CHAPTER 1

INTRODUCTION

A. Background

We live in an exciting time for biology. Technological advances have made data collection easier and cheaper than we could ever have imagined just 10 years ago. In a world filled with the products of scientific inquiry, scientific literacy has become a necessity for everyone. Everyone needs to use scientific information to make choices that arise everyday. Everyone needs to be able to engage intelligently in public discourse and debate about important issues that involve science and technology. Everyone deserve to share in the excitement and personal fulfillment that can come from understanding and learning about the natural world. Scientific literacy also is of increasing importance in the workplace. More and more jobs demand advanced skill, requiring people be able to learn, reason, think creatively, make decisions, and solve problems. An understanding of science and the process of science contributes in an essential way to these skills (National Research Council, 2009).

The second half of the twentieth century has seen frequent and rapid changes in our understanding of the growth of knowledge and its development. Dynamic reconfigurations have taken place in theories of learning (from an emphasis on the bahavioural to a concern with the cognitive and social nature of thinking); in the theoris of mind (from a belief in *tabula rasa* to a constructivism); and in theories of knowledge (from the notion that knowledge is cumulative to ideas that knowledge is often reconfigured, adapted and even abandoned) (Duschl and Osborne, 2002). During the past few years there has been a call to expand curriculum standards and assessment in order to better equip upper secondary students with the skills, knowledge and expertise to success in work and life in this century (Ullman, 2008). In order to master the recommended twenty-first century set of outcomes, classroom instruction will have to become more interactive and engaging than it currently is. The skill deemed necessary for students in the modern interdependent global society are: 1) learning and innovation skills (for example, creativity and innovation, critical thinking, and problem solving); 2) information, media, and technology skills, core subjects and twenty-first century themes (for examples, global awareness and financial literacy); and 3) life and career skills (for example, initiative and self-direction) (Partnership for 21st Century Skills, 2009). According to (Millar and Osborne, 1999 in Duschl and Osborne, 2002) such changes have led to arguments which would suggest that (a) classroom instruction needs to be centred around students' active learning and take into account research that demonstrates that students' prior knowledge is a significant factor affecting learning; and (b) that the focus of student's work should transcend the declarative to include procedural and strategic-knowledge that is to enable students' abilities to reason and reflect metacognitively on their own learning and the construction and evaluation of scientific knowledge.

Integrative biology, fundamentally integrative science, is an essential and effective approach to resolving many of the complex issues facing the 21st century. It is a way of perceiving and practicing science and of transforming science its processes and its result to deal with societal issues. It is both an attitude about the scientific process and a description of a way of doing science (Wake, 2000, 2001, 2003; Lakhotia, 2001; Barbault *et al.*, 2003, in Wake 2008). Those principles emphasize not just multidisciplinary but also transdisciplinary research that incorporates the biological, physical, socioeconomic, mathematical, engineering, and humanities components appropriate for addressing complex questions and problem (Wake, 2008).

In the case of Indonesia, the need for STEM Education is very high. Data from the Central Bureau of Statistics Indonesia (2010) shows that Indonesia workforce is dominated by unskilled workers (nearly 90 million) compared to only 28 million of skilled workers (The HEAD Foundation, 2017). Over the next five years, employment is predicted to increase in professional, scientific and technical services by 12 percent and in health care by almost 20 percent. Besides, the Australian Bureau of Statistics has estimated that some Science Technology

Engineering and Mathematics (STEM) related jobs, such as ICT professionals and engineers, have grown at about 1.5 times the rate of other jobs in recent years. Being competent and informed in STEM are not only necessary for jobs but also for daily life and participation in the community. This situation presents a special challange to education to prepare students who have such skills (The HEAD Foundation, 2017). STEM education is a term used to refer collectively to the teaching of the disciplines within its umbrella (science, technology, engineering and mathematics) and also to across-disciplinary approach teaching that increases student interest in STEM-related fields and improves students' problem solving and critical analysis skill (Education Council, 2015). Based on Wulandari's (2016) field study result about the *Implementation of STEM-based learning on Ecosystem Topic at Lower Secondary Students* resulted in four ground theories those are: 1) STEM-based learning is an integrated learning; 2) STEM-based learning process is an inquiry-based learning; 3) STEM-based learning could facilitate students to develop 21st century skill; and 4) STEM-based learning could develop students' designing skill.

Science education reform initiatives emphasize 1) the value of concepts over facts; 2) the benefits of open-ended, inquiry based problem solving rather than protocols leading to a single correct answer; and 3) the importance of a multidisciplinary approach to teaching that is not confined by departmental boundaries (Lynd-Balta, 2006). Problem-solving skill in 21st century recommended the education field to change the educational framework and learning processes in class (Matthews *et al.,* 2010). National Research Council (2003) was a timely and credible call to action on reforming high school students and undergraduate science education, and it also offered a "blueprint" for this change. The report particularly catalyzed international discussion and debate around the need for *stronger interdisciplinary* approaches and *greater quantitive rigor* in life science education, resulting in broad consensus that change is urgently required (Kennedy and Gentile, 2003; Steitz, 2003; Bialek and Botstein, 2004; Gross *et al.,* 2004; May, 2004; Slonczewski and Marusak, 2004 in Mathhews *et al.,* 2010).

Many science educators view inquiry as a key component of any efforts to help students develop science proficiency (Duschl, Schweingruber, and Shouse 2007; NRC, 2012). Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry referes to understanding of how scientists study the natural world as well as the activities that students engage in when they attempt to develop knowledge and understanding of scientific idea (NRC, 2000). The framework from National Research Council (2003), in this 21st century education must facilitate students to develop *communication skill*. One form of communication skill can be represented by students argumentation when learning in classrrom. According to Pacific Policy Research Center (2003) the integration of scientific *argumetation* into the teaching and learning of biology can be difficult for both the teachers and students. In fact, teachers often ask for specific instructional strategies and engaging activities based on these instructional activities that would allow students to learn how to engage in scientific argumentation as part of the inquiry process (Sampson and Schleigh, 2016). From the empirically evidence, when any discussion sessions in classroom, some students just reluctant and only give their simple argumentation about the issue. Almost students do not convey their whole thinking perspectives or they have not involve the interdisciplinary solutions when explaining or solving problem.

The pervasive relevance of evolution can be seen in the 2009 report commisioned by the National Research Council of the National Academies, *A New Biology for the 21st Century*, which identified four broad challenges for biology, those are develop better crops to feed the world, understand and sustain ecosystem function and biodiversity in a changing world, expand sustainable alternative energy sources, and understand individual health. In each of these areas, the report noted, evolutionary concepts and analyses have played and will continue to play an integral role (Losos *et al.*, 2013). The essence of the New Biology is integration and re-integration of the many sub-disciplines of biology, and the integration into biology of physicists, chemists, computer scientists, engineers, and mathematicians to create a research community with the capacity to tackle a borad range of scientific and societal problems. Integrating knowledge from many disciplines will permit deeper understanding of biological systems, which will both lead to biology-based solution to enrich the individual scientific disciplines that contribute new insights (National Research Council, 2009).

According to (NRC, 2009) science and technology alone, cannot solve all of our food, energy, environmental, and health problems. Political, social, economic, and many other factors have major roles to play in both setting and meeting goals in these areas. Indeed, increased collaboration between life scientists and social scientists is another exciting interface that has much to contribute to developing and implementing practical solutions.

The most crucial topic in biology is plants. The long-term future of agriculture depends on a deeper understanding of plant growth. A wide variety of plants with faster maturation, drought tolerance, and disease resistance could contribute to a sustainable increase in local food production. Food crops could be engineered for higher nutritional value, including higher concentrations of vitamins and healthier oils. Biological systems could remove more carbon dioxide from the atmosphere, thus helping to maintain a stable climate, the carbon dioxide they capture could be used to create biologically based materials for construction and manufacturing (NRC, 2009). Plant reproduction is also play a very important role related with the environmental changes. The environmental changes it self contribute to the continuity of life, so it gives interrelated impact to each other. The high market demand of food is giving impact to the high need toward the plant stocks. Besides for food, decorative plants are also need in some aspects. The plant stocks must be supported by certain ways which can make sure about the availability of plants. An artificial vegetative helps us to provide the plant stock in order to produce plant faster and easier. According to Yeboah *et al.*, (2011), stem cutting is the most frequent method use for vegetative propagation of many plants species from herbaceous to woody plants. Based on the interview result, the florists at Lembang, West Java, stated that from about a thousand cutting plants, approximately one hundred plants were died because of spoiled or parasite infection. It needs special treatment and certain skills to avoid these failure.

Based on explanations above, this research intend to analyze upper secondary school students's interdicsiplinary thinking skill through their argumentations on Plant Reproduction topic by implementing STEM-based instruction. This research is important to do because this result could then be used to recommend specific strategies for implementing or improving teaching strategies on Plant Reproduction topic. Through developing a model to practice the plant propagation, it can facilitate students to build their reasoning skills from some facts related with plant reproduction. In order to describe the real situations of students' argumentation skill related with their interdisciplinary thinking skill levels, also to find the effective learning in increasing students's thinking skill comprehensively, deeply, and represented by their argumentations. It can show the important teaching strategy to support the succes of 21st century challange, especially in thinking and communication skills. So, this research has the title *Interdisciplinary Thinking Skill of Upper Secondary Students' through Argumentations Analysis in STEM-based Instruction on Plant Reproduction*.

B. Statement of Problem

Biology in twenty-first century proposed that curriula based on the report's recommendations would result in students gaining an increased interdisciplinary thinking and communication skill. In order to achieve interdiscipline level, students must have the comprehensive insights in their cognitive scheme, then their thinking framework can be relate each other, and it can be found in how they argue about an issue or how their way to solve problems. Hence (hopefully) leading to greater intentions to enroll in more effective learning in 21st century. The problem that will be focused in this research is as follow "*How is students' interdisciplinary thinking skill through argumentation analysis in STEM-based instruction on plant reproduction?"* This research is shaping by following research questions:

1) How is students' *interdisciplinary thinking skill* in STEM-based instruction on plant reproduction?

2) How is students' *argumentation level* in STEM-based instruction on plant reproduction?
3) How is the correlation between students' *interdisciplinary thinking skill* and *argumentation level* in STEM-based instruction on plant reproduction?

C. Purposes of the Study

The main purpose of this study is to *analyze interdisciplinary thinking skill of upper secondary students' through argumentation analysis in STEM-based instruction on Plant Reproduction.* The purposes are broken into specific aims as below.

1) Analyzing students' *interdisciplinary thinking skill* in STEM-based instruction on plant reproduction
2) Analyzing students' *argumentation level* in STEM-based instruction on plant reproduction.
3) Analyzing the correlation between students' *interdisciplinary thinking skill* and *argumentation level* in STEM-based instruction on plant reproduction.

D. Problem Limitation

In order to this study to more focus, so to limit the problem as follows:

1) Argumentation level is based on the Toulmin Argumentation Pattern that comprises of level 1 until level 6 (*Lee et al.*, 2013).
   a. First level represents non-scientific statements.
   b. Second level, students write or choose only a scientific claim without supporting evidence or relevant knowledge.
   c. Third level, students make a claim based on salient data or relevant knowledge.
   d. Fourth level, students make a claim based on coordination between salient evidence and relevant knowledge.
   e. Fifth level, students modify the strength of their scientific argument.
   f. Sixth and highest level, students can distinguish conditions where their scientific arguments are held true and recognize limitations associated

with measurement, current knowledge based or model, and phenomena.

2) Criteria of interdisciplinary thiniking skill level according to Golding (2009) are limited in:
   a. *Unidisciplinary:* disciplines are seen as separated and isolated. Students at this level tend to be uninterested in other disciplines (and potentially xenophobic of them), while dogmatic about their own discipline or unreflective beliefs.
   b. *Awareness of other disciplines:* students at this level are aware of different disciplines and their different methods and purposes. However they tend to have stereotyped, superficial beliefs about other disciplines as well as misconceptions and inaccuracies. They also tend to see each discipline as offering its own separate and incommensurable perspective.
   c. *Pluralism and multidisciplinary:* students at this level have an accurate understanding of the methods and findings of different disciplines. They use the different disciplines to provide multiple ways of approaching a common problem or issue, but do not integrate the perspectives.
   d. *Interdisciplinary:* students at this level are truly interdisciplinary and attempt to develop one reasoned perspective from the various disciplinary perspectives and methods, which they support by evidence from multiple disciplines. They engage in sophisticated integration, and have a clear sense of purpose for why the disciplines needed to be integrated.
3) This research use plant reproduction topic to reveal interdisciplinary thinking skill of students in relevant with STEM-based instruction.
4) Plant Reproduction topic include asexual reproduction; natural and artificial vegetative reproduction; parts of a flower; pollination; fertilisation; and fruit and seed development (Kwan and Lam, 2007). Mathematics concept which relevance with this biology concept is linear

programming (Cambridge, 2013). Crosscutting concepts that will be used in this chapter are system and system models; structure and function; and scale (NGSS, 2013). The materials are containing the connections to Engineering, Technology, and Application of Science. Students will be act as an engineer to design a solution of the problem by involving technology and their mathematics skill.

E. Significance of the Study

Hopefully, this research can contribute any benefits for those who involved in this research as follow.

1) For students: through this instruction which is by inserting or integrating the mathematics, technology and engineering process onto biological context can extend students to associate their learning experiences. Even though, by integrating other relevance concepts from different perspectives onto biology concept can build the possitive athmosphere and make students aware that 'comprehensive learning' is very important. It also can supply and provide some skills (communication and thinking skills) for the students in facing 21st century. Another worth considering is how inter-textual processes affect scientific discourse and argumentation. Students today have access to many sources of scientific information that transcend the boundaries of the classroom – the internet, books, magazines, textbooks, museums, lectures, science centers, movies, TV, and so forth.
2) For teachers: it is one of the challanges for teachers to improve quality of teaching and provide students the adequate learning experiences in 21st century based education. It is important to recognise that other disciplines share some of these values. However, what distinguishes science is the application of the combination of this value in determining the worth of any new idea or theory. We should seek to examine the use and development of argumentation across multiple-disciplinary contexts (e.g.: food production, human health, environmental issues, an so on) that transcend the boundaries of the school science laboratory. As teachers, we need to learn more about how

these diverse sources can be incorporated in the argumentation discourse of classroom. Besides, this research produced a set of three-tier test instruments on plant reproduction topic that has been validated and tried out limitedly. The reseacher hope that it can inspire the other teachers and educators to develop the test instrument which able to explore students' thinking and understanding comprehensively and can detect students' misconception about certain materials.

3) For other reseachers: the result of this research can lead the way in facing 21st century challanges. Integrative attitudes and approaches will lead to innovative, progressive, and enlightened in the 21st century. It can be a choice for curricula designer to construct the new strategy for conducting the collaborative teaching and research in cross-discipline or interdisciplinary ways.

F. Organization of the Writing

Chapter 1 gives introduction of the research, and it consist of six subchapters which are background of the study (A), statements of problems (B), purpose of the study (C), problem limitation (D), significance of the study (E), and organization of the writing (F). Chapter 2 comprehensively discusses theories used in this research, which include interdisciplinary thinking skill (A), argumentation as representation of thinking process (B), STEM-based instruction (C), and characteristic of plant reproduction. Chapter 3 present the operational definition (A), data source (B), research design (C), instrumentation (D), data processing (E), data analysis (F), and summary of the previous subchapter (of chapter 3) in the procedure of the study.

Chapter 4 include the findings and discussion of the study which organized into several subchapter based on the design of the study into: (A) interdisciplinary thinking skill (B) argumentation level, and (C) correlation between students' interdisciplinary thinking skill and argumentation level. Finally, in chapter 5 conclusion (A), recommendation (B) and limitedness of the study complete this paper.