruber et al., 2004) as supported by RAPD (Random Amplified Polymorphic DNAs) study (Tanpitayacoop & Na-nakorn, 2005). Recent work of Sriwattanarothai, Steinke, Ruenwongsa, Hanner and Panijpan (2010) has shown that the putative species Betta sp. Mahachai from central Thailand is a species distinct from other members of the *B. splendens* group and represents a new and hitherto undescribed species. This new species of *Betta* from Thailand was confirmed by using both morphological and molecular evidence. The technique of barcoding, using two regions of mitochondria DNA (COI, and 16s rRNA) was utilized in the molecular study.

2.4.4 Using fighting fish in the classroom

The Siamese fighting fish (*Betta splendens*) is a large, attractive, and hardy tropical fish that lives up to its name as a "fighting" fish. In its native Thailand, this species has been used in fish fights for centuries and has even been selectively bred for aggressiveness. Only the colorful males display this aggressive, agonistic behavior. The male fish makes a bubble-nest of mucus-coated, floating bubbles to which he attempts to attract the drab female to lay her eggs. When the territory of his nest is threatened by another male, the male Siamese fighting fish is particularly likely to show aggressive behavior. Fighting fish can be easily raised and is commercial available in pet shops, and thus can be used in biology class for school students.

Early in 1970s, Kuhn has found the Siamese fighting fish, *Betta splendens* to be effective in arouse student interest. Fighting fish is a marvelous organism for studies in behavior, development, or structural biology and also seems to excite the fancy of students-opening the door to instruction in many areas of biology. Peck and walker (1991) have employed fighting fish in designing laboratory exercise to give high school students experience in using the scientific method. In this exercise, students design and conduct their own research studies on the behavior of Siamese fighting fish that are kept in classroom aquaria.

More recently Kremer, Walker and Schlüter (2007) developed a course in inquiry-based science for students training to become primary school teachers. The course involved simple observation experiment on behavior of Siamese fighting fish. In the college level, Lynn, Egar, Walker, Sperry & Ramenofsky (2007) used the fighting fish to set a simple and low cost physiology laboratory for undergraduate students to investigate the mechanism of aggressive behavior.

CHAPTER III
METHODOLOGY

Overview

This chapter presents research methodology for two instructional units. The first unit is on development and implementation of cooperative learning unit on primary students. The second unit is on development and implementation of hands-on experiment with an emphasis on inquiry learning for secondary students. Methods for data collection and analysis of both instructional units were described.

3.1 Theoretical basis of this study

The field of science education has benefited substantially from efforts to seek out and establish strong connections between theory, research, and classroom practice. More importantly, theory provides a powerful set of guidelines for researchers and practitioners in science teaching (Mintzes & Wandersee, 1998). Constructivist theory has had a prominent position in science education for more than a decade, and this approach currently serves as the theoretical framework for many research studies (Appleton, 1997; Hofstein & Lunetta, 2004; Matthews, 1998)

According to the 1999 National Education Act, Thai education was reformed to emphasize lifelong learning with a balance of knowledge, skill and attitudes. It was reformed in 2002 (Ministry of Education, 1996) to accommodate change in the scope of work of Ministry of Education.

A Thai Education Act seeks to develop new types of teaching/learning approaches such as student-centered learning which was determined as a national pilot study to introduce the new learning approach (Piya-Ajariya, 2002). The Education Act does not specify student-centered learning as the only approach for teaching/learning, but student-centered learning is now the main focus change. It is hoped that the traditional teacher-centered or didactic approach that has existed for a long time in Thailand will be gradually supplanted.

The learner-centered teaching approach has been used in the classrooms. This approach is based on constructivist views of teaching and learning which posit that students actively and purposefully construct their own knowledge in order to make sense of scientific phenomena by using and building on their existing knowledge and new information (Dahsah & Faikhamta, 2008). The concepts of constructivism, (e.g., epistemological and pedagogical views), cooperative learning, inquiry based learning and teaching are discussed as the framework of this present study.

3.1.1 A framework of this study

According to the theories that described in the previous section, the researcher used them to develop the theoretical framework for this study as shown in Figure 3-1. It gives the outline of this section which influences the development of the invention: a cooperative learning unit for primary students, and a hands-on learning unit with an emphasis on guided inquiry for secondary learning outcomes. Both instructional units aimed at promoting students learning outcomes.

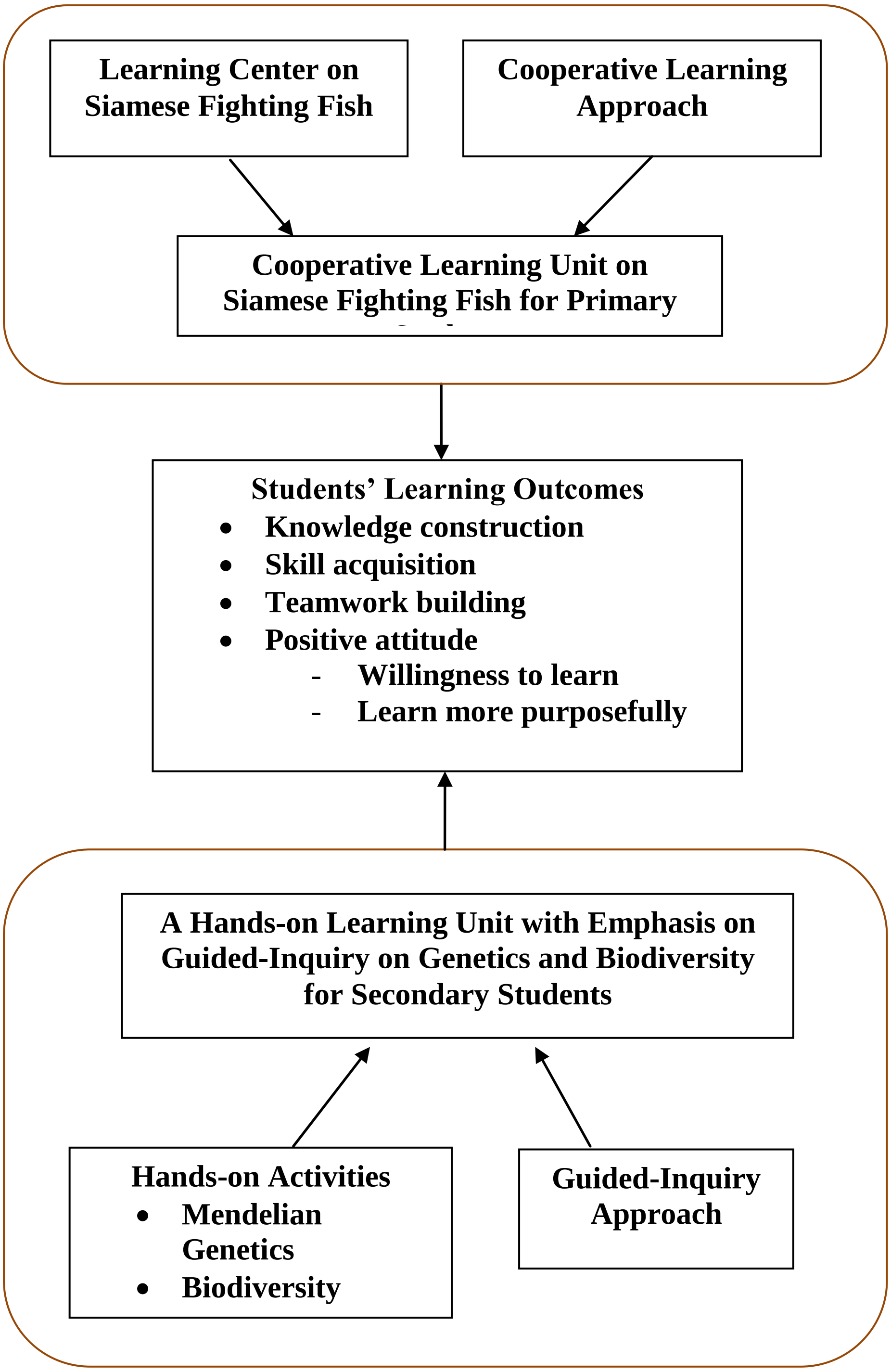

Figure 3-1 Diagram of the framework of this study

3.1.2 Data collection and analysis

3.1.2.1 Students' document

Documents are a rich source of data in social research (Punch, 2005). Documents refer to students' materials, such as written texts, pictures, diagrams, tables, and charts presented in books, lecture notes, worksheets, laboratory reports, diaries or others. In other words, the documents can be presented in text (e.g., essays, reports) and visual form (e.g., pictures, diagrams, photographs). The documents are made for recording evidence of an event or fact as well as for negotiating and communicating the specific information.

Student documents were analyzed and the results were used to indicate student ability such as the ability to plan and conduct the investigation, to draw a conclusion from the evidence, and to answer questions. The findings of document study were supplemented with other methods such as classroom observation.

3.1.2.2 Students' concept map

Concept map is one of the effective tools used for investigating student understanding of the scientific concepts (Novak, 2002). It is a graphic organizational technique designed to help individuals (and groups), and to explain and explore their knowledge and understanding of the topic. It has some commonality with some more familiar techniques, like mind mapping (Hey & Kinchin, 2006). Concept maps are constructed by writing concepts and linking them by labelled lines. The labels are important because they require whoever is constructing the map to actively select appropriate linking words. The links need to make sense between the two concepts and they need to relate the two concepts in some meaningful way (Novak & Gowin, 1984).

Concept maps were used as research tools at the beginning and the end of the instructional process in order to examine student preconceptions and relevant knowledge, to identify misconceptions or misunderstandings, and to assess student understanding and progressions in concepts. The ideas of concept map such as the structure and method to produce the good map were introduced to students by a using hand-out. In the hand-out, the characteristic of concept maps, examples of good and bad concept maps, and directions on how to begin mapping were presented.

Students should try to make their own concept map in order to familiarize themselves with concept map procedures. The students also need time for practicing concept map construction, for example, with the researcher at a convenient time (e.g., home room time).

3.1.2.3 Semi-structured interview

Interview method is used for obtaining in-depth data in research study. In this present study, the semi-structured interviews were used for gathering data from students. Students were interviewed with a series of open-ended questions. The questions ran from general to specific questions to allow the respondent to relax and feel comfortable to answer the questions. A face-to-face (or one-on-one) interview was used.

The interviews were conducted at a time convenient to the participant, such as in their own classroom after school. The aims of the interviews were, for example, to investigate student views of the learning environment based on the intervention, the student's feelings, and the student-teacher interactions in the classroom. An audio recorder was used for recording all dialogs in the interview process.

All interview data were translated to text verbatim from audio tape. All dialogues of each respondent were written in the form of files of Microsoft Office Word. The broad categories of teachers and students responses were identified. All categories were reorganized to indentify themes and then interpretation was employed for the findings. All data helped to find and develop meaning or patterns or ideas that identified the teaching and learning situation, teacher and student views of teaching and learning, and the effectiveness of the intervention.

3.3.2.4 Classroom observation

Observation is one of the main research tools for collecting in-depth data for understanding the phenomena (Cohen et al., 2007). It is commonly used with other tools such as interviews. The types of observer in observational situations used in research study varied depending on the objective of study. In this study, video cameras were used to record the teaching and learning process as well to analyze the in-depth data later (i.e., first camera focused on general activities in classroom and secondary camera focused on students' activities in one group). These data were used together with other data to support findings such as student science process skills. These data also provided specific examples of teacher and student activities in classes.

3.2 Research methodology

3.2.1 Cooperative learning unit on Siamese fighting fish for primary students

3.2.1.1 Participants

The participants in this study were grade-4 students of a provincial primary school in the central part of Thailand. Their GPA ranged from 2.0 to 3.5 (out of 4). 12 boys and 18 girls ages between nine-eleven years were randomly divided in to five groups of six students each.

3.2.1.2 Development of the cooperative learning unit on Siamese fighting fish

"The Siamese Fighting Fish Biology" was employed as a case study for the learning unit on the animal living process for grade-4 students. Cooperative learning was the theoretical framework for this investigation. The learning center on Siamese fighting was developed to be used as learning resources for cooperative activity of the students

3.2.1.2.1 Establishment of the learning center on Siamese fighting fish

The learning center on Siamese fighting fish was established in a room specially allocated by the school for this purpose (see appendix A). The learning resources in the center comprised relevant posters, CD-ROMs, books, magazines, computers, and a television set with a DVD player. Live specimens of a variety of the Siamese fighting fish (*B. splendens*), included wild-caught fish and home-grown ones for fighting and ornamental purposes. Information on fighting fish displayed in the posters included general background, such as history of the fish as pet, raising, culturing, spawning, and breeding by hobbyists and farmers; general biology and taxonomy; maintenance standards for their health, e.g., water quality, feeds; disease prevention and cure.

All the learning materials on the five main topics were located in different areas of the center. The topics were biodiversity, history, classification, breeding and conservation of local fighting fish. Each group of students was assigned to a particular topic with its activities.

This learning center was established as a year-round fixture for both formal and informal learning about the fighting fish. The primary students took turns in its maintenance.

3.2.1.2.2 Study design

The learning activity in this study was designed in such a way that the students would work as cooperative team to accomplish their learning goals (Johnson & Johnson, 1999). Students in each group were expected to help each other in using information displayed in the learning center to answer questions in the worksheet. The students then should share ideas and discuss in the group and then to the class. Finally, by cooperation in learning, students in all groups should be able to grasp all the concepts expected from this learning unit, even though each group did only its own assignment.

3.2.1.3 Implementation of the cooperative learning unit on Siamese fighting fish for primary students

The three-week learning unit was implemented to one classroom of grade 4 students. The students worked cooperatively in group of 4. The main activities in every weeks involved both group activities and knowledge sharing as guided by the teacher. In the first week, the students gathered knowledge from the learning center and shared within group and within class. In the second week, group of students used the knowledge acquired in the first period to work cooperatively in designing group project. In the third week, the students from each group presented the project to class. Finally in the debriefing session, the teacher encouraged students discussion to ensure that all students were able to construct their own knowledge. The evaluation of students' outcomes was a formative assessment starting from the first week through the last week on student quizzes, classroom observation, students' worksheet, students' mind map and interviewing. The details of the learning sequence are shown in Table 3-1. In all these learning processes, teacher acted as the facilitator to encourage and motivate the students while giving guidance for acquiring knowledge.

Table 3-1 The cooperative learning sequence on living process of fighting fish for primary students

Duration	Activity	Assessment of knowledge gained
Week 1 (2 h)	Group activities - Each group of the students cooperatively studied the information on the assigned topic. - Students were encouraged to work in groups, share their findings and help each other in learning.	Individual students answered quizzes on the activity sheet
Week 1 (2 h)	Knowledge sharing - Students from each group presented what they knew on the assigned topic to the class - Students in the out- groups asked questions, gave comments, shared ideas. - Teacher helped to ensure that all important points were covered.	Individual students wrote their own conclusion on the given conclusion sheet. Each student had to cover all five topics.
Week 2 (2 h)	Group activities - Each group of students worked cooperatively in designing a group project of their own choice. - Every student helped to search for information for the group project. - Students were required to put the knowledge learned in a wider context.	Evaluation of projects for knowledge synthesis, linkage with other disciplines, creativity, application and group presentation.

Week 3 (2 h)	Knowledge sharing - Students from each group presented their group project to the class in their own way with an effort to ensure understanding of their classmates in other groups. - All students commented, discussed, asked questions and shared ideas.	Evaluation of projects for knowledge synthesis, linkage with other disciplines, creativity, application and group presentation.
Week 3 (2 h)	Debriefing - Teacher and students worked together in the discussion and conclusion to make sure that all essential points are covered in accordance with the learning objectives. - Students helped each other to ensure understanding of all members.	Individual students wrote their own mind map representing all the knowledge acquired.
Week 3 (2 h)	Ten randomly selected students were interviewed both on knowledge acquired and attitude toward the cooperative learning activity.	

3.2.1.4 Data collection and analysis

The students were assessed for the effects of cooperative learning had on their learning outcomes based on both the qualitative and quantitative methods. The data collected were students' worksheets, students' conclusion sheets, students' project, individual mind map, interview and classroom observation. Descriptive statistics was used for analysis of the quantitive data. The thematic approach was used to analyze the interviews. These data were used for triangulation to corroborate those from other sources.

Activity sheet

Individual students had to answer short questions and fill in the blanks in the given activity sheet after completing their studies of the topic assigned to each.

Conclusion sheet

Individual students had to conclude what they had learned from their own group work and from the knowledge shared in class by other groups on the other topics. Points were given based on the extent and depth of knowledge of all the five topics.

Group project

The quality of students' group project was evaluated based on four criteria namely; synthesis of the knowledge learned, linkage with other disciplines, creativity and application. Another attribute evaluated was presentation to the class. Background knowledge supporting the project was also included. Projects were graded by using five-point Likert scale ranging from excellent (5), very good (4), good (3), fair (2) to poor (1). The maximum points for each the project is 25.

Mind map

Individual students had to write the mind map after the debriefing session to ensure understanding of all the concepts learned. The mind map was evaluated for content, logic, understanding and presentation with a scoring rubric scale adapted from Moni, Beswick and Moni (2005).

Semi-structured interviews

Ten students were randomly selected for a 15-minute interview. The purpose of the interview was to investigate the students' views on cooperative learning, students' feelings and student-student interactions in the group activity. The questions also concerned knowledge learned during the study. All the interviews were recorded and transcribed verbatim. These data were used for triangulation to corroborate those from other sources.

Classroom observation

Video cameras were used in the classroom to record the teaching and learning process: the first camera for general activities and the second camera for group activities. Video-tape was analyzed for in-depth information on student-student interactions, student-teacher interactions, participation of students in group activities and in-class discussion. These data were used together with other data to support findings on students' achievement and attitude.

3.2.2 A hands-on learning unit with an emphasis on guided inquiry on genetics and biodiversity for secondary students

3.2.2.1 Participants

The participants were grade 9 students enrolled in a biology course of two neighboring schools in the central part of the country. One classroom (12 boys and 12 girls) served as control in which the students were given conventional lecture. The other classroom (9 boys and 15 girls) served as experimental group with the inquiry-based instruction. Both groups were taught the same topics with the same objectives and duration by the same teacher. The students from both groups were given the pretest prior to the instruction and posttest after completing the learning activity. The students in the experimental group were randomly divided into four subgroups of six students each.

3.2.2.2 ***Development of hands-on learning unit with emphasis on guided inquiry-based for secondary students***

The study employed the Siamese fighting fish as an animal model for development of hands-on experiment with emphasis on guided-inquiry approach. The unit comprised two main topics on Mendelian inheritance and biodiversity (identification and classification of living things). There was no lecture involved in both topics. Instead the students were engaged and challenged with games, followed by the hands-on activity, group poster and presentation. During the hands-on activity students in each group had to provide short answer to worksheet questions individually. Then they discussed in their own group before class discussion. The teacher helped in the debriefing session to ensure that all students could construct knowledge from all activities learned. Each group of students then cooperated in writing and presenting a poster reflecting the knowledge learned in each topic.

The details of hands-on activities in each topic are as follows:

1. Mendelian inheritance

This topic was composed of 3 activities (see appendix C)

Activity 1 Students were asked to predict and explain "What would be the color of the fish resulting from crossing a yellow fighting fish with a red one?".

Activity 2 Making use of differently colored clippers, students were asked to predict from the given conditions "What would happen to the first generation and second generation fish if we cross fish to look for inheritance of only one trait or two traits?"

Activity 3 Specify two desirable traits and theoretically cross the fish to observe the traits in the ensuing generations, F1 and F2. Without using any clippers, describe in your worksheet what you would expect to see.

2. Biodiversity

This topic is composed of 2 activities (see appendix C)

Activity 1 Provide with different plastic models of animals and plants, the students were asked to distinguish outward characteristics (traits) of the organisms. Finally, they were asked to classify the organisms into group from their own criteria.

Activity 2 Following the procedure in activity 1, students distinguished 10 different traits of fighting fish and end up with their classification.

3.2.2.3 Implementation of the hands-on learning unit

The 2-week learning unit on Mendelian genetics and biodiversity was giving to two groups of students from the classroom. The control group received traditional lecture on the same topics with same objectives. The treatment group received the guided-inquiry learning unit with hands-on activity as described in Table 3-2. There were reformed lecture in this group. The students learned through doing the two hands-on activities once per week. In the first week, on Mendelian genetics, the students were engaged with the games (Which is the offspring?) to stimulate extensive discussion on Mendelian laws of inheritance. Then they did the hands-on activities which composed of three sub activities. They were expected to acquire their knowledge from doing activity and from group/class discussion. To ensure the knowledge acquisition, the students were asked to write group poster containing all knowledge learning in well organized structure. The students had to present what they wrote in the poster to class for further discussion and critiques. In the next week, the students learned the second topic on biodiversity which emphasized only identification and classification. After engaging with games the students worked in group to discuss on biodiversity of fighting fish. Then they conducted the hands-on activity on finding their own criteria for classification from the given plastic models of several animals. They were expected to set to own key to classify the fighting fish given in the next activity. This session ended up with extensive discussion and the students wrote poster and performed oral presentation in a similar way to those in the first week.

The learning sequence of the inquiry-based unit on genetics and biodiversity is summarized in table 3-2. In all these processes, the teacher acted as facilitator to encourage, motivate and give guidance to ensure student achievement.

Table 3-2 A guided-inquiry learning sequence on Mendelian genetics and biodiversity for secondary students

Duration	Activity	Assessment
Phase I : Prior knowledge (30 min)	Students took pretest	20-item pretest questions
Phase II : Implementation Week 1 (3 h) implementation of the first topic	Topics: Heredity and Mendelian inheritance • Students were engaged with the game "Which is the offspring?" • Students discussed Mendelian's law of inheritance • Students conducted hands-on activity on "Mendelian genetics" based on the	• Classroom observation • Student worksheet • Student poster • Student presentation

	Siamese Fighting Fish as model • Students answered questions in the worksheet • Students discussed their findings with group and then with class • Students constructed knowledge through discussion and conclusion Each group of students prepared their poster from the self-constructed knowledge on “Heredity and Mendelian inheritance” and then presented to class	
Week 2 (3 h) implementation of the second topic	<u>Topics</u>: Biodiversity • Students were engaged with games on “Where do they belong in this chart?” • Students discussed biodiversity of the fighting fish • Students conducted hands-on activity on −Phenotype and genotype −Classification • Students answered questions in the worksheet • Students constructed knowledge through discussion and conclusion in class	• Classroom observation • Student worksheet • Student poster • Student presentation

	• Students discussed their findings within group then to class • Each group of students prepared their poster on "biodiversity" and then presented to class	
Phase III : Evaluation	• Student took posttest and wrote their reflection • Students were interviewed	• 20-item posttest questions • Students reflection • Interviewing questions

3.2.2.4 Data Collection and Analysis

For the experimental group, the data were gathered from pretest, posttest, student worksheet, student poster and presentation, student reflection and interviews. For the traditional group, the data collected were pretest and posttest. The quantitative data were analyzed by using statistics software package SPSS version 16. The interviews were analyzed by using a thematic approach (Attride-Stirling, 2001).

Pretest/Posttest

The pretest/posttest focused on conceptual understanding of genetics and biodiversity on three topics: phenotype and genotype inheritance, Mendel's laws and biodiversity. The test comprised 20 two-tier questions. The reliability test score using K-R 20 for the overall items was 0.879.

Student Document

Each student was asked to write their procedure and short answers to questions posed in the given worksheet. Each group of students was also asked to organize all the knowledge learned into a well-presented poster and presented it to class. The-5-point Likert scale was used to rate the worksheet, poster and presentation. The documents were used as supporting data for students' conceptual understanding.

Student Reflection

Students were asked to reflect on what they had learned or understood in writing (15 min allowed).

Semi-structured interview

At the end of the unit, ten students were randomly selected for the semi-structured interview lasting 20 min each. The interview was audio taped and transcribed verbatim.

CHAPTER IV
RESULTS

Overview

This chapter reports the results on the effectiveness of the two newly developed learning units on students' achievement and attitudes. The first part describes the results obtained from implementation of the cooperative learning units on fighting fish for primary students. The second part reports the outcomes of the secondary students after implementation of the hands-on learning unit on genetics and biodiversity. In both cases, results on students' conceptual test, students' documents, and students' interviews are described.

4.1 A cooperative learning unit on Siamese fighting fish for primary students

4.1.1 Effects of the cooperative learning unit on students' achievement

4.1.1.1 Students' documents

Each group of six students was assigned to one of the five different topics located in five corners of the learning center. The students in each group cooperated in learning from the resources provided, e.g., posters, CD-ROMs, books, fighting fish live specimens. The students shared idea and discussed among themselves; however they had to answer the questions in the given activity sheet individually.

Table 4-1 Mean scores from answers to the activity sheet questions of the five groups of students

Group	Topic	* Mean ± SD (Max 10 points)	Percentage
1	Biodiversity of Siamese fighting fish	7.92 ± 0.58	79.2%
2	History of Siamese fighting fish	6.92 ± 0.34	69.2%
3	Classification of Siamese fighting fish	7.08 ± 0.49	70.8%
4	Breeding of Siamese fighting fish	7.25 ± 0.52	72.5%
5	Conservation of local fighting fish	8.20 ± 0.60	82.0%

*n = 6

As shown in Table 4-1, the mean scores from each group of students undergoing different activity ranged from 6.92-8.20. After submitting the filled activity sheets to the teacher, each group of students presented what they had learned in the assigned topic to the class. The students were encouraged to share and discuss extensively about all they did and learned in the learning center. Then the students were tested for their overall knowledge in the learning center. The results in Table 4-2 show the scores from two types of activity from the topic that each group had already undergone and from what each group learned from peers during class discussion. The percentage scores in each group varied somewhat, ranging from 64.50% to 81.75%. Learning scores from the total assignment for the in-group and between-group ranged from 68.40% to 82.00%. Groups one and four seemed to have lower scores than other groups.

Table 4-2 Mean scores of conclusion sheet of the five groups of students

Group	In-group activity		Out-group activities		Total activity	
	Mean ± SD (Max 4 points)	Percentage	Mean ± SD (Max 16 points)	Percentage	Mean ± SD (Max 20 points)	Percentage
1	2.74±0.56	68.50	11.39±1.34	71.18	13.68±1.85	68.40
2	3.27±0.81	81.75	13.13±0.38	82.06	16.40±0.79	82.00
3	2.77±0.61	69.25	13.15±0.37	82.18	15.92±0.88	79.80
4	2.58±0.32	64.50	11.99±1.42	74.94	14.56±1.34	72.80
5	3.17±0.67	79.25	12.17±0.61	76.06	15.33±1.10	76.65

4.1.1.2 Students' projects

Each group of students was assigned a one-week project work. The students had to exploit the knowledge learned in the first phase to design a group project which should include other disciplines as well.

The students were encouraged to search for more information from other media of their choice as supporting information. One week afterwards all groups submitted their completed projects, some of which were hand-held models. One project resulted in a mime show. Each group of students presented their work to a class in their own way. The scoring for presentation focused mainly on the ability of each group to convey the message of their project in such a way that their classmates could conceptualize about the life of the fighting fish. The students' projects and the scores given are shown in Table 4-3. The scores of the five projects ranged from 18 to 23 (out of a total 25 points). The results showed that all groups had similar scores in synthesizing and applying of the knowledge learned. The ability to convey messages was also similar, except for group two, who had an outstanding presentation. However, each group of students differed in terms of creativity and ability in linking with other disciplines. The two groups with high scores were able to link science with other three disciplines, e.g., environment, arts and English. For example, students had to learn the word "mobile" in English, artistically design and color the mobile parts, and balance these parts based on the physical principle about the "moment", another English term. The inhospitable environment (with low dissolved oxygen) of most fish was mimed by showing the fish gulping air for supply of oxygen in addition to that by the gills.

Table 4-3 Mean scores of the projects of the five groups of students

Group	Project	Score					
		Synthesis of knowledge learned (Max 5 points)	Linkage with other discipline (Max 5 points)	Creativity (Max 5 points)	Application (Max 5 points)	Presentation (Max 5 points)	Total (Max 25 points)
1	Fighting fish mobiles made from used plastic bottles	4	5	4	4	4	21
2	Mime show on fighting fish environment and habitat	4	5	5	4	5	23
3	Demonstration of raising of fighting fish	4	3	3	4	4	18
4	Fighting fish mobiles made from coconut leaves	4	4	3	4	4	19
5	Breeding and spawning of fighting fish	4	3	4	4	4	19

4.1.1.3 Students' mind map

During project presentation, the teacher encouraged students to listen carefully, shared ideas and/or asked questions and enabled them to learn as much as possible. The students were told to use the knowledge learned in drawing the mind map to represent their conceptual understanding about the life of the fighting fish. The students were allowed to discuss with friends to ensure their understanding before drawing the mind map individually. Students argued earnestly until there was some kind of agreement based on reasonableness rather than personality.

Table 4-4 Mean scores of the mind map of the five groups of students

Group	Mean ± SD			
	Content (Max 5 points)	Logic and understanding (Max 5 points)	Presentation (Max 5 points)	Total (Max 15 points)
1	4.55±0.55	4.33±0.52	3.67±0.82	12.50±1.52
2	4.30±0.52	4.67±0.52	4.17±0.42	13.17±1.17
3	4.33±0.52	4.50±0.55	4.00±0.63	12.83±1.47
4	4.17±041	4.17±0.42	4.17±0.42	12.33±0.52
5	4.67±0.52	4.33±0.52	4.50±0.55	13.50±1.38

Results of student mind map evaluation are shown in Table 4-4. Three main criteria as adapted from Moni, Beswick, and Moni (2005) were used to evaluate student's conceptual understanding. Relatively high scores (at levels four and five) were seen in the content knowledge, logic and understanding. The students put most of the relevant concepts in their correct places, even though some students seemed to have slight problems with their logic. The presentations showed that most of the students' mind maps were rather neat and clear as well as colorful, although there were spelling errors. The overall picture of mind maps of the five groups seemed to be of similar quality. Results from a one way ANOVA tests showed no significant difference in the mean scores between the five groups of students (data not shown).

4.1.2 Effects of a cooperative learning unit on students' perception

4.1.2.1 Semi-structured interview

The results from semi-structured interviews of ten randomly selected students revealed that most students were acquainted with the fighting fish. Some of them had experience with culturing of fighting fish as shown in the following excerpts:

"I help my father in raising and spawning the fighting fish. My uncle also raises the fish for sale."

"I have never raised the fighting fish myself, but I remember seeing my grandfather breed the fighting fish and also let the fish fight each other."

"I raise the fighting fish myself at home but as ornamental."

"Even though I have never raised any fighting fish, I think I can do it with no problem."

The students, after exposure to the learning center, were able to recall tidbits about the fish.

"I now know that there are many kinds of the fighting fish, e.g., they are wild caught fighting fish, home grown fighting fish, ornamental fighting fish."

"Some people around here raise their fish for fighting, I find the activity objectionable."

"In the old days, people raised fighting fish for gambling, now more people raise them as ornamentals

"I can differentiate the males from the females. Male fish are much more beautiful than the females."

"I learn how to breed the fighting fish from this learning center."

The students were also interviewed on their opinions toward cooperative learning. Student's opinions are as follows:

"I like to work cooperatively, because we can share ideas, we can help each other in solving problems."

"Working in the group leads to communication and unity."

"I prefer to work in a group because we can learn from each other."

"I think it is better to work in a group, but I'd rather choose my own company, especially responsible people. Somebody in my group didn't help at all."

"In my group, we had to fight to be heard, the girls just didn't give the boys a chance to share ideas."

"In the cooperative learning, some students were too shy to talk to the class but our group didn't have this problem."

"I think it is good that we don't have to study a lot by ourselves, but instead we can learn from listening to our friends."

The students had positive attitudes toward the learning activities in the learning center. Excerpts from the students are as follows:

"Some activities were difficult but it's very interesting, they motivated me to learn. If I didn't understand any point I could consult my friends in the group."

"I had no problem in learning. I could look up information from the posters, CD-ROMs and books in the learning center. The teacher helped in pointing out the main features of the unit."

"The topics in the learning center were very interesting and easy to understand. They were also related to our local way of life, especially, raising fighting fish."

Most students, however, commented that the time allocated for studying in the learning center was too short.

"I wish I could have more time studying in the learning center."

"I prefer experiencing all activities, not just only the one in the group. I wish the teacher could have given me more time. I will go back to the learning center again on my free time."

"I need more time to complete the given activities."

"The time allocated to do the assignments activity was about right, but I prefer having more time so that I could do more activities. I will go back to the learning center again on my free time."

Students commented that most of the activities in the learning center were good, however, they suggested some improvements in group management.

"The teaching/learning was already good, but the teacher should have allowed students to choose their own group members for better outcomes in cooperative learning."

"Some students did not have any input at all. Teacher should find a way to let everyone work, and share ideas equally."

4.2 A hands-on learning unit with an emphasis on guided inquiry on genetics and biodiversity for secondary students

4.2.1 Effects of the guided inquiry hands-on learning unit on students' achievement

4.2.1.1 Conceptual test

The prior knowledge of the students in genetics and biodiversity in both traditional and experimental group was measured by 20 two-tier questions on three topics: phenotype and genotype inheritance, Mendel's laws and biodiversity. The results in Table 4-5 show no significant difference in mean scores in the three topics between the traditional and experimental group. It should be noted that all students had low prior knowledge in all three topics i.e. ranging from 35-44% in traditional group and 34-47% in experimental group.

Table 4-5 Pretest scores of traditional and experimental group

Topic	Traditional group		Experimental group		*t*
	(Mean ± SD)	Percentage	(Mean ± SD)	Percentage	
1. Phenotype and genotype inheritance (7 points)	2.46±0.51	35.14	2.67±0.51	38.14	1.10
2. Mendel's law (5 points)	2.21±0.59	44.20	2.08±0.59	41.16	0.90
3. Biodiversity (8 points)	3.46±1.02	43.25	3.83±1.02	47.88	1.81
Total (20 points)	8.12±1.15	40.60	8.58±1.35	42.90	1.27

Table 4-6 Posttest scores of traditional and experimental group

Topic	Traditional group		Experimental group		*t*
	(Mean ± SD)	Percentage	(Mean ± SD)	Percentage	
1. Phenotype and genotype inheritance (7 points)	3.58±0.72	51.14	5.46±0.66	78.00	9.26*
2. Mendel's law (5 points)	2.67±0.56	38.14	4.83±0.48	96.60	16.66*
3. Biodiversity (8 points)	5.37±1.02	67.12	6.58±0.58	82.25	7.60*
Total (20 points)	11.58±1.21	57.90	16.88±0.99	84.40	18.97*

* Significant difference at $p < 0.001$

After completing the learning unit, the mean scores of posttest in both traditional and experimental group were significantly higher than those of the pretest (data not shown). However, the posttest scores of the experimental group were significantly higher than those of the control group in all three topics tested (Table 4-6). The percentage gains of the experimental group in all topics were higher than those of the control group (Table 4-7). They ranged from 17.2% to 38.8% in the traditional group and 41.4%-56.9% in the experimental group. The highest percentage gain in the experimental group was in the topic of Mendel's law while for this topic in the control group had the lowest percentage gain. The results showed that intervention by the hands-on activity resulted in higher knowledge gained.

Table 4-7 Comparison between percentage gains of traditional and experimental group

Topic	Traditional group % gain	Experimental group % gain
1. Phenotype and genotype inheritance (7 points)	31.28	51.09
2. Mendel's law (5 points)	17.23	56.94
3. Biodiversity (8 points)	38.78	41.39
Total (20 points)	29.88	41.51

4.2.1.2 Students' document

Results in Table 4-8 show the mean scores of the three activities as reflected in the students' worksheets on Mendelian inheritance topic. In all four groups there seemed to be a slight increase in the mean scores from activity 1 to 3 in spite of the increase in complexity of the problem. This suggested that the work done in first activity helped build up the knowledge to be used in subsequent ones.

Table 4-8 Students' worksheet scores on Mendelian inheritance

Group	Scores (Mean ± SD)			
	Activity 1 (10 points)	Activity 2 (10 points)	Activity 3 (10 points)	Total (30 points)
1	7.50±0.55	7.66±0.52	7.83±0.75	23.00±0.63
2	7.50±1.05	8.00±0.89	8.67±0.82	24.17±2.56
3	7.50±0.84	7.70±0.52	8.50±0.55	23.33±1.36
4	7.33±0.52	8.00±0.63	8.17±0.75	23.50±1.52

Table 4-9 Students' worksheet scores on biodiversity

Group	Scores (Mean ± SD)		
	Activity 1 (15 points)	Activity 2 (15 points)	Total (30 points)
1	12.83±0.75	13.67±0.52	26.50±1.05
2	13.50±0.84	13.50±0.55	27.00±1.26
3	13.00±0.89	13.50±0.55	26.50±0.55
4	13.00±0.89	12.50±0.55	25.50±1.05

As shown in Table 4-9 the mean scores of activity 1 and activity 2 of all four groups of students seemed to be similar. In activity 1, each group of students identified its own criteria for subsequent classification of the fighting fish in activity 2. The results show rather high scores ranging from 85-90% suggesting that the hands-on activity helped students build up their knowledge on identification and classification.

4.2.1.3 Students' poster and presentation

At the end of each hands-on activity, the students were encouraged to discuss within their group and then to class. This step helped them construct their knowledge to be employed in writing the poster and presenting to class. The results in Tables 4-10 and 4-11 show the group's mean scores of poster and oral presentation of the two topics. For the topic on Mendelian inheritance, the total mean scores ranged from 8.00±0.55 to 9.50±0.49 (of total of 10). The mean scores on the topic biodiversity ranged from 8.50±0.58 to 9.50±0.49 (of total of 10).

Table 4-10 Poster writing and presentation scores on Medelian inheritance

Group	Scores (Mean ± SD)		
	Poster writing (5 points)	Oral presentation (5 points)	Total (10 points)
1	4.00±0.43	4.00±0.61	8.00±0.55
2	4.90±0.54	4.60±0.55	9.50±0.49
3	4.00±0.63	4.50±0.52	8.50±0.52
4	4.50±0.56	4.40±0.59	8.90±0.58

Table 4-11 Poster writing and presentation scores on biodiversity

Group	Scores (Mean ± SD)		
	Poster writing (5 points)	Oral presentation (5 points)	Total (10 points)
1	4.00±0.82	4.50±0.68	8.50±0.58
2	4.50±0.42	4.00±0.45	8.50±0.34
3	4.90±0.35	4.60±0.58	9.50±0.49
4	4.90±0.63	4.50±0.42	9.40±0.52

4.2.1.4 Student reflection

The students were asked to reflect on what knowledge they have gained through their writing. The results summarized in Table 4-12 as frequency of similar responses. The details of student writing pointed out that most of the students were able to acquire knowledge from doing the activity themselves. This resulted in their ability to link pieces of knowledge together for a better understanding of both topics. The results also showed that most students had positive attitude toward the hands-on activities.

Table 4-12 Students reflection on the knowledge gained from the inquiry-based learning unit

Topic	Content	% frequency
Knowledge on Mendelian inheritance	- Without the hands-on activity, it would be difficult to understand Mendel’s law as I do now	57
	- I now know the meaning of genetic unit	57
	- I know what Mendelian genetics is	53
	- I know the meaning of phenotype/genotype	50
	- I can apply the knowledge of Mendel’s law in breeding different types of fighting fish	33
	- I understand the process of genetic transfer	30
Knowledge on biodiversity	- It is a good idea to use colored clips to represent segregating genes, because this makes me understand Mendel’s law	60
	- I can classify different types of fighting fish	57
	- I know what is meant by biodiversity	53
	- I am able to identify the criteria for classification instead of memorizing from textbooks	50
	- I know different types of fighting fish in my local community	40
	- I can draw a flow chart of classification	27
	- I understand the relationship between organisms in the ecosystem	27
Attitude	- I like using games for engaging	67
	- I like the cooperative work, because we can divide tasks in the group	50
	- I like the way teacher guided us during the process of learning	40
	- I prefer to do real experiments on breeding of fighting fish instead of theoretical ones in the hands-on activity	23

4.2.2 Effects of a hands-on learning unit on students' attitude

4.2.1.1 Student interview

The interviews focused mainly on students' attitude. The students voiced that the learning unit helped them to acquire knowledge by doing instead of only listening to the lecture. The following are excerpts from the students in the experimental group.

"I enjoyed learning by working hands-on because I could play with the given materials in such a way that I could find the answer myself."

"I am so very proud that I could identify the criteria for classification myself from just observing the given animal models."

"Learning by doing is much easier than reading from textbooks or listening to teacher."

"It is my first time at classifying animals. Now I can classify different types of fighting fish."

"I really enjoyed breeding (even just theoretically from the chart) fighting fish to achieve the desired characteristics. I'm going to breed the real fish at home to find out."

However, the students from the traditional group commented that.

"It is difficult to understand Mendel's laws and Mendelian inheritance from reading the chart in the textbooks."

"I think the teacher should find a more appropriate way to convey the message so that most students can understand."

"The topics of classification is boring, it is difficult to remember things."

"I like to do experiments and go on the field trip rather than just listening to lectures."

The students from experimental group also commented that learning by hands-on activity helped them develop science process skills.

"On actively identifying criteria for classification we have to observe a lot. This learning unit trained us to observe and classify."

"I now know the difference between types of fighting fish and other animals."

The students who learned by the hands-on activity enjoyed working as the team as shown in the following excerpts:

"I like group work because I can learn from friends who can help me gain more knowledge."

"Cooperative work leads to esprit de corp and communication skills."

"We enjoyed sharing ideas as well as sharing duties in the group."

"Friends helped in explaining and constructing knowledge within group."

"Group work is a good idea, but we preferred to choose our teammates, because there were members who did not help in group work."

The students commented that they needed more of this kind of activity.

"Learning by hands-on activity is much easier than from textbooks or teacher. I wish there were more hands-on or other similar activities for other topics."

Some students, however, commented that the time used in this activity was rather short.

"The time for the hands-on activity was not enough. I could have produced more work if more time had been allowed."

"I really enjoyed learning through the hands-on activity and would like to spend more time on it."

CHAPTER V
DISCUSSION

Overview

This chapter presents the interpretation and discussion of research findings in two main sessions. The first session discusses how the newly developed cooperative learning unit, using the fighting fish learning center as learning resources, enhanced learning outcomes and helped develop teamwork of the primary students. The perception of the students toward the learning activity is reported. The second session explains how a hands-on learning unit with emphasis on inquiry strategy helped the secondary students understand difficult topics in biology. The limitation, recommendation and implication of this study are discussed.

5.1 Effectiveness of a cooperative learning unit on Siamese fighting fish on students' outcomes

The study demonstrates the achievement outcomes from cooperative learning of primary students on the topic of the living process of the fighting fish. The students in this case study were exposed to the cooperative learning for the first time. However, they enjoyed the activity because the topic was relevant to their life: people in this locality raise fighting fish for both hobby and commerce. The Siamese fighting fish is a good example of fish territoriality and aggression (Monvises, Nuangsaeng, Sriwattanarothai & Panijpan, 2009). Gill cover flaring and expansion of the colorful fins as well as the darkening of the body enhance the appearance of the fish, and thus their value as pets. Also the courtship behavior is interesting to watch. After spawning, the caring of the egg stages to newly hatched fry by the male parent provides an interesting alternative example for the female parental care generally found in nature.

The experimental results showed gradual improvement in the students' learning outcomes during the three-week period in which groups of students worked together both in and out of class. The study design anticipated four products, three of which were individual tasks while one was a group project. The results from the first cooperative work on the answer from the activity sheet together with the classroom observation suggested that some students tried to help others to understand the learning materials. However, some students did not see the value of cooperative work and seemed not to participate, resulting in low scores. The results also showed that the extent of each intra-group cooperation was different. The mean scores in the activity sheet that a lower score was found in the group that cooperated the least.

However, the students' performance improved in the second task, that was, the conclusion of the whole activity in the learning center. With peers the students had to learn as well the other activities that were not assigned to them directly. The results showed that every group of students was able to learn from each other during idea sharing and discussion. However, the extent of knowledge gained in different groups was still different probably due to different abilities in grasping what was being said to them. It should also be noted that some groups did not score well even in questions related to the task they performed themselves. This might be due to both the differential ability of the students to conceptualize and lack of cooperation in the first activity or other. Unaccounted factors, such as attentiveness, background knowledge. This is not surprising, since children required an unstructured period to organize themselves and to learn together toward the group goal (Mueller & Fleming, 2001). Latane, Williams and Harkins (1979) reported that in groups lacking individual accountability, one or two students may do the group work, while others loiter around.

Apart from the two individual assignments for the activity sheet and the conclusion sheet, the students in each group worked together to produce an innovative group project to present to the class. Although this study did not give rewards as incentive as reported by several researchers for successful cooperative works (Slavin, 1996), our students encouraged each other to put in the maximum effort. They persisted in the completion of the project. The success was supported by the high rubric-based scores for the projects. In each group, students were able to construct new knowledge as judged by the design of their projects which had an input of innovative ideas and linkages with other disciplines. Moreover they did well in explaining the ideas behind their projects. During the presentation of each project, the students shared ideas, asked questions and discussed extensively. From classroom observation, there was group cohesiveness, there was an increased team spirit. Most of the students felt responsible for the achievements of their friends. They helped motivate members of their group to engage in the cognitive learning process resulting in enhanced achievement in learning about the fighting fish way of life. This may be due in part to the teacher's competence in classroom management. However, in some groups there were still one or two students who did not help in the group work but they performed reasonably well in the mind map score.

The mind maps in that the students made after their discussion, sharing idea and tutoring among groupmates clearly indicated successful outcomes of the learning process. Most of the students were able to conceptualize the various aspects about the fighting fish life as expected. The results in this study are in accordance with several other research works that cooperative learning helped students develop academic achievement, motor skills, social skills, team work skills and responsibility (Ross, 1988; Watters & Ginns, 2000; Lord, 2001). The cooperative learning has been successfully conducted in many subjects areas, e.g., biology, mathematics and science (Marbach-Ad & Sokolove, 2000; Kramarski & Mevarech, 2003; Gillies, 2004).

The primary students enrolled in this learning unit came with a wide range of individual achievement scores. To the question whether all students benefited from this cooperative learning, the results showing that all the five groups of students had similar mean scores for the mind maps with a narrow range of standard deviation also suggested that almost all students, except for a few inattentive students, benefited from this learning unit despite their different grades. This is in accordance with most studies (Webb, 1992; see Slavin, 1996) that reported equal benefits for high, average and low achievers. However, there are a few studies that found better outcomes for high achievers and a few that found that low achievers gained the most (Webb, 1992; see Slavin, 1996). Nevertheless, King (1993) reported that low achievers were generally passive during group work.

Apart from the group goal and individual accountability as key success factors as suggested by Slavin (1996), this topic of fighting fish, which is relevant to the student's live, provided well structured interactions among students in a cooperative group. Although each group of students worked on only one of the five topics, they were able to gain knowledge from the other four groups through effective interactions. Results from interviewing and classroom observations suggested several academic and social benefits of the cooperative learning agreed with previous findings (Antil, Jenkins, Wayne & Vadasy, 1998; Gillies, 2004; Gillies, 2008). Although the students in this study were only at the primary level of grade-4, they improved their communication skills, especially the oral ones, as judged by the ability to convey correct and comprehensible messages to peers. They developed responsibility for learning as well as a sense of control on task as evidenced by both good quality of the group projects and of mind maps. Most important, low achievement students improved their performance and learning outcomes by interacting with higher achieving students during their cooperation. Also the students developed team spirit as well as interpersonal relationship. Because the teacher also an played important role as a facilitator and a guide in this cooperative learning, the student- teacher interaction was also promoted.

5.2 Effectiveness of a hands-on learning unit with an emphasis on guided inquiry

The enhancement of student learning outcomes in this study is an indicator of the effectiveness of the developed hands-on activity with an emphasis on inquiry. The students were able to understand two biology topics that they had merely memorized previously. Evidence for student conceptual understanding was the higher percentage gain in the posttest in the students who learned through the hands-on activity compared to the traditional group. This was corroborated by students' worksheet writing, posters and presentation as well as from their reflections. Groups of the students were engaged into genetics and biodiversity to undergo the inquiry process in a similar way that scientists do. This finding is comparable to those of Johnson and Stewart (1990) who used philosophy of science in the curriculum development on genetics. Students worked from effect (phenotype) to cause (genotype models) resulting in construction of their own concept. Nevertheless, recent study (Yilmaz, Tekkaya & Sungur, 2010) on student understanding of genetics has shown that the student developed their genetics concepts and retained them better by using prediction and discussion-based learning cycle.

In the hands-on activity the students were encouraged by teacher to observe the data pattern and to explain it. As a result the students were able to set their own criteria for classifying organisms, which were later employed in identification and classification of the fighting fish. Furthermore, the hands-on activity on Mendelian genetics helped the students develop their own understanding on Mendelian inheritance (phenotype, genotype and alleles). Therefore, they were able to predict the results of a variety of genetic crosses. They even learned how to theoretically breed the fighting fish for desirable characteristics. The achievement of the students from this discipline-specific inquiry unit is not surprising since the latter consisted of essential features of inquiry according to the National Science Education Standards (National Science Research Council, 1996).

Students were engaged with games activities that provided discipline-specific questions allowing them to develop explanation from evidence. The activities allowed the students to further develop their inquiry abilities and better understanding of science concepts. They could employ their knowledge in solving more complex questions such as crossing of genes carrying different traits or learning how to breed organisms with characteristics designed by them. Some would even want to apply their knowledge to real life situations in breeding and classification of different types of fighting fish in their local community. Students' abilities to prepare a well-designed informative poster and to give good presentations are indicators for good communication.

The inquiry-based hands-on activity developed in this study was in agreement with the model of Huber and Moore (2001) which described approach for extending limited hands-on activity into fully-inquiry science lessons. These are engaging students with discrepant events which are quite comparable to the games in our study. Other strategies involved teacher facilitation in the inquiry activities, student written documents, posters, class presentation and discussion.

The success of using hands-on activity to develop a deeper understanding of the students in genetics and biodiversity is in agreement with several other research findings (Krajcik, Mamlok-Naaman & Hug, 2001; Hofstein, Shore & Kipnis, 2004; Hofstein, Navon, Kipnis & Mamlok-Naaman, 2005). For example, Stewart, Cartier and Passmore (2005) used model-based learning to enhance students learning outcomes in genetics and evolution. Randler (2008) employed different methods in teaching and learning about species identification. Although different materials, e.g., plastic models, stuffed taxidermies, could be used, dichotomous keys fostered methodology skills of the students.

These students learned to explain the patterns in their data by using several models in a consistent fashion. In another research work, students were engaged with a structured experience before exposure to general principles and concepts by using Lego pieces as the manipulative materials in learning Mendelian genetics concepts (Grumbine, 2006). Both results were similar in that the students built their understanding of key Mendelian genetics concepts by the inductive method. Several studies have shown that inductive lesson plans are effective in enhancing understanding of concepts. For example, Haws and Bauer (2009) created a genetics game, Omoto (1998) employed a simple coin toss game to help student learn Mendelian genetics. Hands-on activities connecting Mendelian laws with the physical process of cell division has been shown to enhance student understanding (McKean & Gibson, 1989).

Although the students seemed to acquire knowledge through “doing” and “solving problems” in the hands-on activity, the knowledge gained was fragmented. Student in-group discussion helped to further connect pieces of knowledge together but this still was not enough. In the whole-class debriefing session, the student discussion along with scaffolding by the teacher helped students construct their conceptual understanding further. The teacher must play this important role of ensuring the effectiveness of the inquiry process for better achievement of the students. The success in this learning process is evidenced by posters that integrated all the acquired knowledge as well its clear presentation.

Apart from the well-designed hands-on activity, one reason of the success in student achievement was due to the cooperative learning among groups of students, as evidenced by classroom observation. This is also supported by student reflection and student interview: they felt that they learned a lot from their own and other groups, through sharing, discussing and even receiving explanations from friends. This is especially true for the low achievers who needed to interact with the higher achievement ones to better their performance. Obviously, the teacher also played a significance role in encouraging the cooperative activity. Several research studies have reported several academic and social benefits of cooperative learning (Monvises, Ruenwongsa, Panijpan & Sriwattanarothai, 2010). Lazarowitz and Karsenty (1990) found that students who learned biology in small cooperative groups scored higher in achievement and inquiry skills then did students who learned traditionally in a large group.

Analysis of student reflection and interview provided evidence and explanation to support both student conceptual understanding and student attitude. Positive attitudes result in better attention and more willingness to participate in the classroom activity, which can then lead to improvement of student outcomes even among the low achievers. This is in agreement with several reports that opportunities for more interaction among students and teacher promoted social interaction and healthy learning environment conducive to meaningful inquiry and collaborative learning (Tobin, 1990; DeCarlo & Rubba, 1994). The students voiced that they enjoyed participating in the activity because of the tasks that were interesting and challenging and the materials used were relevant to everyday life. The fighting fish arouses student’s interest, because it is easily found in all pet shops and even in their local community. The students came to realize that the previously perceived boring topics of genetics are relevant.

The students responded favorably to the learning unit. This is not only because the materials were relevant to every life but also the facilitation of the teacher made the classroom environment more conducive to a variety of experiments. This finding is similar to that of Strgar (2007) in that teachers' involvement and management are major factors in influencing student interest. The students' positive perception of the classroom environment is an important factor in promoting student learning (Fouts & Myers, 1992; Fraser, 1994).

5.3 Implication of the study

The results of this study although preliminary may benefit other educators for adapting and adopting this learning unit to meet their needs. However, for a better result there is still work to be done in order to identify the key success factors of the student achievement. It should serve also as a guideline for teachers in designing a proper hands-on activity with an emphasis on inquiry to help students build up their own knowledge. However, teachers should support students throughout the learning activity for example, in asking thoughtful questions, design investigation and draw conclusion from data (Marx et.al, 1998).

The teaching unit that contains three components: hands-on experiment, inquiry approach and cooperating activity, seems to be effective in promoting students' learning outcomes as shown in this study. Nevertheless, the most important issue to be concerned is that the teacher should be trained to be well equipped with both content and pedagogy.

The learning units presented in this study may help teacher design appropriate program that is more likely to lead to significant and sustained improvement in students' achievement. The learning unit on cooperative learning and hands-on experiment provided example of the activity that made students more actively engaged in the learning activities so that they are learning more purposefully and had few difficulties in what they are being taught. In addition, they could access and use materials and resources more effectively. The teacher or educator could use these learning units as a guideline to develop their own units that match the needs of both instructor and student.

5.4 Limitation of the study

5.4.1 A cooperative learning unit

The success from this cooperative learning unit was partly due to the tasks that were challenging and interesting. The students developed positive attitudes toward the learning process. However, there were drawbacks: the students had direct experience in one task only while learning indirectly from the other four groups. In this study students did not go through the formal process of jigsaw which was commonly used in cooperative learning. The students did not meet with the “expert group” to share information; however each group worked on a given topic and presented their findings to the class as a whole, a rather unstructured method. Better learning outcomes could be obtained by using the jigsaw method (Aronson, Blancy, Stephan, Sikes & Snapp, 1978; Colosi & Zales, 1998). Additionally the study did not seriously investigate student retention, so nevertheless the knowledge could help them in their family business in raising, breeding and culturing of the fighting fish.

5.4.2 A hands-on learning unit with emphasis on guided inquiry

Although this newly developed learning unit did enhance the students’ learning outcomes, it was carried out with only one group of students. The result should be confirmed by other groups of students in different school settings. Comments from students should be taken into account, especially, the time spent on the activity. Since the inquiry-based activities take more time than those based on a more didactic approach, students should be given more time to make the transition from passive learning to an active one. Teachers should also be persuaded that they can manage laboratory activities in ways that are consistent with contemporary professional standards (Hofstein & Lunetta, 2003).

5.5 Recommendation for further studies and development

The results from the two newly developed learning units although success in promoting learning outcomes, in both students and pre-service teacher, they still need confirmation with larger sample sizes of participants. These units should repeated with a more diverse larger population of both students and pre-service teachers in order to become generalisanable. Another point to be improved in such as inquiry-based learning in this study is about the time given to each session. Most of the students although enjoy collaborating activity, freedom to design their own experiment and share ideas and discuss in class, they complained about insufficient time and workload. Teacher or educator that would like to adapt or adopt these learning units should seriously take this point into consideration. Because more effective results could be gained upon appropriate balance of time and amount of work.

Furthermore, the topic to be used should be relevant to real-life context to engage and stimulate students.

Finally, the teachers should design the assessment that corroborate with the learning activity. Formative assessment to follow students' progress during the course of the inquiry-based learning should be considered as important as the final examination.

CHAPTER VI
CONCLUSION

Overview

This chapter summarizes the interpretation and discussion of research findings of the two newly developed learning processes by using fighting fish as a model in studying living process and genetics and biodiversity. Both the cooperative and inquiry-based learning have been shown to enhance students' learning outcomes. Both learning process have positive impact on students learning attitude.

A cooperative learning unit for primary students and a hands-on learning unit with an emphasis on guided-inquiry for secondary students

This study has indicated that a cooperative learning helped primary students gain similar level of knowledge in the learning unit on living process of fighting fish despite differences in their grades. With this learning process the students' outcomes gradually improved from the first week to the third week of the learning unit. Finally, they were able to conceptualize from what they learned making it into good mind maps. Apart from showing one's own accountability, the students also felt responsible for the achievement of their friends. Moreover, the students viewed the cooperative learning unit favorably, as evidenced by group engagement in the cognitive process and thus enhanced learning outcomes. These preliminary results, however, should be confirmed with other students and teachers. For better achievement, both teachers and students should be trained by explicit instruction for better group interaction.

Furthermore, this study shows that it is possible to implement a learning unit for rural students to involve them in hands-on and inquiry-based activities rather successfully. The teacher was also enabled by the research team to guide the students through the topics of genetics and biodiversity thought to be among the more difficult. One reason for student enthusiasm and deeper learning was the hands-on simulation of genetic crossing of Mendelian genotypes responsible for pigment characteristics (traits) of the fighting fish which the students were also familiar with. The use of Punnett square helped simplify things for the students (while sacrificing the truer probability derived from crossing a large population of fish). Having students decide for themselves which animals are more related than other by using their own criteria also made them learn more about principles of classification, albeit at a rather superficial level. Because the two topics were juxtaposed, some students could extend from Mendelian genetics through classification to biodiversity indicating knowledge transfer.

Workings in a team made most of them try harder at communicating and cooperating and to end up realizing the importance of teamwork. The most encouraging outcomes were that a few students wanted to pursue their own experiments with the fighting fish available to them locally. However, we wish to point out that for city-based students with their pre-occupation with electronic entertainment devices, the fighting fish may not be an appropriate learning material. As shown above, teachers convinced by the effectiveness of hands-on and guided-inquiry will surely be able to come up with challenges appropriate for their students.

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APPENDICES

APPENDIX A
COOPERATIVE LEARNING UNIT

Posters about fighting fish in the learning center

ประวัติความเป็นมาของการเลี้ยงปลากัดไทย

จากหลักฐานที่บันทึกไว้เป็นลายลักษณ์อักษรโดยชาวต่างชาติที่เข้ามาค้าขายในสมัยโบราณ ทำให้ทราบได้ว่าคนไทยนิยมเลี้ยงปลากัดมาตั้งแต่สมัยอยุธยาตอนปลาย เพื่อไว้ดูเล่นและนำมากัดกันในหมู่เพื่อนฝูงในช่วงที่เสร็จสิ้นงานจากฤดูเพาะปลูก ต่อมากลายเป็นกีฬาการกัดปลาซึ่งเป็นที่นิยมกันไม่แพ้การตีไก่ชนและชนวัว จนกระทั่งขยายวงกว้างออกไปยังชาวต่างชาติ

ปลากัดสายพันธุ์ดั้งเดิมมีลักษณะรูปร่างแตกต่างจากปลากัดในปัจจุบันและดูไม่น่าจะมีคุณค่า ราคาอะไรนัก แต่ด้วยความสวยงามและความเป็นนักสู้นี่เองจึงทำให้คนไทยหลายคนทุ่มเทเวลาในการพัฒนาสายพันธุ์เพื่อให้มีความสวยงามและมีความสามารถในชั้นเชิงการต่อสู้มากขึ้น หากย้อนไปศึกษาเรื่องราวประวัติความเป็นมาของปลากัดไทยพบว่ามีทั้งข้อมูลที่เขียนไว้โดยคนไทยและชาวต่างชาติซึ่งหาอ่านได้จากหนังสือและเว็บไซต์ต่างๆ อาทิเช่น "THE FRESH WATER FISHES OF SIAM, OR THAILAND" โดย Dr. Hugh McCormick Smith นิตยสาร Betta News และ นิตยสารปลากัดนักสู้ ส่วนเว็บไซต์ที่เขียนเกี่ยวกับเรื่องราวความเป็นมาของปลากัดไทย คือ เว็บไซต์ http://www.bettatalk.com/betta_history.htm และ http://www.plakatthai.com เป็นต้น

จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล

การพัฒนาสายพันธุ์ปลากัดไทย

ปลากัดทุ่งภาคกลาง
ต้นกำเนิดของสายพันธุ์ปลากัดสวยงามในปัจจุบัน

ในช่วงแรกการพัฒนาสายพันธุ์ปลากัดไทยเริ่มจากการนำปลากัดป่าภาคกลาง *Betta splendens* Regan, 1910 จากธรรมชาติที่มีลักษณะดีมาผสมพันธุ์กันจนได้ลูกผสมที่มีสีสันแปลกใหม่และมีรูปแบบของสีที่สมบูรณ์มากขึ้น และต่อมาความสนใจในการพัฒนาลักษณะรูปทรงลำตัวและครีบก็มีมากขึ้นด้วย จนทำให้นักเพาะเลี้ยงปลากัดที่สหรัฐอเมริกาได้ผสมพันธุ์ปลากัดจนได้สายพันธุ์ "**ลิบบี**" ซึ่งมีลักษณะครีบหางที่ใหญ่และกว้างกว่าลำตัว และยังสามารถสร้างสายพันธุ์ปลากัดหางสามเหลี่ยมที่เรียกว่า "**เดลตา**" (delta) และ "**ซุปเปอร์เดลตา**" (superdelta)

ต่อมานักเพาะพันธุ์ปลากัดในทวีปยุโรปได้เพาะพันธุ์ปลากัดที่มีลักษณะของหางรูปครึ่งวงกลม ที่เรียกว่า "**ฮาร์ฟมูน**" (halfmoon) ได้สำเร็จและนิยมเลี้ยงกันทั่วโลก จนกระทั่งล่าสุดนักเพาะเลี้ยงปลากัดชาวสิงค์โปร์ได้พัฒนาปลากัดหางจัก เรียกว่า "**ปลากัดหางมงกุฎหนาม**" หรือ "**คราวน์เทล**" (crown tail) และได้รับความนิยมเป็นอย่างมาก ปัจจุบันนอกจากการพัฒนาในเรื่องของครีบที่สวยงามแล้วยังพัฒนารูปแบบของหางจากปลากัดหางเดี่ยวไปเป็น**ปลากัดหางสองแฉก** (double tail)

ปลากัดฮาร์ฟมูน

ปลากัดหางมงกุฎ

ปลากัดหางสามเหลี่ยม

ปลากัดครีบสั้นหางสองแฉก

ฟาร์มเพาะขยายพันธุ์ปลากัด

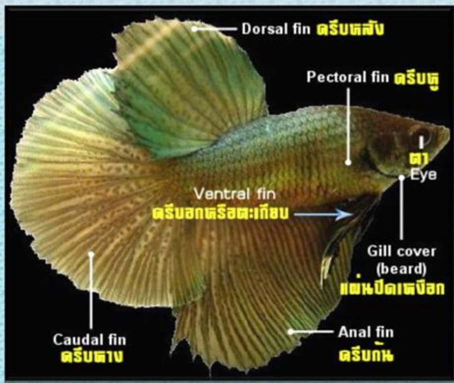
จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล

ชีววิทยาของปลากัด

ลักษณะทั่วไปของปลากัดไทย

ปลากัดป่า *Betta splendens* Regan,1910 ที่พบในธรรมชาติมีขนาดเล็ก ลำตัวยาว แบนข้าง หัวเล็ก ปากเล็กและเชิดขึ้นด้านบนเล็กน้อย มีครีบต่างๆสั้น มีอวัยวะพิเศษช่วยในการหายใจ ในปลาวัยอ่อนจะพบอวัยวะนี้เมื่อมีอายุ 10 วัน และเมื่อปลาโตเต็มวัยอวัยวะนี้จะเจริญเติบโตและมีการพัฒนาให้มีความซับซ้อนมากขึ้น ทำหน้าที่คล้ายกับปอดและเหงือกช่วยในการหายใจของปลาอีกทางหนึ่ง ปลาในกลุ่มนี้สามารถฮุบเอาอากาศที่อยู่เหนือผิวน้ำมาใช้ได้โดยตรงไม่ต้องผ่านเหงือก


ปลากัดทุ่งภาคกลางเพศผู้




การเกี้ยวพาราสี
และผสมพันธุ์


ปลากัดทุ่งภาคกลางเพศเมีย


เพศผู้สร้างหวอด


ลูกปลากัด

ลักษณะนิสัยของปลากัดไทย

พฤติกรรมความก้าวร้าวและหวงแหนอาณาเขต (territoriality) ปลากัดไทยมักมีนิสัยก้าวร้าวโดยเฉพาะปลากัดเพศผู้จะชอบต่อสู้กันเอง เพื่อปกป้องอาณาเขตที่อาศัยอยู่ และอาจทำร้ายปลาเพศเมียในช่วงฤดูผสมพันธุ์ พฤติกรรมความก้าวร้าวของปลากัดเพศผู้จะเริ่มพบในช่วงที่มีอายุประมาณ 1 เดือนครึ่ง ถึง 2 เดือน

พฤติกรรมในการผสมพันธุ์และเกี้ยวพาราสี ปลาเพศผู้จะเป็นผู้สร้างรัง ดูแลไข่และตัวอ่อน รังจะเป็นหวอดที่ก่อขึ้นจากฟองอากาศที่ฮุบเข้าไปผสมกับเมือกในปาก แล้วนำมาพ่นเป็นหวอดบริเวณผิวน้ำ สำหรับไข่และตัวอ่อนเกาะติด หลังจากเกี้ยวพาราสีตัวเมียจนเป็นที่ยินยอมพร้อมใจ ตัวผู้จะทำการรัดโดยตัวเมียจะปล่อยไข่และตัวผู้จะปล่อยน้ำเชื้อออกมาผสมกันภายนอก ไข่จะถูกปล่อยออกมาเป็นชุดๆ และจมลงสู่พื้นอย่างช้าๆ ตัวผู้จะใช้ปากฮุบฟองไข่แล้วนำไปพ่นไว้ที่หวอดจนกว่าไข่จะหมด หลังจากนั้นตัวผู้จะทำหน้าที่เฝ้าระวังไข่จนกระทั่งลูกปลาฟักออกเป็นตัว


พฤติกรรมก้าวร้าวของปลากัดเพศผู้

จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล

อนุกรมวิธานของปลากัด

หลายคนอาจจะสงสัยว่าอนุกรมวิธานนั้นหมายถึงอะไร? แล้วเกี่ยวข้องกับปลากัดได้อย่างไร? จริงๆแล้วอนุกรมวิธานก็หมายถึงวิชาทางชีววิทยาแขนงหนึ่งที่เกี่ยวข้องกับการจัดกลุ่มของสิ่งมีชีวิต (classification)ที่มีอยู่บนพื้นโลกให้เป็นหมวดหมู่อย่างมีระบบและหลักเกณฑ์ นอกจากนี้ยังรวมถึงการตั้งชื่อวิทยาศาสตร์ของสิ่งมีชีวิตที่พบให้ถูกต้องตามหลักเกณฑ์(nomenclature) และตรวจสอบชื่อวิทยาศาสตร์ของสิ่งมีชีวิตชนิดนั้นๆ(identification) ด้วย

ปลากัดจัดอยู่ในกลุ่มของปลาน้ำจืดที่เรียกว่า เอนาแบนทอยด์ (Anabantoids) พบแพร่กระจายอยู่ทั่วไปในภูมิภาคเอเชียตะวันออกเฉียงใต้ ปลากัดมีชื่อเป็นที่รู้จักกันทั่วไปว่า fighting fishes การวิจัยเกี่ยวกับวิวัฒนาการระดับโมเลกุลทำให้ปัจจุบันปลากัดถูกจัดอยู่ในครอบครัวออสโพรนีมิดี (family osphronemidae) ซึ่งมีสมาชิกคือ ปลากริม ปลากระดี่ และปลาแรด (ซึ่งเดิมปลากัดถูกจัดไว้ในครอบครัวเอนาแบนทิดี) ครอบครัวย่อยมาโครโพดินี (subfamily macropodinae) สกุลเบททา (genus Betta)

ปลากัดไทย (The Siamese Fighting Fish) มีชื่อชนิดว่า สเปลนเดนส์ (specie splendens) และผู้ที่จำแนกชนิดและตั้งชื่อ คือ นายชาร์ล เทท เรแกน (Charles Tate Regan) นักมีนวิทยาชาวอังกฤษ เมื่อปี ค.ศ.1910 ดังนั้นชื่อวิทยาศาสตร์ของปลากัดไทยก็คือ *Betta splendens* Regan,1910

ปลากริมเป็นปลาที่มักพบในแหล่งน้ำที่ปลากัดอาศัยอยู่

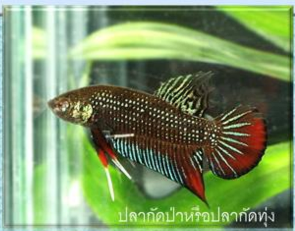
ปลากัดทุ่งภาคกลาง *Betta splendens*

ปลากระดี่เป็นปลาที่มักพบในแหล่งน้ำที่ปลากัดอาศัยอยู่

5

จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล

การแบ่งกลุ่มของปลากัดไทย



ปลากัดป่าหรือปลากัดทุ่ง

โดยทั่วไปแล้วนักเลงปลากัดมักแบ่งปลากัดออกเป็น 4 กลุ่มหลักๆได้แก่

1. **ปลากัดทุ่งหรือปลากัดป่า** ซึ่งพบอยู่ตามธรรมชาติอาทิเช่น ทุ่งนา หนองน้ำ บึง มีความสามารถในชั้นเชิงการต่อสู้แตกต่างออกไปในแต่ละถิ่น ความพิเศษของปลากัดป่าอยู่ที่ความเป็นนักสู้โดยธรรมชาติ และที่พิเศษยิ่งกว่านั้นคือการที่ปลาตัวผู้สามารถเปลี่ยนสีให้งดงามเมื่อถูกกระตุ้น ในสภาวะตื่นตัวครีบทุกครีบจะแผ่กางออกเต็มที่ แผ่นเยื่อหุ้มเหงือกขยายพองตัวออก พร้อมกับสีน้ำเงินหรือแดงที่ปรากฏขึ้นมาชัดเจน ทำให้ดูสง่า อาจหาญ และสวยงาม

ปลากัดลูกหม้อ หรือปลากัดหม้อ

2. **ปลากัดลูกหม้อ** เป็นปลากัดที่ได้จากผู้เลี้ยงในสมัยก่อนคัดพันธุ์ปลากัดทุ่งหรือปลากัดป่าจากแหล่งต่างๆมาผสมพันธุ์กันเพื่อให้ได้ลูกปลากัดที่มีลักษณะดี แข็งแรง กัดทน และดุ ลูกปลาที่ได้จะนำไปเลี้ยงในหม้อดิน ดังนั้นคำว่า **"ลูกหม้อ"** หรือ **"ปลากัดลูกหม้อ"** นั้นจึงได้ชื่อมาจากการใช้หม้อดินในการเพาะและอนุบาลปลากัด นั่นเอง ปลากัดลูกหม้อจะมีรูปร่างหนาและใหญ่กว่าปลากัดชนิดอื่น สีสันสวยงามดูแล้วน่าเกรงขาม สีส่วนมากจะเป็นสีน้ำเงิน แดง เทา เขียว คราม หรือแดงปนน้ำเงิน

ปลากัดลูกสังกะสี

3. **ปลากัดสังกะสี** เป็นปลากัดลูกผสมระหว่างปลากัดหม้อเพศผู้กับปลากัดทุ่งเพศเมีย ปลากัดสังกะสีจะกัดทนไม่เท่ากับปลากัดหม้อแต่จะทนกว่าปลากัดทุ่ง นอกจากนี้ยังมีผู้คิดเอาปลากัดสังกะสีเพศผู้ผสมกับปลากัดทุ่งเพศเมียออกมาเป็นปลากัดที่เรียกว่า **ซ้ำสาม** หมายถึงปลาที่มีลูกผสมระหว่างปลาลูกทุ่ง ลูกหม้อ และสังกะสี

4. **ปลากัดครีบยาวหรือปลากัดจีน** หลายคนเข้าใจผิดว่าปลากัดจีนเป็นปลากัดอีกสายพันธุ์หนึ่ง ซึ่งมาจากประเทศจีน ซึ่งโดยแท้จริงแล้วปลาชนิดนี้ก็เป็นปลากัดไทยที่มีพื้นเพมาจากปลากัดป่าซึ่งเกิดจากการผสมคัดพันธุ์เพื่อให้ได้ปลาลูกหม้อที่กัดเก่งมีลักษณะที่ดีสวยงาม แต่เผอิญได้ปลาชนิดใหม่ที่ครีบและหางยาวออกมามากกว่าปกติ หลังจากนั้นก็มีการปรับปรุงพันธุ์ให้ได้ครีบ และหางที่แผ่กว้างขึ้น มีลักษณะสวยงามขึ้น มีสีสันใหม่ ๆ โดยมีวัตถุประสงค์หลักที่จะเลี้ยงเป็นปลาสวยงาม โดยเฉพาะลักษณะครีบที่ยาว รุ่มร่ามและสีสันฉูดฉาดนี้เองจึงมองดูเหมือนตัวอุปรากรจีน หรือ งิ้ว ซึ่งใส่ชุดที่มีสีสันฉูดฉาด ปลายแขนและขอบชุดยาวทำให้เวลาร่ายรำมองดูพลิ้วไปมา จึงเรียกปลากัดพวกนี้ว่า **ปลากัดจีน**

ปลากัดครีบยาวหรือปลากัดจีน

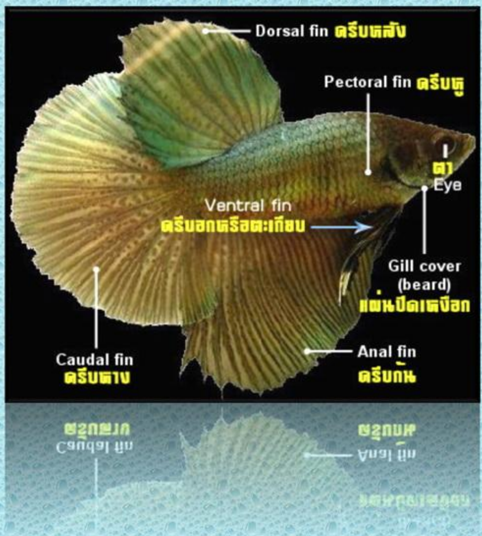
ปลากัดครีบยาวหรือปลากัดจีน

ปลากัดครีบยาวหรือปลากัดจีน

รูปแบบและมาตรฐานของปลากัดไทย

ความสวยงามของปลากัดในสายตาของแต่ละคนอาจจะไม่เหมือนกัน ทั้งนี้ขึ้นอยู่กับความชอบที่แตกต่างกันไป แต่ถึงอย่างไรก็ตามการกำหนดรูปแบบและมาตรฐานของปลากัดเพื่อใช้สำหรับเป็นเกณฑ์เพื่อพิจารณาความสวยงามนับว่าเป็นสิ่งสำคัญ เพราะหากมีการจัดประกวดหรือแข่งขันเกณฑ์เหล่านี้จึงมีความจำเป็นเพื่อนำมาใช้ในการตัดสิน


ปลากัดครีบสั้นสีขาว



มาตรฐานทั่วไปของปลากัด

ลักษณะของปลากัดจะดู 3 ส่วนใหญ่ ๆ คือ สี รูปทรง (ครีบและลำตัว) และกริยาอาการของปลา ปลาที่สมบูรณ์มีลักษณะที่ดีต้องมีอาการกระฉับกระเฉง สีสันสวยงาม มีความสมดุลระหว่างขนาดและลักษณะของครีบและลำตัว ลำตัวควรมีรูปร่างคล้ายกระสวยมีส่วนกว้างของลำตัวอยู่บริเวณครีบท้องแล้วลาดอย่างสวยงามไปทางด้านหัวและด้านหาง โดยต้องสมส่วนกับโครงสร้างของครีบ

ครีบทุกครีบต้องมีลักษณะสวยงาม ปลากัดมีครีบเดี่ยวสามครีบ คือ **ครีบหาง ครีบหลัง และครีบก้น** และมีครีบคู่สองคู่คือ **ครีบท้อง(ทวนหรือตะเกียบ) และครีบอก(ครีบหู)** ซึ่งอยู่ติดบริเวณแผ่นปิดเหงือก

มาตรฐานลักษณะสีของปลากัด

สีของปลากัดที่เป็นมาตรฐาน จะมีรูปแบบพื้นฐาน 5 รูปแบบ คือ สีเดี่ยว สองสี ลายผีเสื้อ ลายหินอ่อน และหลากสี

1. **ปลากัดสีเดี่ยว** (single color)

ปลากัดสีเดี่ยว เป็นปลากัดที่มีสีเดียวทั้งลำตัว และครีบ และเป็นสีโทนเดียวกันทั้งหมด ปลากัดสีเดี่ยวแบ่งออกเป็น 2 กลุ่มใหญ่ ๆ คือ ปลากัดสีเดี่ยวสีเข้ม และปลากัดสีเดี่ยวสีอ่อน


ปลากัดสีเดี่ยว(สีเข้ม)


ปลากัดสีเดี่ยว(สีอ่อน)

2. **ปลากัดสองสี** (bicolor)

ลักษณะที่สำคัญของปลากัดสองสี คือลำตัวจะต้องมีสีเดียว และครีบทั้งหมดจะต้องมีสีเดียวเช่นกัน แต่สีของครีบจะต้องต่างกับสีของลำตัว ปลากัดสองสีอาจแบ่งออกได้เป็น 2 กลุ่มใหญ่ ๆ คือ ปลากัดสองสีชนิดลำตัวสีเข้ม และปลากัดสองสีชนิดลำตัวสีอ่อน

ปลากัดครีบสั้นหางคู่สองสี

ปลากัดครีบยาวหางคู่สองสี

ปลากัดลายผีเสื้อ

ปลากัดลายผีเสื้อ

3 **ปลากัดลายผีเสื้อ** (butterfly color)

ปลากัดลายผีเสื้อจัดเป็นปลากัดที่มีสีเป็นลวดลายรูปแบบเฉพาะที่บริเวณครีบ โดยครีบจะมีสีเป็นแถบ ๆ ขนานกับเส้นวงขอบลำตัว(ดังรูป) ปลากัดลายผีเสื้อสามารถแบ่งออกได้เป็น 2 กลุ่มใหญ่ ๆ คือ ลายผีเสื้อครีบ 2 แถบสี และ ลายผีเสื้อครีบหลายแถบสี

4. **ปลากัดลายหินอ่อน** (marble color)

ปลากัดลายหินอ่อนเป็นปลากัดที่มีสีเป็นลวดลายรูปแบบเฉพาะ บริเวณครีบไม่มีแถบสี ลำตัวจะมีสีอื่นแต้มเป็นจุดหรือลายกระจัดกระจายอยู่ทั่วไป มองดูคล้ายลวดลายหินอ่อน ปลากัดลายหินอ่อนแบ่งออกเป็นชนิดหลัก ๆ 2 ชนิด คือ ปลากัดลายหินอ่อนธรรมดาซึ่งไม่มีสีแดง เขียว น้ำเงินและเทาปน และปลากัดลายหินอ่อนซึ่งมีสีแดง เขียว น้ำเงิน และเทาปนอยู่

ปลากัดครีบยาวสองหางลายหินอ่อน

ปลากัดครีบสั้นลายหินอ่อน

5. **ปลากัดหลายสี** (multicolor)

เป็นกลุ่มของปลากัดที่มีสีตั้งแต่ 2 สี ขึ้นไปที่ไม่จัดอยู่ในประเภทลวดลายที่มีรูปแบบเฉพาะ เช่น ลายผีเสื้อ หรือลายหินอ่อน ลักษณะที่ดีคือลวดลายต้องเด่นและสีแต่ละสีต้องตัดกันอย่างชัดเจน

ปลากัดครีบยาวสองหางหลายสี

ปลากัดครีบสั้นสองหางหลายสี

ปลากัดหางมงกุฎหลายสี

8

จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล

การเพาะเลี้ยงและขยายพันธุ์ปลากัดไทย

ปลากัดที่นิยมเลี้ยงกันอย่างแพร่หลายในปัจจุบันเป็นปลากัดที่พัฒนามาจาก **ปลากัดทุ่งภาคกลาง** แต่เดิมที่พบในธรรมชาติจะมีสีน้ำตาลขุ่นหรือสีเทาแกมเขียว ครีบต่างๆสั้น ปลาตัวผู้จะมีครีบยาวกว่าตัวเมีย จากอดีตจนถึงปัจจุบันได้มีการพัฒนาสายพันธุ์ปลากัดจนได้สีที่สวยงาม ครีบที่ยาวและแผ่กว้างกว่าสายพันธุ์ดั้งเดิม

<u>การเลี้ยงและดูแลปลากัด</u>

ปลากัดเป็นปลาที่มีนิสัยก้าวร้าว และชอบต่อสู้กันเมื่ออายุประมาณ 1 เดือนครึ่งถึงสองเดือน ดังนั้นจึงจำเป็นต้องแยกปลากัดไปเลี้ยงในภาชนะที่เตรียมไว้ภาชนะละ 1 ตัว ภาชนะที่เหมาะที่สุดสำหรับการเลี้ยงปลากัดได้แก่ ขวด (สุรา) ชนิดบรรจุน้ำได้ 150 ซีซี เพราะสามารถเรียงกันได้โดยไม่สิ้นเปลืองเนื้อที่ ส่วนการแยกเพศ จะสังเกตได้จากปลาตัวผู้จะมีลำตัวสีเข้ม ครีบยาวลายบนลำตัวมองเห็นชัดเจนและขนาดมักจะโตกว่าตัวเมีย ส่วนปลาตัวเมียจะมีสีซีดจาง มีลายพาดตามขวางลำตัว 2-3แถบและมักจะมีขนาดเล็กกว่าปลาตัวผู้

น้ำที่ใช้เลี้ยงปลากัดต้องสะอาดปราศจากคลอรีน มีความเป็นกรด-ด่าง(pH) ประมาณ 6.5-7.5 มีความ กระด้าง 75-100 มิลลิกรัมต่อลิตร และมีความเป็นด่าง(alkalinity) 150-200 มิลลิกรัมต่อลิตร ควรบรรจุน้ำลงในขวดที่ใช้เลี้ยงเพียงเศษ 3 ส่วน 4 ของขวด เพื่อให้เหลือช่องว่างของอากาศเหนือผิวน้ำให้ปลาได้หายใจหรือฮุบอากาศ

สถานที่เลี้ยงปลากัดไม่ควรที่จะเป็นที่ที่โดนแสงแดดโดยตรง เพราะจะทำให้ปลาตายได้เนื่องจากความร้อนที่มากเกินไป อุณหภูมิที่เหมาะสมควรอยู่ในช่วง 25-28 องศาเซลเซียส

<u>การคัดเลือกปลากัดเพื่อเป็นพ่อแม่พันธุ์</u>

ปลากัดที่จะใช้นำมาผสมพันธุ์ต้องแข็งแรงและสมบูรณ์เพศเต็มที่ ปลาที่เหมาะสมนำมาผสมพันธุ์ต้องมีอายุประมาณ 5-7 เดือน เนื่องจากแม่พันธุ์จะให้ไข่ถึง 500-1,000 ฟอง และลูกปลาที่ฟักออกมาจะมีความแข็งแรงกว่าลูกปลาที่ได้จากแม่พันธุ์ที่มีอายุน้อย

ปลาตัวผู้ต้องมีความแข็งแรง มีลักษณะสีสันตามต้องการ และต้องเป็นปลาที่ชอบสร้างหวอด ซึ่งมีลักษณะเป็นฟองอากาศจับกลุ่มลอยอยู่บริเวณผิวน้ำ หวอดเกิดจากปลาตัวผู้พ่นฟองอากาศที่ประกอบด้วยเมือกจากปากและลำคอห่อหุ้มอากาศเอาไว้

ปลาตัวเมียต้องมีความแข็งแรง และมีลักษณะสีสันตามต้องการเช่นกัน ปลาตัวเมียที่พร้อมผสมพันธุ์ต้องมีท้องที่เป่งใต้ท้องมีตุ่มสีขาวที่เรียกว่า **ไข่นำ** มองเห็นได้ชัดเจน และจะมีลายพาดตามขวางของลำตัว 2-3 แถบ เรียกว่า **ลายชะโด**

9

จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล

การเพาะเลี้ยงและขยายพันธุ์ปลากัดไทย

การเทียบคู่ปลากัด

การเทียบคู่ปลากัด

เมื่อคัดเลือกพ่อแม่พันธุ์ปลากัดที่จะนำมาผสมพันธุ์ได้แล้ว ให้นำมาใส่ขวดขวดละตัว แล้วนำขวดมาตั้งคู่กันโดยไม่ต้องมีอะไรกั้น ขั้นตอนนี้เรียกว่า **การเทียบคู่** การเทียบคู่นี้เพื่อต้องการให้ปลามองเห็นกันตลอดเวลา และเร่งให้ไข่พัฒนาได้เร็วขึ้น บริเวณที่เทียบคู่ควรเลือกสถานที่ที่ไม่มีสิ่งรบกวน เพราะจะทำให้ปลาตกใจ ใช้เวลาเทียบคู่ประมาณ 3-10 วัน ในระหว่างเทียบปลาควรเตรียมภาชนะที่จะใช้เพาะฟักซึ่งเราเรียกว่า **อ่างรัด** หรือ **อ่างเพาะ** เช่น ขวดโหล ตู้กระจก อ่างซีเมนต์ ขนาดพื้นที่ไม่กว้างมาก (ไม่ควรเกิน 1 ตารางเมตร) ปากอ่างควรมีฝาปิดเพื่อป้องกันปลากระโดด

เติมน้ำที่มีคุณภาพเดียวกับที่ใช้เลี้ยงพ่อแม่พันธุ์ ระดับน้ำสูงไม่เกิน5-7 เซนติเมตร ระดับน้ำมีผลคือ เมื่อแม่ปลากัดปล่อยไข่ พ่อปลาจะได้ใช้เวลาไม่นานในการว่ายเก็บไข่มาใส่หวอดหรือเมื่อลูกปลาฟักออกจากไข่ลูกปลาจะจมลงก้นอ่าง ถ้าน้ำลึกเกินไปลูกปลาจะไม่สามารถว่ายขึ้นมาหายใจได้ ใช้พันธุ์ไม้น้ำที่สามารถหาได้ง่ายเช่น สาหร่ายน้ำจืด จอก ใบผักตบชวา หรือพันธุ์ไม้น้ำอื่นๆ ที่หาได้ง่ายมาเพื่อใช้เป็นที่เกาะของหวอด

ปลาตัวผู้กำลังเก็บไข่ใส่หวอด

การผสมพันธุ์และวางไข่ของปลากัด

เมื่อปลาตัวผู้และตัวเมียได้เทียบคู่กันแล้ว ขั้นต่อไปจึงนำปลาทั้งคู่มาใส่ลงในอ่างเพาะที่เตรียมไว้ โดยจะต้องมีฝาปิดด้านบนเพื่อป้องกันปลากระโดด อ่างที่ใช้ควรมีสีเข้มพื่อปลาตัวผู้จะได้มองไข่ได้ชัดเจน เมื่อปลาสามารถปรับตัวเข้ากับสภาพแวดล้อมใหม่(ใช้เวลาประมาณ 1-2 วัน) ในอ่างเพาะได้แล้ว ปลาตัวผู้จะเริ่มก่อหวอดติดกับพันธุ์ไม้น้ำ หลังจากก่อหวอดเสร็จจะเริ่มพองเหงือกและ กางครีบไล่ต้อนตัวเมียให้ไปอยู่ใต้หวอด เมื่อปลาตัวเมียลอยตัวขึ้นบริเวณผิวน้ำ ปลาตัวผู้จะงอตัวเป็นรูปตัวยู หรือตัวเอส รัดปลาตัวเมียตรงบริเวณช่องอวัยวะเพศ ถ้าปลาตัวเมียมีไข่แก่เต็มที่ไข่ก็จะหลุดออกมาทางช่องอวัยวะเพศ ทันทีที่ปลาตัวเมียปล่อยไข่ ปลาตัวผู้ก็จะฉีดน้ำเชื้อเข้าผสมทันที ไข่ที่ปล่อยออกมาจะค่อยๆจมลงสู่ก้นอ่างเพาะ ปลาตัวผู้ก็จะตามลงไปใช้ปากอมไข่ที่ละฟองมาพ่นใส่ไว้ที่หวอดจนหมด ส่วนตัวเมียอาจช่วยตัวผู้เก็บไข่ที่ได้รับการผสมแล้วไปพ่นที่หวอดบ้างเป็นบางครั้งในช่วงต้นๆของการผสมพันธุ์ เมื่อปลาตัวเมียเมื่อวางไข่แล้วจะลอยตัวนิ่งๆสักพักหนึ่งแล้วเริ่มว่ายหงายท้องเพื่อให้ตัวผู้รัดอีกครั้ง พฤติกรรมดังกล่าวจะเกิดขึ้นหลายๆครั้งจนกว่าตัวเมียจะวางไข่หมด ตัวเมียจะใช้เวลาในการวางไข่ทั้งหมดประมาณ 1-6 ชั่วโมง ทั้งนี้ขึ้นอยู่กับขนาดและความสมบูรณ์ของตัวเมีย เมื่อสิ้นสุดการวางไข่ตัวผู้จะทำหน้าที่ดูแลไข่เพียงตัวเดียว และจะไล่ต้อนตัวเมียไม่ให้เข้าใกล้หวอด ช้อนตัวเมียออกจากอ่างเพาะ เพราะตัวเมียอาจกินไข่ที่ผสมแล้ว ปล่อยให้ตัวผู้ดูแลไข่ประมาณ 2 วัน แล้วจึงแยกออกจากอ่างเพาะ ช่วงที่ตัวผู้ดูแลไข่มันจะไม่ยอมกินอาหาร อาจเนื่องมาจากกลัวจะเข้าใจผิดคิดว่าไข่เป็นอาหาร ไข่จะเริ่มฟักออกเป็นตัวหลังจากได้รับการผสมจากน้ำเชื้อประมาณ 36 ชั่วโมง

การผสมพันธุ์ของปลากัด

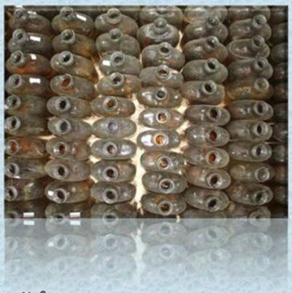
จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล


การเพาะเลี้ยงและขยายพันธุ์ปลากัดไทย
การอนุบาลลูกปลากัด
ลูกปลาที่ฟักออกจากไข่ใหม่ๆจะเกาะอยู่ที่หวอด และมีถุงอาหารติดอยู่ที่ตัว ลูกปลาจะใช้อาหารจากถุงอาหารหมดภายใน 3-4 วัน ดังนั้นในช่วงนี้จึงไม่จำเป็นต้องให้อาหาร
เมื่อลูกปลาเริ่มกินอาหารควรให้ไข่แดงต้มสุกบดละเอียดกรองผ่านกระชอนตาถี่ๆ หยดกระจายในน้ำที่เลี้ยงลูกปลาวันละ 1 ครั้ง เป็นเวลา 3-5 วัน แล้วจึงเปลี่ยนไปใช้ไรแดงที่มีขนาดเล็กเลี้ยง เมื่อลูกปลาเริ่มโตจึงเปลี่ยนไปเลี้ยงด้วยไรแดงขนาดใหญ่จนกระทั่งลูกปลาสามารถกินลูกน้ำได้ จึงควรเลี้ยงด้วยลูกน้ำต่อไป
เมื่อปลากัดอายุได้ประมาณ 1 เดือนครึ่งถึง 2 เดือน จะสามารถแยกเพศได้ ควรแยกปลากัดตัวผู้และตัวเมียออกจากกัน โดยเฉพาะปลากัดตัวผู้จะต้องแยกจากกันเนื่องจากพวกมันจะเริ่มกัดกันเองเพื่อแสดงลำดับขั้นความสำคัญในกลุ่ม แต่ไม่ถึงขั้นที่กัดกันจนตาย พฤติกรรมนี้อาจเป็นสาเหตุทำให้ปลาได้รับบาดเจ็บและเกิดเป็นโรคได้ แต่จากการสังเกตพบว่า ถ้านำตัวผู้ครอกเดียวกันที่แยกจากกันไปแล้วมาใส่รวมกันอีก มันจะกัดกันจนอาจถึงตายได้
เมื่อลูกปลามีอายุ 4 เดือน นับว่าปลากัดโตเต็มที่แล้ว พร้อมที่จะจำหน่ายและผสมพันธุ์ ในช่วงนี้อาหารที่ให้คงเป็นลูกน้ำ หรือเป็นอาหารที่มีชีวิตอื่นๆ เช่น ปลวก ไส้เดือน ลูกกุ้ง เป็นต้น
หวอด
ลูกปลากัด
ลูกปลาวัยอ่อน
ลูกปลาวัยอ่อน
การคัดลูกปลาเพื่อแยกเลี้ยง
ไรแดง
ลูกน้ำ
ปลากัดที่แยกเลี้ยงในขวด
จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล

การหมักปลากัด

การหมักปลาคืออะไร

เรามักได้ยินอยู่บ่อยๆว่าผู้เลี้ยงปลากัดมักมีการหมักปลาในบางช่วงที่มีการเลี้ยงปลากัด ซึ่งการหมักปลานั้นหมายถึง วิธีการรักษาปลาและบำรุงปลาด้วยวิธีการทางธรรมชาติโดยใช้สมุนไพร หลังจากการหมักปลากัดจะมีสีและเกล็ดเรียบเป็นมันเงา



จุดประสงค์ของการหมักปลา คือ

1. การหมักปลาเพื่อให้ปลากัดเก่ง สู้เก่ง
2. การหมักเพื่อรักษาแผลจากการต่อสู้
3. การหมักเพื่อรักษาแผลที่ไม่สบายหรือมีอาการตกใจ

วิธีการหมักปลา

1. ใช้ใบตองแห้งหรือใบหูกวางแห้งจำนวน 1 ใบ
2. ใช้ใบตะไคร้ประมาณ 4-5 ใบ
3. ดินเหนียวปั่นตากแห้งพอประมาณ
4. นำส่วนผสมในข้อ 1-3 มาใส่ลงในน้ำที่เตรียมไว้ เพื่อให้ได้น้ำหมักใบหูกวาง
5. นำน้ำที่ได้จากการหมักมาเลี้ยงปลากัดประมาณ 10 -15 วัน ให้กินอาหารทุกวัน หรือ 2 วันให้กิน 1 ครั้ง
6. ถ้าเป็นการหมักเพื่อการแข่งขัน ผู้เลี้ยงจะนำปลามาเลี้ยงต่อในน้ำปกติประมาณ 10 วัน แต่ละวันจะนำปลาตัวเมียมาปล่อยลงไปเพื่อให้ตัวผู้ไล่ประมาณ 3-4 นาที จากนั้นให้ลูกน้ำกินเป็นอาหาร

***หมายเหตุ....ในธรรมชาติใบหูกวางและใบตองแห้งจะมีสารพวกแทนนินเป็นองค์ประกอบ ซึ่งสารนี้จัดว่าเป็นสารที่มีพิษ แต่การนำใบหูกวางและใบตองมาใช้ในการหมักปลานั้นนับว่าเป็นภูมิปัญญาของไทย และปัจจุบันเริ่มมีการศึกษาวิจัยที่ถึงผลของสารแทนนินที่มีต่อปลากัดดังกล่าว

ใบหูกวาง

ปลาที่เลี้ยงในน้ำหมัก

น้ำใบหูกวางสำเร็จรูป

ใบหูกวาง

จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล

อาหารที่ใช้เลี้ยงปลากัด

ปลากัดเป็นปลาขนาดเล็กที่กินอาหารเก่งและปริมาณมาก อาหารที่ใช้เลี้ยงมีอยู่หลายชนิดด้วยกันทั้งนี้ขึ้นอยู่กับช่วงอายุของปลากัด และความนิยมของผู้เลี้ยงแต่ละคน ในธรรมชาติอาหารของปลากัดได้แก่ ลูกน้ำ ไรแดง ไส้เดือน และหนอนแดง เป็นต้น ปลากัดชอบกินอาหารที่เคลื่อนไหวได้โดยเฉพาะอาหารที่มีชีวิตมากกว่าอาหารที่ไม่มีชีวิต นักเพาะพันธุ์ปลากัดส่วนใหญ่นิยมใช้ลูกน้ำในการเลี้ยงปลากัดที่โตเต็มวัยแล้วเพราะว่าจะทำให้แข็งแรงและโตเร็ว

ในปัจจุบันเราอาจแบ่งอาหารของปลากัดออกเป็น 2 ประเภท ได้แก่

1. **<u>อาหารสำเร็จรูป</u>** อาหารประเภทนี้เป็นการผสมวัสดุอาหารที่ได้จากพืชและสัตว์ เพื่อให้ได้อาหารที่มีคุณค่าทางอาหารสูง มีสารอาหารต่างๆครบถ้วน แต่อย่างไรก็ตามปลากัดมักไม่ค่อยชอบกินอาหารสำเร็จรูป จึงทำให้ผู้ผลิตพยายามพัฒนาอาหารที่มีคุณภาพเพื่อให้ปลากัดยอมรับมากขึ้น

2. **<u>อาหารที่มีชีวิต</u>** อาหารที่มีชีวิตเป็นอาหารที่นิยมใช้เลี้ยงปลากัดตั้งแต่มีขนาดเล็กจนถึงโตเต็มวัย ปลากัดจะชอบกินอาหารที่มีชีวิตมากกว่าอาหารสำเร็จรูป แต่ในการให้อาหารที่มีชีวิตต้องระวังเรื่องความสะอาด เพราะอาจทำให้ปลาติดโรคหรือปรสิตได้ อาหารมีชีวิตหรืออาหารเป็นๆ หมายถึงสัตว์น้ำขนาดเล็กๆ ชนิดต่างๆ ได้แก่

2.1 **ลูกน้ำ หรือตัวอ่อนของยุง** พบได้ทั่วไปตามแหล่งน้ำขังต่างๆ นักเลี้ยงปลากัดมืออาชีพส่วนใหญ่ใช้ลูกน้ำเป็นอาหารหลักของปลากัด ปัจจุบันมีการนำลูกน้ำมาทำแห้งและผสมสารอาหารเพิ่มเติมเพื่อทำเป็นอาหารเม็ดขนาดเล็กๆให้ปลากัดกิน

2.2 **หนอนแดง** เป็นตัวอ่อนของแมลงริ้นน้ำจืด ลักษณะเหมือนหนอนขนาดเล็กพบตามบริเวณที่มีน้ำขังเป็นเวลานาน จัดเป็นอาหารชนิดหนึ่งที่ปลากัดชอบมาก

2.3 **ไรแดง** มีชื่อภาษาอังกฤษว่า water flea จัดเป็นสัตว์น้ำจืดในกลุ่มของแมลงที่มีขนาดเล็กสีแดง พบอยู่ตามคูน้ำ หรือการเพาะขยายพันธุ์เพื่อขาย หาซื้อได้ง่ายตามร้านขายปลาตู้ เหมาะกับลูกปลาหรือปลาขนาดเล็ก

2.4 **ไส้เดือนดิน** เป็นอาหารที่เหมาะกับปลากัดอีกอย่างหนึ่ง สามารถหาได้ง่ายตามพื้นดินร่วนซุย ถ้าเป็นไส้เดือนขนาดเล็กก็ให้ปลากินได้เลย แต่ถ้ามีขนาดใหญ่ต้องมาสับให้เป็นชิ้นเล็กๆ

2.5 **อาร์ทีเมีย หรือ ไรสีน้ำตาล หรือไรน้ำเค็ม** มีชื่อภาษาอังกฤษว่า artemia มีขนาดเล็กพบอาศัยอยู่ในน้ำเค็ม ในท้องตลาดจะขายกันในลักษณะของไข่บรรจุกระป๋อง เมื่อนำไปใส่น้ำเค็มและให้อากาศก็จะฟักเป็นตัวภายใน 24 ชั่วโมง อาร์ทีเมียที่เพิ่งฟักออกจากไข่เหมาะกับลูกปลาขนาดเล็ก แต่อาร์ทีเมียที่โตเต็มวัยจะเหมาะกับปลาขนาดใหญ่ แต่เนื่องจากไรสีน้ำตาลเป็นสัตว์น้ำเค็มที่มีเปลือกชนิดอ่อนนุ่มห่อหุ้มตัวอาจทำให้มีผลต่อระบบย่อยอาหารได้

2.6 **ไข่สัตว์ชนิดต่าง ๆ** นับว่าเป็นแหล่งอาหารที่ดีอย่างหนึ่งของปลากัด โดยเฉพาะไข่กุ้งนับได้ว่าเป็นอาหารที่ดีเยี่ยม มีคุณค่าทางอาหารสูงมาก อีกทั้งยังเป็นอาหารที่ช่วยให้ปลามีสีสันสดใสชัดเจนยิ่งขึ้น นอกจากไข่กุ้งแล้ว ไข่มด ไข่หอย และไข่กบก็ใช้เป็นอาหารปลาได้เป็นอย่างดีเช่นกัน

จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล

ปลากัดป่าที่พบในประเทศไทย

ปลากัดแบ่งออกเป็น 2 กลุ่มใหญ่ๆ คือ **กลุ่มที่ฟักไข่ในปาก**(mouth brooder) และ**กลุ่มที่ก่อหวอด**(bubble-nest builder) ประเทศไทยพบปลากัดป่าทั้งหมด 10 ชนิด (1 ชนิดยังไม่สามารถจำแนกชนิดได้และอยู่ในระหว่างการศึกษาวิจัย) เป็นกลุ่มที่ฟักไข่ในปาก 6 ชนิดและกลุ่มที่ก่อหวอด 4 ชนิด(ชนิดที่ยังไม่ได้จำแนกอยู่ในกลุ่มนี้)

<u>ปลากัดกลุ่มที่ก่อหวอดที่พบในประเทศไทย</u>

หวอด คือ แพฟองอากาศที่ปลาสร้างขึ้น ลอยอยู่บนผิวน้ำ เพื่อให้ไข่และตัวอ่อนที่ฟักวันแรกเกาะอยู่ Goldstein (2004) ได้เขียนไว้ในหนังสือ The Betta Handbook เกี่ยวกับปลากัดกลุ่มนี้ที่พบในประเทศไทย ว่ามีกระจายตัวอยู่ในประเทศไทยจำนวนทั้งหมด 4 ชนิด ด้วยกันดังนี้ ปลากัดป่าภาคกลาง *Betta splendens* Regan, 1910; ปลากัดป่าภาคอีสาน *B. smaragdina* Ladiges, 1972; ปลากัดป่าภาคใต้ *B. imbellis* Ladiges, 1975 และ ปลากัดป่ามหาชัย *B.* sp. Mahachai ปลากัดป่ามหาชัยยังไม่ได้รับการจำแนกชนิด เนื่องจากมีข้อถกเถียงกันอยู่ว่าอาจเป็นปลาที่เกิดจากการผสมข้ามพันธุ์ หรืออาจเป็นปลากัดชนิดใหม่เนื่องจากอาศัยอยู่ในพื้นที่จำกัดที่เป็นน้ำกร่อยที่ไม่ใช่แหล่งที่อยู่อาศัยของปลากัดชนิดอื่นๆ

<u>ปลากัดกลุ่มที่ฟักไข่ในปากที่พบในประเทศไทย</u>

ปลากัดกลุ่มนี้ฟักไข่และปกป้องตัวอ่อนโดยการอมไว้ในปาก ปลากัดในกลุ่มนี้ที่พบในประเทศไทย รายงานว่ามีทั้งหมด 6 ชนิด ได้แก่ *B. prima* Kottelat, 1994; *B. simplex* Kottelat, 1994; *B. pi* Tan, 1998; *B. pallida* Schindler&Schmidt, 2004; *B. apollon* Schindler&Schmidt, 2006 และ *B. ferox* Schindler&Schmidt, 2006 สองชนิดสุดท้ายเป็นชนิดที่เพิ่งพบใหม่ในบริเวณภาคใต้ของประเทศ

14

จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล

โรคของปลากัดและวิธีการรักษา

โรคที่พบในปลากัดมักไม่ค่อยมีอาการรุนแรงถึงขนาดทำให้ปลาตายได้ ดังนั้นหากว่าผู้เลี้ยงทราบถึงสาเหตุและอาการของโรคที่เกิดขึ้นก็สามารถหาวิธีป้องกันและรักษาได้อย่างถูกต้อง การรักษาปลากัดที่เป็นโรคจะแบ่งออกเป็น 2 ขั้นตอน คือ

1. **การแยกปลากัดที่ป่วยออกจากกัน** ถ้าพบว่าปลากัดตัวหนึ่ง หรือมากกว่าหนึ่งมีอาการป่วยให้ทำการคัดแยกปลาป่วยออกมาใส่ภาชนะใหม่ เพื่อรอการรักษาต่อไป ส่วนวัสดุอุปกรณ์ที่ใช้คัดแยกปลาที่ป่วยควรทำความสะอาด หรือฆ่าเชื้อทุกครั้งหลังใช้งาน รวมทั้งทำความสะอาดอวัยวะต่างๆของผู้เลี้ยง เพื่อป้องกันการแพร่กระจายของโรคไปยังบ่ออื่นๆ
2. **การพิจารณาโรคและการรักษา** หลังจากคัดแยกปลากัดที่ป่วยออกมาแล้วให้พิจารณาอาการของปลา โดยดูจากลักษณะภายนอกว่ามีลักษณะอย่างไร สาเหตุของโรคมาจากอะไร และจะทำการรักษาวิธีไหน ตลอดจนจะป้องกันโรคได้อย่างไร เมื่อพิจารณาแล้วก็ดำเนินการวางแผนการรักษาต่อไป

โรคที่มักพบได้บ่อยในปลากัดมีอยู่หลายโรคด้วยกัน แต่ละโรคมักมีสาเหตุที่แตกต่างกันไป บางโรคอาจเกิดจากเชื้อแบคทีเรีย บางโรคอาจเกิดจากเชื้อรา และบางโรคอาจเกิดจากปรสิตภายนอก ดังนั้นเราควรมารู้จักโรคที่สำคัญๆเหล่านี้คือ


โรคไฟลามทุ่ง

1. โรคไฟลามทุ่ง เป็นโรคที่ติดต่อกันได้เร็วที่สุดใช้ระยะเวลาเพียง 2 -3 วันก็จะติดต่อกันหมด
ลักษณะอาการ เป็นแผลบริเวณโคนครีบหาง ครีบหู และครีบท้อง ขอบแผลจะมีลักษณะเป็นรอยช้ำแดง และเป็นเส้นปุยสีขาว เกล็ดของปลาจะพอง ปลาที่เป็นโรคจะลอยตัวอยู่บริเวณผิวน้ำ
การป้องกันรักษา ให้รีบช้อนปลาที่เป็นแผลออกทันที ส่วนปลาที่เหลืออยู่ใช้ต้นหญ้าไทรที่ตากแดดหมาดๆนำมาใส่ในบ่อเลี้ยงให้มีปริมาณมากพอที่จะทำให้น้ำมีสีเข้ม และเป็นฝ้าเล็กน้อย แช่ปลากัดไว้ประมาณ 5 – 7 วัน คล้ายกับการหมักปลากัด เมื่อแผลของปลากัดหายแล้วให้ย้ายปลากัดไปเลี้ยงในตู้หรืออ่างใหม่ที่ใส่หญ้าไทรเล็กน้อย พอให้เกิดเป็นสีชา ปลากัดที่เลี้ยงจะค่อยๆแข็งแรง และหายเป็นปกติ


โรคปากดำ

2. โรคปากดำ เป็นโรคที่รักษาไม่หาย ปลากัดที่เป็นโรคปากดำจะนำไปกัดไม่ได้ทั้งนี้เพราะปลากัดใช้ปากในการต่อสู้ ถ้าปากของปลากัดเจ็บก็ไม่สามารถต่อสู้กับศัตรูได้
ลักษณะอาการ ปลากัดที่เป็นโรคปากดำ ขอบปากด้านบนจะมีขอบหนามากผิดปกติ และจะมีสีดำเพิ่มขึ้นมาเรื่อยๆ
การป้องกันรักษา แม้ว่าโรคปากดำเป็นโรคที่ไม่ร้ายแรง แต่โรคนี้ยังไม่มีทางรักษา ดังนั้นเมื่อพบว่าปลากัดที่เลี้ยงเป็นโรคปากดำให้ตักทิ้ง อย่าเสียดาย เพราะมิฉะนั้นจะทำให้ปลากัดตัวอื่นติดโรคนี้ไปด้วย


โรคปากเปื่อย

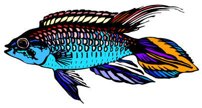
3. โรคปากเปื่อย จัดเป็นโรคที่ร้ายแรงชนิดหนึ่งของปลากัด โรคนี้รักษาไม่หาย ดังนั้นถ้าพบว่าปลากัดเป็นโรคปากเปื่อยต้องแยกออกทันที
ลักษณะอาการ เริ่มจากขอบปากเป็นแผลสีขาวและลักษณะเป็นขุยเส้นเล็กๆ ปลากัดที่เป็นโรคปากเปื่อยจะไม่ค่อยว่ายน้ำและมักลอยตัวอยู่บริเวณผิวน้ำเฉยๆ
การป้องกันรักษา เนื่องจากโรคนี้ไม่มีทางรักษา ถ้าพบว่าปลากัดเป็นโรคชนิดนี้ควรรีบแยกออกทันที


โรคท้องมาน

4. โรคท้องมาน เป็นโรคที่อาจทำให้ผู้เพาะเลี้ยงปลาเข้าใจผิดคิดว่าปลาตั้งท้อง เพราะส่วนท้องของปลากัดจะพองออก โรคท้องมานอาจเกิดจากการที่ปลากัดติดเชื้อภายในช่องท้องและมีอาการอักเสบ
ลักษณะอาการ ปลากัดมีลักษณะท้องโตเนื่องจากการติดเชื้อภายในช่องท้องจนทำให้ท้องมีขนาดโตผิดปกติ
การป้องกันรักษา ผู้เลี้ยงบางรายใช้วิธีเอาดีเกลือ 1 ช้อนชา ผสมกับน้ำ 1.5 ลิตร จากนั้นจึงจับปลากัดลงแช่ 1-2 วัน อาการจะทุเลาลง

จัดทำโดย...สถาบันนวัตกรรมการเรียนรู้ มหาวิทยาลัยมหิดล

Activity sheets



Activity sheet 1

(Biodiversity of Siamese fighting fish)

1. Name your favorite fighting fish?

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   …………………………………………………………………………………...

2. Describe general information of your favorite fighting fish and its habitat

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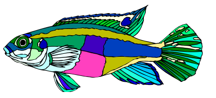
   …………………………………………………………………………………...

3. Draw a picture of your favorite fighting fish in the space provided. Label the important part of your drawing.



Activity sheet 2

(History of Siamese fighting fish)

1. Describe the historical data and background of Betta fighting fish in a short paragraph..

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2. What is the original strain of fighting fish in Thailand?

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3. Write three names of fighting fish that were developed from wild type Betta, *Betta splendens* ?

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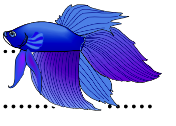
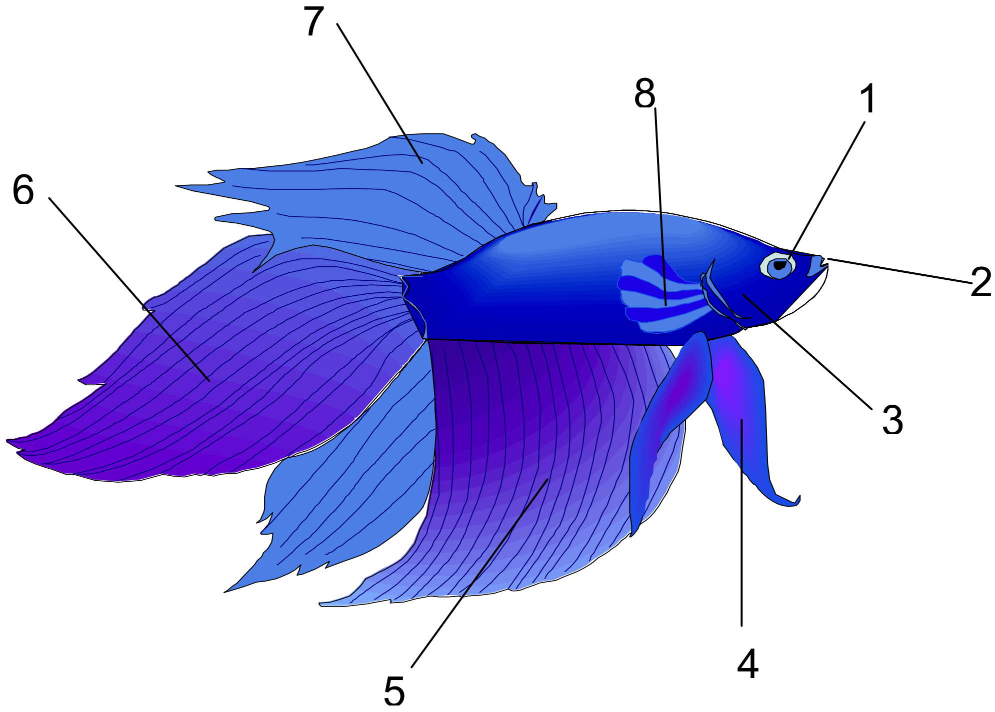


Activity sheet 3

(Classification of Siamese fighting fish)

1. Write the name of each part of the fighting fish in the picture below.



Number 1..

Number 2..

Number 3..

Number 4..

Number 5..

Number 6..

Number 7..

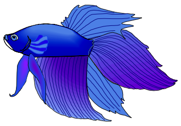
Number 8..

2. From fighting fish data in the learning center, fighting fish can be classified into..........groups, i.e.,

1. ....
2. ....
3. ....
4. ....

Activity sheet 4

(Breeding of Siamese fighting fish)



1. What are the general characteristics of the male fighting fish?

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2. How do you know that female betta is ready to breed?

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3. Most Thai people believe that female betta will pregnant if she looks at male fish. Do you agree with this belief? Give reason for your answer.

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4. Summarize the breeding and raising process of fighting fish according to your understanding

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5. Food of fighting fish can be dived into………….groups, i.e,

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Activity 5

(Conservation of local fighting fish)

1. Wild type fighting fish mean...
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2. How many groups of wild type fighting fish were found in Thailand?
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3. Write the name of 9 species of wild type fighting fish that you known.
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4. What are the reasons that will make extinction of the local fighting fish?
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5. Purpose the appropriate mean for conservation of fighting fish.
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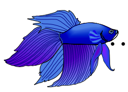

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Semi-structured interviewing questions

The interviewing questions consisted of three parts; 1) knowledge of fighting fish (item 1-7), 2) group learning (items 8-10), and 3) learning and teaching management in the classroom (items 11-16).

1). Knowledge of fighting fish.

1. Have you ever bred and raised fighting fish at your home? Describe process of breeding and raising the fighting fish.
2. From your studying in the fighting fish learning center, name three fighting fish.
3. What are the differences between male and female betta?
4. Do you know why the male fighting fish have to build bubble nest?
5. Why do local people in ancient period like to rear fighting fish?
6. Name two kinds of the food for fighting fish.
7. Give two of proverbs that concerns with the fighting fish.

2). Group learning

8. Do you like to work in team, give reason for your answer?
9. What activity in the classroom did you often work in group?
10. Are there any problems on team working?

3). Learning and teaching management in the classroom

11. Are the learning content and media in the learning center interesting?
12. Is the time allocated in learning period appropriate?
13. Are the learning activities in this class easy or difficult?
14. Does the teacher help you understand the subject content?
15. Does the teacher facilitate class activities?
16. Does the teacher have to improve on this teaching and learning process?

APPENDIX B
INQUIRY-BASED LEARNING UNIT

Pretest
Inheritance and biodiversity

Objectives:

To measure knowledge and understanding of secondary students on genetics and biodiversity

Instructions for completing the test:

Choose True or False or I don't know the answer for the following statements. Also give the reason for your choice in the space provide.

1. By looking at handsome boy or beautiful girl a pragnant women would give birth to a handsome baby boy or beautiful baby girl.

☐ True ☐ False ☐ I don't know the answer

Reason

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2. If you want to study on inheritance of easily breeding fish but this fish would take 2 years to mature (ready to mate) while other fish takes only 3 months. According to Mendelian inheritance, this fish is not suitable for studying on genetics.

☐ True ☐ False ☐ I don't know the answer

Reason

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3. "Baby human must be born from human, monkey must be born from monkey and fish fry must be born from fish". Is this state true or false?

☐ True ☐ False ☐ I don't know the answer

Reason

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4. Chromosome was found in cytoplasm of cell.

☐ True ☐ False ☐ I don’t know the answer

Reason

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5. Gene is a unit of heredity in a living organism which can be seen by using optical microscope with high magnification

☐ True ☐ False ☐ I don’t know the answer

Reason

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6. Each species of living organism have different in chromosome number. The highly evolved organisms have more chromosome number than the lower evolved organisms.

☐ True ☐ False ☐ I don’t know the answer

Reason

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7. In breeding of double tails fighting fish, the breeder always use tail cutting method in mature male and female fighting fish before breeding. This method succeeds in producing double tails fighting fish fry.

☐ True ☐ False ☐ I don’t know the answer

Reason

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8. Fish breeding based on different in one trait according to Mendels' law of heritance showed results that are different from Mendels' law. This means that the experiment had error in preparing of mature male and female fish.

☐ True ☐ False ☐ I don't know the answer

Reason

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9. Red-colored male fish (homozygous dominant) was bred with yellow-colored female fish (homozygous recessive) and 100 fries were produced (red: yellow, 50:50). The results followed the 1st law of Mendel.

☐ True ☐ False ☐ I don't know the answer

Reason

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10.Genotypes of one dog are short-hair (Aa) and long-tail (Bb) these genotypes produce eight gametes, i.e., AB, BA, Ab, bA, aB, Ba, ba and ab.

☐ True ☐ False ☐ I don't know the answer

Reason

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11.Breeding of ornamental fish between mature male (homozygous dominant) and mature female (homozygous dominant) or mature male (homozygous recessive) and mature female (homozygous recessive) resulted in genetics biodiversity.

☐ True ☐ False ☐ I don't know the answer

Reason

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12.Mendel's law can be used in cultivation by budding, grafting and cutting.

☐ True ☐ False ☐ I don't know the answer

Reason

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13.Upon surveying the organisms at the big natural pond, you found only fishes with different types size and shape. It can be conduct that there are varieties of organisms or species biodiversity in this pond.

☐ True ☐ False ☐ I don't know the answer

Reason

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14.If your local area has a problem about biodiversity deterioration, the people will be affected by this problem.

☐ True ☐ False ☐ I don't know the answer

Reason

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15.Studying on classification of organisms in the school pond. The skills needs are observation and comparison on similarity and difference of these organisms.

☐ True ☐ False ☐ I don't know the answer

Reason

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16.From the following number, 1=kingdom, 2=Family, 3=Genus, 4=Species, 5=Order, 6=Phylum, 7=Class, the set of number from the biggest to smallest groups of organism is as follows; 1-6-2-7-5-3-4.

☐ True ☐ False ☐ I don't know the answer

Reason

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17.The scientific name of one fighting fish is *Betta splendens* and while the another one is *Betta smaragdina*. This means that both of them are different in species but not same genus.

☐ True ☐ False ☐ I don't know the answer

Reason

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18.If we classify fishes differently from rats, pigs, birds, monkeys, crocodiles and dolphins. This means that main criteria for classification is based on respiratory organ.

☐ True ☐ False ☐ I don't know the answer

Reason

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19.Upon surveying and collecting of fishes from Northern and Southern part of Thailand, the results showed that the fishes collected from each part of the country have similar characteristics and can crossbreed to produce first generation (F1) and second generation (F2). It can be concluded that both collected fishes belong to the same species.

☐ True ☐ False ☐ I don't know the answer

Reason

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20. At present, we classify and identify organisms only from comparing and contrasting among the external characteristics.

☐ True ☐ False ☐ I don't know the answer

Reason

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Posttest

Inheritance and biodiversity

Objectives:

To measure knowledge and understanding of secondary students on genetics and biodiversity

Instructions for completing the test:

Choose True or False or I don't know the answer for the following statements. Also give the reason for your choice in the space provide.

1. Mendel's law can be used in cultivation by budding, grafting and cutting.

☐ True ☐ False ☐ I don't know the answer

Reason

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....

....

2. Fish breeding based on different in one trait according to Mendels' law of heritance showed results that are different from Mendels' law. This means that the experiment had error in preparing of mature male and female fish.

☐ True ☐ False ☐ I don't know the answer

Reason

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3. Breeding of ornamental fish between mature male (homozygous dominant) and mature female (homozygous dominant) or mature male (homozygous recessive) and mature female (homozygous recessive) resulted in genetics biodiversity.

☐ True ☐ False ☐ I don't know the answer

Reason

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4. Red-colored male fish (homozygous dominant) was bred with yellow-colored female fish (homozygous recessive) and 100 fries were produced (red: yellow, 50:50). The results followed the 1st law of Mendel.

☐ True ☐ False ☐ I don't know the answer

Reason

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5. By looking at handsome boy or beautiful girl a pragnant women would give birth to a handsome baby boy or beautiful baby girl.

☐ True ☐ False ☐ I don't know the answer

Reason

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6. "Baby human must be born from human, monkey must be born from monkey and fish fry must be born from fish". Is this state true or false?

☐ True ☐ False ☐ I don't know the answer

Reason

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7. If you want to study on inheritance of easily breeding fish but this fish would take 2 years to mature (ready to mate) while other fish takes only 3 months. According to Mendelian inheritance, this fish is not suitable for studying on genetics.

☐ True ☐ False ☐ I don't know the answer

Reason

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8. Gene is a unit of heredity in a living organism which can be seen by using optical microscope with high magnification

☐ True ☐ False ☐ I don’t know the answer

Reason

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9. Chromosome was found in cytoplasm of cell.

☐ True ☐ False ☐ I don’t know the answer

Reason

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10. Each species of living organism have different in chromosome number. The highly evolved organisms have more chromosome number than the lower evolved organisms.

☐ True ☐ False ☐ I don’t know the answer

Reason

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11. In breeding of double tails fighting fish, the breeder always use tail cutting method in mature male and female fighting fish before breeding. This method succeeds in producing double tails fighting fish fry.

☐ True ☐ False ☐ I don’t know the answer

Reason

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12. Genotypes of one dog are short-hair (Aa) and long-tail (Bb) these genotypes produce eight gametes, i.e., AB, BA, Ab, bA, aB, Ba, ba and ab.

☐ True ☐ False ☐ I don't know the answer

Reason

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13.If your local area has a problem about biodiversity deterioration, the people will be affected by this problem.

☐ True ☐ False ☐ I don't know the answer

Reason

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14.Upon surveying the organisms at the big natural pond, you found only fishes with different types size and shape. It can be conduct that there are varieties of organisms or species biodiversity in this pond.

☐ True ☐ False ☐ I don't know the answer

Reason

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15.Studying on classification of organisms in the school pond. The skills needs are observation and comparison on similarity and difference of these organisms.

☐ True ☐ False ☐ I don't know the answer

Reason

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16.The scientific name of one fighting fish is *Betta splendens* and while the another one is *Betta smaragdina*. This means that both of them are different in species but not same genus.

☐ True ☐ False ☐ I don't know the answer

Reason

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17.From the following number, 1=kingdom, 2=Family, 3=Genus, 4=Species, 5=Order, 6=Phylum, 7=Class, the set of number from the biggest to smallest groups of organism is as follows; 1-6-2-7-5-3-4.

☐ True ☐ False ☐ I don't know the answer

Reason

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18.At present, we classify and identify organisms only from comparing and contrasting among the external characteristics.

☐ True ☐ False ☐ I don't know the answer

Reason

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19.If we classify fishes differently from rats, pigs, birds, monkeys, crocodiles and dolphins. This means that main criteria for classification is based on respiratory organ.

☐ True ☐ False ☐ I don't know the answer

Reason

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20. Upon surveying and collecting of fishes from Northern and Southern part of Thailand, the results showed that the fishes collected from each part of the country have similar characteristics and can crossbreed to produce first generation (F1) and second generation (F2). It can be concluded that both collected fishes belong to the same species.

☐ True ☐ False ☐ I don't know the answer

Reason

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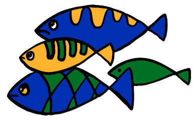
APPENDIX C
MENDELIAN INHERITANCE AND BIODIVERSITY



Mendelian inheritance hands-on activity sheets

Activity 1 "Follow the trail of Mendels 1"

1. What would be the color of the fish resulting from crossing between a yellow fish with a red one?"

Answer..

Reason...

2. Gene is…..………………………………………..……………………

3. The color of the fish from crossing between a yellow fish with red fish is red. Fish color was control by red gene and yellow gene. Can you explain why color of the crossing fish is red?

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4. Genotype is……………………..………………………………………

....

5. Phenotype is...

…………………………………………………...…………………………………....

6. From the crossing fish in item no. 3, answer following questions:

Genotype of the yellow fish is..

Genotype of the red fish is...

Genotype of the red fish from crossing a yellow fish with a red one is…....

…………………………………………………...…………………………………....

7. Homozygous dominant means..…………………………………………

…………………………………………………...…………………………………....

8. Heterozygous dominant means……………………………………..…...

…………………………………………………...…………………………………....

Activity 2 "Follow the trail of Mendel"

Part 1 Making use of different colored clippers, students have to predict, explain and answer the following questions;

1. Crossing a yellow fighting fish (♂) with a red one (♀).

AA = Heterozygous dominant (a male yellow fighting fish)

aa = Heterozygous recessive (a female red fighting fish)

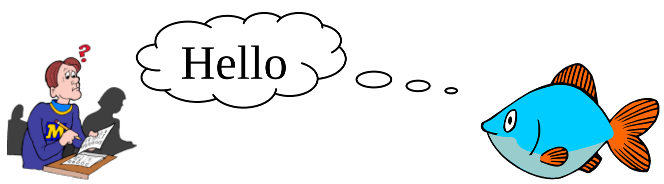
The first generation fighting fish

AA (male) X aa (female)

♀ \ ♂				

The inheritances of first generation of fighting fish are as follows;

genotype									
proportion									
phenotype									
proportion									



<u>The second generation fighting fish</u>

……. (male) X …..(female)

♀ \ ♂				

The inheritances of second generation of fighting fish are as follows;

genotype									
proportion									
phenotype									
proportion									

2. Crossing a short-tailed fighting fish (♂) with a long-tailed one (♀).

BB = Heterozygous dominant (a short-tailed male)

bb = Heterozygous recessive (a long-tailed female)

<u>The first generation fighting fish</u>

BB (male) X bb (female)

♀ \ ♂				

The inheritances of first generation of fighting fish are as follows;

genotype									
proportion									
phenotype									
proportion									

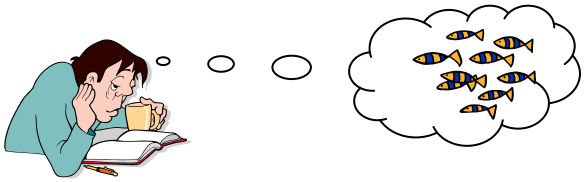
<u>The second generation fighting fish</u>

……. (male) X …..(female)

♀ ♂				

The inheritances of second generation of fighting fish are as follows;

genotype									
proportion									
phenotype									
proportion									



Allele means..

Part 2 Making use of different colored clippers, students have to predict, explain and answer the following questions;

Crossing a yellow short-tailed fighting fish (♂) with a red long-tailed one (♀).

AABB = Heterozygous dominant (a yellow short-tailed male)

aabb = Heterozygous recessive (a red long-tailed female)

The first generation fighting fish

AABB (♂) X aabb (♀)

♀ \ ♂				

The inheritances of first generation of fighting fish are as follows;

genotype														
proportion														
phenotype														
proportion														

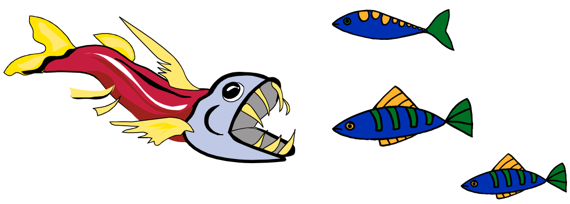
<u>The second generation fighting fish</u>

……. (male) X …..(female)

♀ \ ♂				

The inheritances of second generation of fighting fish are as follows;

genotype														
proportion														
phenotype														
proportion														



Activity 3 “Cross the fighting fish by yourself”

Choose two characteristics of the F1 and F2 fighting fish that you want. Then choose the appropriate characteristics of the parental fish inorder to obtain F1 and F2 of your choice. Without using any clipper, write answer in your worksheet.

Note 1. Red color in fish is heterozygous dominant and yellow one is heterozygous recessive

2. Delta tail is heterozygous recessive and leaf tail is heterozygous dominant

The first generation fighting fish

.... (♂) X ....(♀)

♀ ♂				

The inheritances of first generation of fighting fish are as follows;

genotype														
proportion														
phenotype														
proportion														

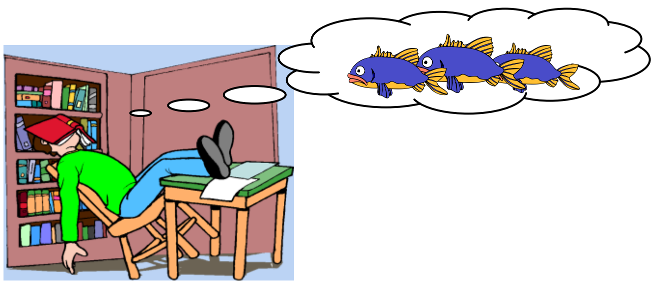
<u>The second generation fighting fish</u>

……. (male) X …..(female)

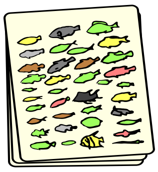
♀ \ ♂				

The inheritances of second generation of fighting fish are as follows;

genotype														
proportion														
phenotype														
proportion														



Biodiversity hands-on activity sheets



<u>Activity sheet</u>

<u>Classification and identification</u>

<u>Activity 1</u> “What are my groups?”

Carefully observe characteristics (traits) of the plastic models of animals and plants, and then classify these organisms into groups your own criteria.

1. Briefly describe the dominant characteristics of each organism in the following table.

Name	Dominant Characteristics

2. Classify the ten organisms into two groups and give the criteria used in your classification.

Criteria used to classify organisms in group 1 are..

....

Criteria used to classify organisms in group 1 are..

....

Organisms in group 1	Organisms in group 2

3. Further classify the organisms in group 1 and 2 into to subgroup, give criteria used in your classification.

Criteria used to classify organisms in group 1 into subgroup are..................

....

Group 1.1	Group 1.2

Criteria used to classify organisms in group 2 into subgroup are..................
....

Group 2.1	Group 2.2

Can organisms in group 1.1, 1.2, 2.1 be further classified in subgroups? Write the criteria and name of organisms in each subgroup in the given table.

4. Write your own conclusion chart on classification of plastic models of animals and plants.

5. Write the benefit of organisms classification

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6. There are many kinds of organisms in the forest, if some of them extinct, will the living organisms in this area be affected. Give answer with reasons and example.

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7. Why do the worlds ecosystems consisted of several kinds of organisms? Explain the relationships between these organisms and between organisms and environment.

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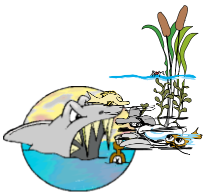

<u>Activity 2</u> "Difference in our group"

Create the key to classify ten fighting fishes by using outward characteristic and explain your own criteria for classification.

1. There are ………..of fighting fish which have characteristics as follows

Name	Outward characteristic

2. Most of fighting fish can be classified to……..group by using criteria as follows;

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3. Write your conclusion chart on classification of plastic models of animals and plants in the provided space.

4. Why do the same specie of fighting fish have different outward characteristics such as fin, color and shape?

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Semi-structured interviewing questions

The interviewing questions consisted of three parts; 1) knowledge of Mendelian inheritance, classification and identification of organisms (item 1-6), 2) group learning (items 7-9) and 3) learning and teaching management in the class room (items 10-15).

1) Knowledge of Mendelian inheritance, classification and identification of organisms.

1. Use the knowledge learned in the class to explain gene and heredity of life?
2. Explain of Mendel's experiment and Mendel's law?
3. Can color clippers and fighting fish in the hands-on activity make you understand crossing of organisms by using Mendel's law? Give your reason.
4. Explain the meaning of biodiversity.
5. Explain the scientific method on classification of organisms in the world from big group to small group?
6. In biodiversity class activity, give your own criteria in classification on organisms classification.

2). Group learning

7. Do you like to work in team, give reason for your answer?
8. What activity in the classroom did you often work in group?
9. Are there any problems on team working?

3). Learning and teaching management in the classroom

10. Are the learning content and media in the learning center interesting?
11. Is the time allocated in learning period appropriate?
12. Are the learning activities in this class easy or difficult?
13. Does the teacher help you understand the subject content?
14. Does the teacher facilitate class activities?
15. Does the teacher have to improve on this teaching and learning process?

BIOGRAPHY

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