THE INFLUENCE OF INVENTIVE THINKING AND MENTORING TOWARD THE ACHIEVEMENT IN SCIENCE PROJECT COMPETITION IN INDONESIA

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SULTAN IDRIS EDUCATION UNIVERSITY

2021

THE INFLUENCE OF INVENTIVE THINKING AND MENTORING TOWARD THE ACHIEVEMENT IN SCIENCE PROJECT COMPETITION IN INDONESIA

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THESIS PRESENTED TO QUALIFY FOR A DOCTOR OF PHILOSOPHY

FACULTY OF TECHNICAL AND VOCATIONAL
SULTAN IDRIS EDUCATION UNIVERSITY

2021

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ACKNOWLEDGEMENT

I wish to express my sincere appreciation to those who have contributed to this thesis and supported me one way or the other during this amazing journey. I would like to express my sincere gratitude to my supervisor, Prof. Dr. Ramlee Mustapha, for the patient guidance, encouragement and advice she has provided throughout my time as her student. I have been extremely lucky to have a supervisor who cared so much about my work, and who responded to my questions and queries so promptly. It would never have been possible for me to take this work to completion without their incredible support and encouragement.

I would also like to take this opportunity to thank Prof. Dr. Widad Binti Othman, Prof. Madya Dr. Mohamed Nor Azhari Azman, and Prof. Dr. Yahya Buntat - my viva examiners, for their valuable insights, comments and suggestions, leading to many improvements in the thesis. My gratitude also goes to Surya University and Center for Young Scientists Indonesia for the encouragement and financial support. I thank all the members of staff at Institute of Postgraduate Studies in UPSI who helped me with all administration affairs.

In particular, I would like to thank Dr. Farah Kristiani, Dr. Leila Susanty, Silka Abyadati, Ms. Sarvathy Terpari Thirupathy, M.Pd., Asep Irvan Irvani, and I.G.N. Mindra Jaya, for the fruitful discussion on methodological approach. I owe thanks to a very special person, my husband, Dr. I G.W. Samsi Gunarta for his continued and unfailing love, support and understanding during my pursuit of Ph.D degree that made the completion of thesis possible. You were always around at times I thought that it is impossible to continue, you helped me to keep things in perspective. I greatly value his contribution and deeply appreciate his belief in me. I appreciate my lovely children, Paksi, Arini, and Komang, for the patience they showed during my study and thesis writing. Words would never say how grateful I am to all of you. I consider myself the luckiest in the world to have such a lovely and caring family, standing beside me with their love and unconditional support.

ABSTRACT

The purpose of the study was to identify the influence of inventive thinking and mentoring toward students' achievement in science project competition. TRIZ and the 21st Century Learning Skills models were used as the underpinning theories in this study. A survey method was used in this study. The instruments consisted of two sets of questionnaires, open-ended items, and an interview protocol. The qualitative data collected from the interview were used for triangulation purpose. The samples of this study were 250 students and 81 mentors were selected using stratified random sampling from ten different sites in Indonesia. The results of the questionnaire showed that both the students and the mentors believed that curiosity ($M = 4.38$; $SD = 0.41$) and adaptability ($M = 4.31$; $SD = 0.42$) were the major elements, and enterprising was the minor element of inventive thinking. The students rated supervision ($M = 4.49$; $SD = 0.41$) and coaching ($M = 4.46$; $SD = 0.40$) as high priority, and research skills ($M = 4.38$; $SD = 0.50$) as the lowest priority. Mentors, on the other hands, rated relationship ($M = 4.52$; $SD = 0.44$) as high mentoring skill, and role model ($M = 4.28$; $SD = 0.42$) as low concern in mentoring. The regression analysis suggested curiosity ($\beta = 0.403$), risk-taking ($\beta = 0.402$), communication ($\beta = 0.551$), and coaching ($\beta = 0.601$) as dominant factors that affect students' success in the science project competition. Qualitative data from interview analyzed through thematic analysis found several themes pertinent to the success of students in science competition such as curiosity in observing the real problems, presentation and communication skills. In the open-ended items, the major barriers for the students to win science project competition were lack of creativity (good ideas), and lack of infrastructure (good science lab). The students also rated good mentors were those teachers who were accessible, friendly, supportive and could provide effective advice and coaching. In conclusion, the empirical data supported the study assertions that the students' science achievement was influenced by their inventive thinking and effective mentoring. The main implication of the study is that a new framework of inventive thinking and mentoring developed from this study could be used by institutions that train students to compete in science fairs.

PENGARUH PEMIKIRAN INVENTIF DAN BIMBINGAN TERHADAP PENCAPAIAN DALAM PERTANDINGAN PROJEK SAINS DI INDONESIA

ABSTRAK

Tujuan kajian ini adalah untuk mengenalpasti pengaruh pemikiran inventif dan bimbingan terhadap pencapaian pelajar dalam pertandingan projek sains di Indonesia. Model TRIZ dan model 21st Century Skills telah digunakan sebagai kerangka teori kajian ini. Kaedah tinjauan telah digunakan dalam kajian ini. Instrumen kajian terdiri daripada dua set soal selidik, item terbuka dan protokol temubual. Data kualitatif dikumpul daripada temu bual untuk tujuan trangulasi. Sampel kajian adalah seramai 250 orang pelajar dan 81 orang mentor yang dipilih secara rawak berstrata daripada 10 tempat pertandingan di Indonesia. Dapatan daripada soal selidik menunjukkan bahawa pelajar dan mentor percaya bahawa rasa ingin tahu (M=4.38; SP=0.41) dan keupayaan menyesuaikan diri (M=4.31; SP=0.42) adalah elemen yang terpenting dalam pemikiran inventif manakala *enterprising* adalah elemen kurang ditekankan. Pelajar juga menyatakan penyeliaan (M=4.49; SP=0.41) dan kejurulatihan (M=4.46; SP=0.40) adalah sangat penting manakala kemahiran penyelidikan (M=4.38; SP=0.50) dianggap kurang penting. Mentor pula mengatakan membina hubungan (M=4.52; SP=0.44) sangat penting manakala menjadi model ikutan (*role model*) (M=4.28; SD=0.42) tidak begitu penting. Analisis regresi pula menunjukkan rasa ingin tahu (β=0.403), mengambil risiko (β=0.402), komunikasi (β=0.551), serta kejurulatihan (β=0.601) sebagai faktor dominan yang mempengaruhi kejayaan pelajar dalam pertandingan projek sains. Data kualitatif daripada temubual dianalisis melalui analisis tematik menunjukkan beberapa tema kemahiran yang penting kepada kejayaan pelajar untuk berjaya dalam pertandingan sains adalah rasa ingin tahu dalam memerhati masalah sebenar, kemahiran pembentangan serta kemahiran komunikasi. Namun halangan utama bagi pelajar untuk memenangi pertandingan projek sains adalah kurang kreativiti (idea yang baik), dan kekurangan infrastruktur (makmal sains yang baik). Karakter mentor yang baik adalah guru yang mudah diakses, mesra, menyokong dan dapat memberikan nasihat dan bimbingan yang berkesan. Kesimpulannya, data empirikal kajian menyokong pernyataan kajian bahawa pencapaian sains pelajar dipengaruhi oleh pemikiran inventif dan mentor yang berkesan. Implikasi utama kajian ini adalah pembangunan kerangka pemikiran inventif dan mentoring yang baharu berdasarkan dapatan empirikal kajian yang boleh digunakan di institusi yang melatih pelajar untuk bertanding dalam petandingan sains.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Science competition is not a new phenomenon. Historically, science competition or science fair dated back to 1942 when William Emerson Ritter and Edward W. Scripps created “The Science Talent Search” for high school students in the United States (Cox, 2018). At the early stage of science fair in the United States, it was defined as a collection of exhibits, each of which was designed to show a science or technical principle, an experiment, an industrial development, or an orderly collection which fit into the broad concept of pure or applied science. After decades, science fair has been growing fast and spread around the world. One of the largest competitions in the world is International Science and Engineering Fairs (ISEF), which started in 1950 and later sponsored by INTEL since 1997 (Marx, 2004). There was also another type of science competition called Science Olympiad. Science Olympiad was subject-specific and originated in Eastern bloc region. For example, International Mathematical Olympiad (IMO) began in 1959 in Romania (Gregor, 2006). Early editions of the Olympiads were limited to the Eastern bloc countries (Turner, 1971) but later they gradually spread to 107 countries (Gregor, 2006).

The main goal of the science competition is to provide opportunity for the students to construct new knowledge, to innovate, and to increase their interest in science through scientific inquiry and scientific methods (Abernathy & Vineyard, 2001). The difference between science olympiad and science project competition can be seen from the concept of the competition. In the science olympiad, the students compete individually or dyadic ally to solve a given problem while in science fair the students work in a team according to a proposed challenge or problem (Abernathy & Vineyard, 2001; Dionne et al., 2012) In science fair, the students conduct a science project in a given subject area by using research and scientific skills to solve a real problem. The output of the science fair can be in the form of a new knowledge, a model or a product. Also, in science project competition or science fair, the participants are expected to expose the results of their work in the scientific poster exhibition and to present their research orally to the panel of judges (Tortop, 2013). However, there was limited studies related to the students' achievement in science project competition (Czerniak, 1996; Longo, 2012).

The quality product of science and technology could be assessed from the aspects of novelty and innovation. In producing an innovative product of science and technology, inventive thinking is needed (Orloff, 2006). EnGauge 21st century skills model has included inventive thinking as one of its critical domains in order to achieve academic success in the digital era (Burkhardt et al., 2003). In addition, according to Czerniak (1996), Jackson and Buining (2011), and Marsa (1993), inventive thinking is pertinent to win a science competition with proper mentoring and supervision.

In the context of inventive thinking, Burkhardt et al. (2003) and McClelland (1987) have included several sub-constructs that can be used to measure inventive thinking, namely, adaptability, self-direction, curiosity, creativity, risk-taking, higher order thinking and enterprising. Besides the theoretical importance of these elements as the foundation of inventive thinking, the empirical data also supported the assertion that these elements are worthy to be studied (Abdullah & Osman, 2010; Burkhardt et al., 2003; Kozlowski et al., 2001).

According to Greef and Ritman (2005), adaptability is the key skill for students to be resilient in conducting their project in order to search for optimal solution. But few studies have been conducted to examine the importance of this sub-construct of inventive thinking especially in project-based learning (Lee et al., 2015). Closely related to adaptability is the individual's self-directed learning. Based on some empirical studies, self-direction and independent learning are critical in project-based learning (Prince et al., 2005). However, the lack of field studies that relate independent learning and science achievement would create a significant gap in the present literature (Choi et al., 2013).

Literature also highlighted the importance of curiosity and creativity in science project competition (Abernathy & Vineyard, 2001). Invention would not happen if people are not curious and creative. In several young scientist programs, curiosity and creativity are the key aspects to be nurtured (Marx, 2004). As the foundation of inventive thinking, curiosity and creativity require the optimal use of the right brain in order to spark new idea for the students' science project (Perlovsky et al., 2010). Nevertheless, there is an obvious paucity of empirical research on curiosity and creativity in science competition.

In winning science project competition, literature has also emphasized risk-taking, higher order thinking and enterprising (Marx, 2004; McClelland, 1987; Society for Science, 2020). According to Tjosvold and Yu (2007), success is seldom achieved if an individual is afraid to try and to make mistakes. To produce scientifically-based products and invention, initial experiment may not provide the desired results at the first run. In some cases, the experimenters may have to modify their research design or materials in order to achieve the optimal solution. This requires risk-taking and higher-order thinking. Higher-order thinking is the cognitive process of asking "why" questions. Finally, inventive thinking is closely related to enterprising mind where individuals look at things from different and alternative perspectives (Gartner, 1989). Several new inventions are created based on the "outside of the box" thinking. In the context of science project competition, however, few empirical studies have been conducted to determine the effects of risk-taking, higher-order thinking and enterprising on students' achievement in winning the science competition (Yee et al., 2011).

Based on project-based literature, the link between inventive thinking and mentoring to win science project competition is scarce (Marsa, 1993). However, several studies have shown that a proper mentoring could have a significant impact on the students' academic achievement (Jacobi, 1991). Theoretically, mentoring is a critical construct in facilitating students' achievement in schools. Specifically, in science project competition, according to Creswell (2008) and Lane (2004), mentoring consists of relationship, supervision, communication, role-model, coaching and research skills. The success of science project competition depends on the strength of the relationship and the effectiveness of the supervision between mentors and mentees (DuBois et al., 2006). But there are differences in terms of the key indicators for relationship and supervision. Relationship focuses on building trust, defining roles and responsibilities, establishing short and long-term goals and collaborating to solve problem, whereas supervision stresses on providing support, opportunity and conducive environment in guiding and nurturing supervisees to grow and achieve their potential (Byington, 2010; Cooper & Forrest, 2009).

In terms of science project competition, however, both elements are critical to be examined. But few studies have been conducted to investigate the roles of relationship and the dynamics of supervision in winning science project competition (Crisp & Cruz, 2009; DuBois et al., 2006). Relationship in mentoring could be maintained through building a good communication between the two actors of mentoring (Adu-Oppong & Agyin-Birikorang, 2014). In mentoring relationship, communication must be developed between the mentor and the mentee. According to Keyton (2011), communication is the transformation of information or common understanding from one person to another. According to Adu-Oppong and Agyin-Birikorang (2014), communication is a critical factor in mentoring. Nevertheless, the empirical studies that examined the effective communication between students and mentor in science project competition are scarce (Scielzo, 2011).

Besides relationship, supervision, and communication, according to Lane (2004), other pertinent factors of mentoring are role modelling and coaching. Role model is a person whose behavior, example and success is or can be emulated by others, especially younger people. Good traits of a role model include confidence, leadership, effective communication, knowledgeable, empathy, and being helpful (Zwilling, 2010). Coaching, on the other hand, is a process of nurturing a person by using critical strategies such as effective listening, asking relevant questions, using feedback, demonstrating, and providing encouragement and support (Canfield & Chee, 2013). Despite the large number of studies on mentoring, Kotter (cited in Orth et al., 1987) argued that there was not much evidence on role modelling and coaching in developing the next generation. According to Cullen (1993), coaching was related to career function by improving performance, while role-modelling was related to psychological function by projecting behaviors and skills. In the context of science project competition, the students can learn science through the teacher as the role model in conducting the science project. Hence, the teacher who engaged students in the science project competition must be seen as a good role model or a coach.

In conducting experiment, research skills are critical for students who involved in empirical research such as conducting a science project. The quality of the science project is often evaluated based on student's research skills (Discovery Education, 2020). According to Creswell (2008), research skills are defined as individual ability to collect and analyze data in order to answer the research questions and ultimately to enhance his or her understanding of the subject under study. In the preparation for the science project competition, the teacher (mentor) should be trained to impart research skills to their students.

As previously mentioned, one of the goals of science project competition is to enhance the creativity and innovativeness of the students. However, literature has shown that, in general, Asian students are less creative and innovative than their western counterpart (Hannas, 2003; Kim, 2005; Lau et al., 2004; Ng, 1999). To move forward, Asian schooling systems should be transformed to enhance the scientific progress in the region. As part of significant countries in the region, Indonesia faced the challenge to upgrade its education system to be at par with OECD countries. However, lack of empirical studies regarding the performance on Indonesian secondary school students in science fair and competition makes it difficult for the policy makers to suggest new initiatives. Hence, it is critical to examine the influence of inventive thinking and mentoring on the students' achievement in science competition in Indonesia.

Indonesia was selected in this study due to its rapidly emerging economy. To be a major economic force in the Southeast Asian region, Indonesia was training its youngsters to be creative, innovative, and entrepreneurial (Directorate General of Secondary Education, 2014). Indonesia was rigorous in sending its youngsters to compete in science competitions locally and internationally, some of them were awarded as champions (Hendayana et al., 2010). The competitions were in the forms of science olympiad or science fair. In general, teachers and parents encourage their students and children to participate in scientific competition, especially for those who intend to enter higher education. Nowadays, several universities in Indonesia seek students with not only high academic achievement but also with high achievement in science competitions (Masruroh, 2009).

However, science project in the form of research is not a common practice in secondary schools in Indonesia – it is being practiced separately as laboratory activities (Permanasari, 2010). Laboratory activities provide instructions on special tasks and special topics in line with classroom lesson, implying less freedom for the students to design a science project. Based on report by Poluakan (2012), Indonesian students have low scores in the three aspects of PISA's assessment: identifying scientific issues, describing phenomena in scientific way, and utilizing scientific evidence. Small numbers of school in Indonesia, which mostly international schools, have included research in their curriculum. Students in these schools were taught with the "inquiry learning" method, which lead them smoothly to the concept of scientific inquiry. Students are required to complete final projects at the end of each year as part of the final examination. Different scenario will be found in public or government schools, where students experience conventional style of learning, which is teacher centered (Bahri, 2013). In public schools, students who have strong interest in conducting research are expected to join out of school activities, or chose science club as an extra curriculum activity.

Supports for students in completing their academic tasks could be in many forms. The learning environment, including parents at home and teachers at school, has its role in students' achievement in academic success (Henderson, 2004). It is believed that effective mentoring process could improve students' academic performance, as well as their attitude toward science competition (Rhodes et al., 2009). In mentoring, a teacher intends to assist students in completing particular tasks, as well as reaching broaden goals (Jacobi, 1991). Mentoring model at school could be either embedded, ad- hoc, social, or self-help depends on its structure and formality (Cranwell-Ward et al., 2004). Nevertheless, few studies have been conducted on mentoring students in science project competition.

In the nut shell, based on the literature and past empirical research, the main challenges faced by young participants in science competition include the lack of inventive thinking (Bahri, 2013) and poor mentoring on science project (Wardani, 2019). Thus, it is critical to conduct this study in order to identify the influence of inventive thinking and mentoring process on the students' achievement in science competition.

1.2 Background of the Study

In the era of the fourth Industrial Revolution and digital transformation, learning models have changed. The use of artificial intelligence, robot and digital simulations in learning have enhanced human-machine interaction. Despite the demands on new and different abilities to face the revolutionary world in the 21st century digital era, the skills needed such as creativity and problem solving are not new (Rotherham & Willingham, 2009). For example, competencies in information literacy, global awareness, digital literacy, inventive thinking, effective communication, high productivity, and mastery of different kinds of knowledge are critical. Furthermore, Rotherham and Willingham (2009) argued the importance to prepare the students with future skills that should be included in the school curricula. Hence, it is critical to examine varied learning models that could enhance students' inventive thinking.

There are several models of new way of learning to face the 21st century challenges such as the model of Partnership for the 21st Century Skills, or in short P21 (Trilling & Fadel, 2009), and the enGauge report on the 21st century learning (Burkhardt et al., 2003). The P21 proposed the framework of learning through the famous rainbow shaped framework (see Figure 1.1). At the center of the rainbow lies the core subjects which are the traditional subjects, and 21st century themes which are the key issues of the digital. The core subjects and the 21st century themes are surrounded by the three skills: (1) learning and innovation skills, (2) information, technology, and media skills, and (3) life and career skills. The first skill is related to critical thinking, problem solving, communication, collaboration, creativity, and innovation. The second skill comprised information literacy, media literacy, and ICT (information, communication, and technology) literacy. Finally, the third skill included flexibility and adaptability, initiative and self-direction, social and cross-cultural interaction.

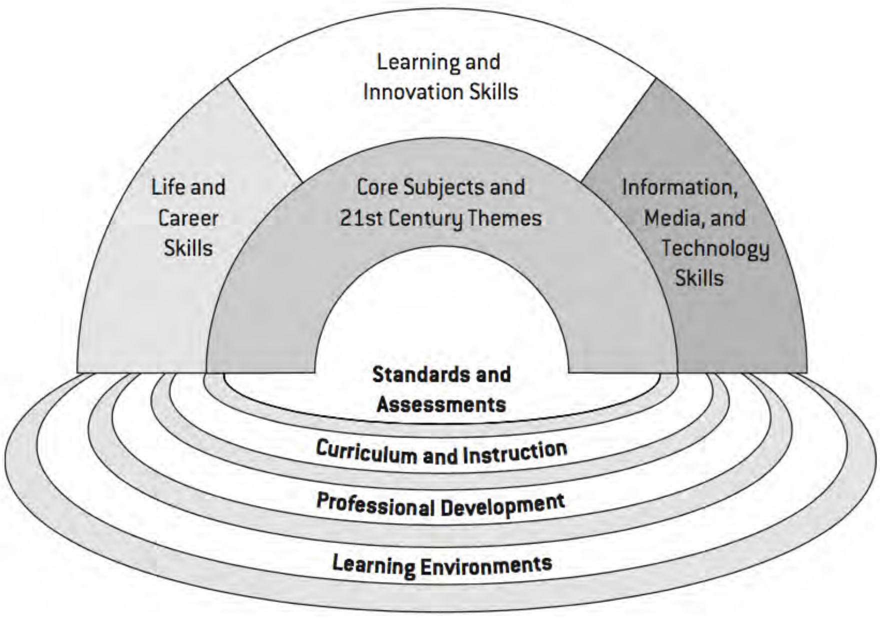

Figure 1.1. The P21 framework for the 21st century learning (Trilling & Fadel, 2009)

Another model of the 21st century learning is the enGauge model (see Figure 2.1) which highlighted four dimensions (Burkhardt et al., 2003). The first dimension is digital-age literacy which comprised eight elements: basic, scientific, economic, technological, visual, information, and multicultural literacy, and lastly is global awareness. The second dimension of the 21st century skills is inventive thinking, which covered six elements: adaptability, self-direction, curiosity, creativity, risk-taking, and higher-order thinking. The third dimension of the model is effective communication, which comprised five constructs: teaming and collaboration, interpersonal skill, personal responsibility, effective communcation in social and civic responsibility, and interactive communication. Finally, the fourth dimension in the enGauge 21st century model is high productivity, which covered three parts. Part one includes managing aspects such as prioritizing, planning and implementation. Part two focuses on real-world tools, and part three is related to production of relevant and high quality products.

The P21 and enGauge 21st century learning models both mentioned the importance of innovative and inventive thinking skills. The concept of inventive thinking was started by Altshuller in 1996 in his TRIZ model. The TRIZ concept was to re-inventing the inventions. The process of thinking started at the point of re-inventing, where the initial problem emerged (Orloff, 2006). At this point, critical questions arose regarding the problems that were not solved at the earlier phase (known as “conflict”), and the later solution to the conflict would lead to making a better product with new features as the innovation. In this way, the process of invention could be learnt by following, or navigating, the steps developed by TRIZ. According to Gadd (2011), several steps were grouped in TRIZ such as Segmentation (Principle 1), Taking Out or Extraction (Principle 2), Local Quality (Principle 3), Asymmetry (Principle 4), and

Merging or Consolidation (Principle 5). In employing the TRIZ to solve a problem, a navigator is needed, and the navigator must be creative (Orloff, 2006). Creativity in TRIZ refers to the process of inventing new system, advising next generation system, and coming up with varied new ideas (Gadd, 2011).

In TRIZ, the levels of invention could be determined using the rubrics to describe the problem (Orloff, 2006). The description of the problem included the initial condition, resources, degree of difficulty, degree of improvement, and the level of innovation. Each aspect will be examined by five levels of invention. Level one is rationalization, level two is modernization, level three is principle, followed by level four which is synthesis, and lastly, level five is discovery. Hence, it could be said that TRIZ promotes creativity, invention and inventive thinking through the navigational tool.

Inventive thinking is the precursor to invention. Scholars such as Altshuller (1996) and later Henderson (2002) have studied the professional inventors. Henderson (2002) has identified five dimensions of invention: novelty, utility, cost-effectiveness, impact in market, and patent. The dimensions showed the importance of originality, benefits to the society, economic aspect, and recognition by the experts. Several traits of the successful professional inventors found in Henderson's (2002) study were tenacious, persistent, focused to problem-solving, open to new experience, and intrinsically motivated. These characteristics are in line with the desired outcomes of the enGauge 21st century skills model.

In the context of education, teachers should be trained to equip the students with the 21st century skills. Nevertheless, the assessment of the learning itself is important. One of the types of assessment for learning is performance assessment (Potter, 2009). Performance assessment was proposed by Shavelson et al. (1991), with the guidelines to use it as follows: (1) to capture the students' understanding, reasoning, and problem solving, in novel and creative processes; (2) to obtain responses from the students, mostly from the hands-on activities; (3) to use advance computer technology for the long-term activities; (4) to use alternative technology to reflect the understanding of the students; (5) to utilize alternative technology in the assessment that is aligned with the curricula.

Looking at the guidelines of the performance assessment developed by Shavelson et al. (1991), a science project competition or a science fair could function as performance assessment on the science learning. The science project itself should meet the conditions in the Shavelson et al. (1991) guidelines. In brief, the assessment must capture: (1) students' scientific understanding, reasoning, problem solving, novelty, creativity, and (2) students' understanding which reflected from the structure of the students' knowledge.

Science project competition or science fair has been very popular for pre-college students nowadays. One of the largest science fairs in the world is the INTEL International Science and Engineering Fair (INTEL ISEF) which started in 1950 (Marx, 2004). Several millions students from 65 countries around the globe participated in this international fairs, more than s 65,000 of them went to the final round (Rilero & Zambo, 2011). Students in grades nine to twelve at the secondary schools are eligible to participate in this competition, and each student only allowed to be involved in one project. The science project must be conducted in the maximum period of twelve-months. In case that the project is part of the bigger project involving professional researchers, the students can only exhibit the part that is their work. In ISEF, students exhibited their science project through scientific poster, supported by the demonstration of the experiment, or the product of their research. The judges will look through the project for the evaluation, based on the judging criteria as follows: clarity of the purpose and research questions, appropriateness of the methodology, and contribution of the science project to the field of the study. The judges also assess the research design, data analysis, and data collection methods. On top of that, the participants are expected to show their creativity in their science project (Society for Science, 2020).

Besides INTEL ISEF, another science project competition for secondary school students namely International Conference of Young Scientists (ICYS). This competition started in 1994 in Hungary (ICYS, 2020). Students aged fourteen to nineteen are eligible to enter the ICYS competition. There are six categories in ICYS: Mathematics, Physics, Engineering, Computer Science, Life Sciences, and Environmental Science. In ICYS, the students should exhibit the scientific poster, and present their project orally. The judging criteria of the ICYS are almost the same as ISEF, such as: (1) clarity of the problem statement and the research questions; (2) proper research design and methods; (3) effective presentation and argumentation; and (4) demonstration of strong scientific foundation.

Another example of a science project competition is the Asia Pacific Conference of Young Scientists (APCYS). This science project competition started in Indonesia in 2012. The aim of APCYS is to promote and encourage young students to be curious in science and to embark on scientific research (Center for Young Scientists, 2013). APCYS participants are students at the level of junior or senior high schools, aged between thirteen to eighteen years old. The science projects are presented in this competition in the forms of scientific poster and oral presentation. Evaluation on the APCYS project covers research question, statement of the problem, experimental design, research methodology, and scientific foundation.

Even though science project competitions focused on the rigorosity of the scientific methods and the innovation of the projects, the mentoring could be an influential factor to win science project competition. Hence, according to Marsa (1993), mentoring could attribute considerably to the success in the science competition. There is an abundance of definitions of mentoring found in the literature. Most of the definitions described mentoring as an interaction of a more-experienced person to a less-experienced person (Schunk & Mullen, 2013). This definition tells about the relationship of persons who involved in mentoring. For example, in the context of science project competition, the more-experienced person is the teacher, and the less-experienced person is the student (Lee, 2007). The experience of the teacher referred to his or her expertise in research or in conducting scientific experiments and in employing research skills. In mentoring science project, the mentors are expected to possess certain competencies such as an effective communicator, a knowledgeable supervisor and a reliable coach, a role model and a skilled researcher (Johnson, 2015; Lane, 2004). In mentoring, there are several roles of a mentor such as, a teacher, a tutor, a guide, a coach, a sponsor, a facilitator, and a role model (Dominguez & Hager, 2013; Lee, 2007).

Mentoring can be categorized in various ways, for example, in the context of the educational programs, there are formal and informal mentoring. Formal mentoring is referred to a classic or a traditional mentoring via one-on-one or face-to-face interaction. Informal mentoring often refers to non-traditional mentoring such as group mentoring, online mentoring or virtual mentoring (Miller, 2007; Schunk & Mullen, 2013). Despite the variety of mentoring categories, the most important goal is to ensure the effectiveness of the mentoring. DuBois et al. (2006) and McCann (2013) asserted that the relationship between the mentor and the mentee is the most important factor to produce an effective mentoring.

Besides mentoring, other moderating variables could affect the success in a science project competition. Literature has shown that internal predispositions such as interest, attitude, motivation, self-efficacy and the external factors such as parental support and teacher's recognition could influence the student's chance of winning a science competition. Several empirical studies have provided the evidence as follows. Czerniak (1996) studied from both students' and parents' sides such as parental influences, self-concept, motivation and anxiety as the predictors of success in a district science fairs covering six counties in Northwest Ohio in March 1992. Dionne et al. (2012) explored the students' motivation toward their achievement in the Canada-Wide Science Fairs in 2008. They found five components to explain student's motivation in participating in science competition: interest in science, high motivation, strong self-efficacy, appreciation to student's work such as achievement, reward or gratification, social aspect of participating, and effective learning strategies. A study conducted by Fisanick (2010) on teacher behaviors, reported how teacher attitudes affected the achievement of their students in science fairs.

Despite the key factors that influence the success in science project competition, such as motivation and attitudes – the demography of the students could also affect to the achievement in science project competition. Miller (2007) reported that there was a difference in preference of choosing a mentor between male and female students. In addition, Schunk and Mullen (2013) proposed researchers to investigate potential moderating factors such as gender that could be affect the relationship between mentors and protégés. Next, specific problems related to inventive thinking, mentoring and the issues of science competiton are discussed in the statement of the problem.

1.3 Statement of the Problem

The report on PISA from 2000 to 2015 showed that Indonesia was below the average of the international PISA scores in science literacy. The 2013 national curriculum has incorporated research and the 21st century skills but it was corrected in 2016 due to the lack of readiness of the teachers and the students in adopting the 21st century skills. Several studies have reported the lack of science skills of Indonesian students has detrimental effect on Indonesia's ranking in PISA and TIMSS. Hence, science and higher-order thinking skills are important to be taught in schools. Higher-order thinking is a precursor to inventive thinking.

The PISA assessment revealed that Indonesian students, in general, have scored lower in the three aspects: identifying scientific issues, scientifically describing phenomena, and utilizing scientific evidence (Poluakan, 2012). A small number of schools in Indonesia have included research in their curriculum, which are mostly international schools. Students in the international schools are taught with the "inquiry learning" method, which leads them smoothly to the concept of the scientific inquiry. Students are required to complete their projects at the end of each year as part of the final examination. A different scenario, however, will be found in public or government schools, where students are taught with conventional style of teaching which is more teacher-centered (Bahri, 2013). In the public schools, students who have a keen interest in doing research are expected to join out of the school activities or choose science club as an extra-curriculum activity.

In general, the main problem faced by young participants in science competition is the lack of creativity (Bahri, 2013). A study on problem-based learning conducted by (Suparman & Husen, 2016) confirmed that the low creativity of Indonesian students. Moreover, several studies reported lack of creativity of the Indonesian students in science projects (Noer, 2011; Sugiyanto & Masykuri, 2011). Another study found that lack of creativity in a science project is due to the lack of science skills (Subali, 2011).

Moreover, based on the PISA report from 2000 to 2015, Indonesian students have had low scores in science literacy as compared to the average international score (Poluakan, 2012). The low scores indicated that Indonesian students were still lagging behind the other advanced countries such as OECD countries in terms of science and mathematics achievement. In 2013, national curriculum in Indonesia was reformed to integrate the 21st century skills. Critical elements in science literacy and inventive thinking such as higher-order thinking, creativity, self-direction, and risk-taking were derived from enGauge model of 21st century skills. They were embedded in the curriculum but the teachers' readiness to implement the curriculum was questionable. Most teachers were not equipped and trained to teach students using the new paradigm of scientific inquiry. Krisdiana et al., (2014) conducted an empirical research on the implementation of the new national curriculum in five provinces in Indonesia. The study reported that both the teachers and the learners faced difficulty in a new curriculum. There was inadequate time for the learners to observe and conduct experiments, whereas the teaching became challenging to the teachers because they were not ready to teach in a new way.

Another indicator of poor science literacy among Indonesia students was unimpressive performance of Indonesian students in international science project competitions or fairs. At international science competitions and olympiads, in general, Indonesian students seldom gain the top places. Scientific and higher-order thinking may be lacking in Indonesian secondary school students. Based on the relevant literature, higher-order thinking plays a vital role in linking the scientific literacy to inventive thinking (Burkhardt et al., 2003).

In addition, according to Pannen and Jamaludin (2003), Indonesian teachers have poor creativity in teaching at schools; they tend to be conformist and uniformist in a sense that they were trained to follow the conventional way of teaching than to try new strategies. Pannen and Jamaludin (2003) also believe that teachers in Indonesia were afraid to be different from the others. Applying the concept of joyful and meaningful learning based on constructivist theory seems to be foreign to the majority of Indonesian teachers. In the context of mentoring in science project, science teachers were not properly trained as a mentor or as a coach. Despite the findings from literature that good mentoring could enhance students' achievement in science project competition, several empirical studies for examples Pidcock et al. (2000), Jackson et al. (2003), Bogat and Redner (1985), and Presbury et al. (2005) have reported poor preparation of students to enter science competitions due to poor mentoring and coaching.

In summary, the researcher found the low achievement in science and mathematics of the students in Indonesia, including in science project competition. The evidence showed that in conducting a science project, inventive thinking is needed. Thus, it is critical to identify which elements of inventive thinking influence the success in science project competition. The evidence also showed that the capability of the teachers did not support the learning process. It is important to determine the elements of mentoring which lead to win a science project competition.

1.4 Conceptual Framework

A conceptual framework is needed to explain the relationship among the pertinent variables in this study. Figure 1.2 shows the conceptual framework of the study. It is based on several theories and models. There are two independent variables in this study – inventive thinking and mentoring. And the dependent variable is the student achievement in the science project. The first independent variable that is the inventive thinking. Inventive thinking, as a construct, is theorized by Altshuller (1996) as the ability to solve problem or create innovative products. The critical elements in inventive thinking were derived mainly from enGauge 21st century skills model by Burkhardt et al. (2003) that comprised adaptability, self-direction, curiosity, creativity, risk-taking and higher-order thinking. The final element of inventive thinking which is enterprising was derived from McClellan's (1987) theory.

The first sub-construct of inventive thinking is adaptability, which according to Morris et al. (1999), is the ability to manage multiple tasks and changes in the environment. Self-direction, as the second sub-construct of inventive thinking, is a personality trait of self-determination, self-reliance, self-sufficiency, independence and locus of control (Cloninger et al, 1993). Next, Berlyne (1954) theorized curiosity as a drive to learn and gain knowledge in reaching a goal, whereas Amabile (2012) theorized creativity as the ability to produce novel and useful ideas. In terms of risk-taking, Burkhardt et al. (2003) defined it as one's willingness to make mistakes, advocate unconventional or unpopular positions, or tackle extremely challenging problems in facing uncertainty. The sixth sub-construct of inventive thinking is higher order thinking skills which according to Conklin (2011) is a critical and careful judgment to evaluate, to make inference, to interpret and to solve problem. The final element of inventive thinking is enterprising which is theorized by McClellan (1987) as a quality of a person who is resourceful, confident, persistent, possess strategic mind to find opportunities and to build network.

The second independent variable in this study is mentoring. Kram (cited in Bozeman and Feeney, 2007) theorized mentoring as a symbiosis relationship whereby a senior or more experienced person (the mentor) provides psychosocial support, career guidance, role modelling, and coaching to a junior person (the protégé). The specific sub-constructs of mentoring are taken from Lane (2004), which consist of relationship, supervision, communication, role model, and coaching. The sixth sub-construct of mentoring is research skill which is critical in mentoring science project according to Creswell (2008).

The first sub-construct of mentoring is relationship, which conceptualized by Byington (2010) as a process of building trust, defining roles and responsibilities, establishing short and long-term goals and collaborating to solve problems. The second sub-construct is supervision which is theorized by Cooper and Forrest (2009) as the facilitation process to provide supportive opportunity and conducive environment to guide and nurture supervisees to grow and achieve their potential. Next, communication is also a critical element in mentoring. According to Keyton (2011) communication is a two-way process to exchange thoughts, ideas, and emotions and to convey and discuss meaning or to provide feedback by using oral, written or gesture to achieve common understanding. Related to communication is a role model which is pertinent in mentoring. Role model is a respected person who could be emulated by others especially by younger generation. Zwilling (2010) hypothesized the traits of a good role model which include confidence, leadership, effective communication, knowledgeable, empathy and being helpful.

The fifth sub-construct of mentoring is coaching which could be defined as a form of development in which an expert or experienced person train a learner or a client to achieve a specific personal or professional goal by providing training or guidance.

Canfield and Chee (2013) theorized that coaching is a process of nurturing a person by using critical strategies such as employing effective listening, asking relevant questions, using feedback, demonstrating, and providing encouragement and support. Finally, the sixth sub-construct of mentoring is research skill which is critical in science competition. Creswell (2008) defined research skill as an individual ability to collect and analyze data or information in order to answer research questions and ultimately to enhance his or her understanding of the subject under study.

As mentioned earlier, the independent variables in this study were inventive thinking and mentoring. The dependent variable of this study was achievement in science project competition which was the score given by the jury to each student who participated in the science competitions (Albert, 2011). Besides the independent and dependent variables, there were also moderator variables – gender, level and of schools, attitude and motivation. These moderator variables were selected based on the previous empirical research which stated that these variables may have affected the students' achievement in science competition (Czerniak, 1996; Fisanick, 2010; Hara, 2012).

The other underpinning theories that have been used in this study include behaviorism, cognitivism, constructivism, and connectivism. Behaviorism is a learning theory which explains the changes of behaviors occur due an individual's response to the external stimuli (Pavlov, 1941; Watson, 1913). This theory is pertinent to explain the effectiveness of a mentor in influencing the behaviors of his or her students in completing a science project.

Next, cognitivism explains about the information processing in the students especially in learning science in order to solve a specific problem. This theory is useful in this study to describe the students ability to acquire and undertand new knowledge and then to apply the knowledge in analyzing and synthesizing the empirical data gained from the experiments.

Closely related to cognitivism is constructivism. According to Hyslop-Margison and Strobel (2007), constructivism is a learning theory which explains how people acquire knowledge. The theory sugests that humans construct knowledge and meaning from their experiences. In this study, this advanced theory explains about higher-order and divergent thinking of the students especially those who are involved in science project. Inventive thinking is largely explained by constructivist theory where solving problem could the lead to creating a new invention. Creativity and innovative learning can also be explained by constructivism.

Finally, connectivism is selected in this study to explain about the power of relationship and connection. According to Siemens (2006), learning which is influenced by technology and socialization is critical especially those involving mentoring, supervision and the ability to use technology to reinforce the relationship. Social learning explained by connectivist theory is pertinent in this study which related mentoring students to win science project competition. Figure 1.2 shows the conceptual framework of the study.

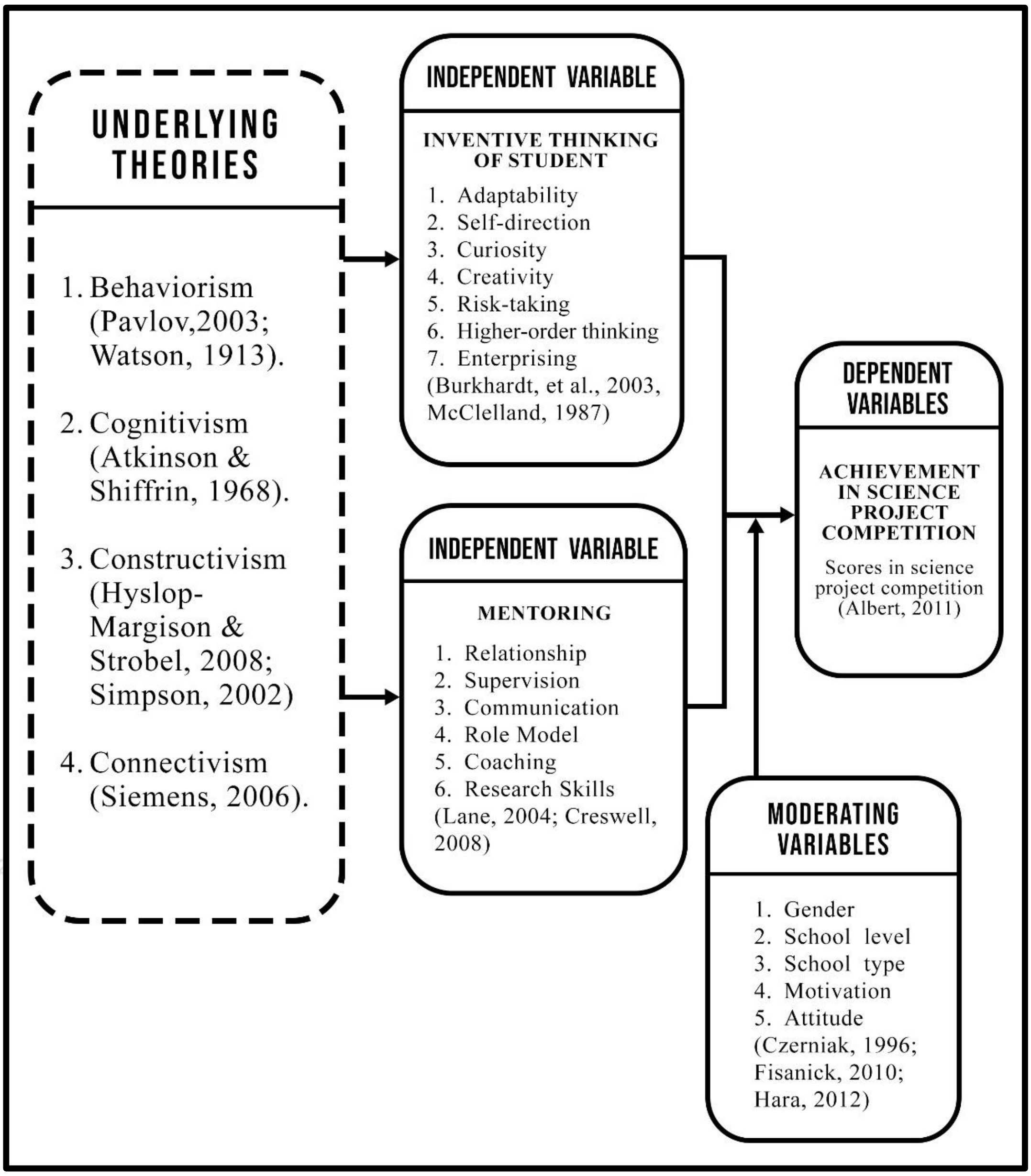

Figure 1.2. Conceptual framework of the study

1.5 Purpose and Objectives of the Study

The purpose of this study was to determine the influence of inventive thinking and mentoring toward the students' achievement in science project competition. Specifically, the objectives of the study were as follows:

1. To identify the inventive thinking of the students based on the demographic factors.
2. To identify the effectiveness of the mentoring in science project competition as perceived by the respondents.
3. To determine the relationship between inventive thinking and mentoring in the context of science project competition.
4. To determine the students' motivation toward science project competition based on the demographic factors.
5. To determine the students' attitudes toward science project competition based on the demographic factors.
6. To determine the influence of inventive thinking and mentoring toward the achievement in science project competition.
7. To propose a new framework of mentoring system for science competition.

1.6 Research Questions

The research questions addressed in this study were:

1. What is inventive thinking of the students based on the demographic factors?
2. How effective is the mentoring in science project competition as perceived by the respondents?
3. What is the relationship between inventive thinking and mentoring in the context of science project competition?
4. What are the students' motivations toward science project competition based on the demographic factors?

5. What are the students' attitudes toward science project competition based on the demographic factors?
6. What is the influence of inventive thinking and mentoring toward the achievement in science project competition?

1.7 Hypotheses

Based on the research questions, several null hypotheses were constructed as follow:

RQ-1 : What is inventive thinking of the students based on the demographic factors?

Ho_1 : There is no significant difference in inventive thinking between male and female students.

Ho_2 : There is no significant difference in inventive thinking between students in junior and senior high schools.

Ho_3 : There is no significant difference in inventive thinking between students in public and private schools.

Ho_4 : There is no significant difference in inventive thinking between the students and the mentors in science project competition.

RQ-2: How effective is the mentoring in science project competition as perceived by the respondents?

Ho_5 : There is no significant difference in mentoring as perceived by the male students and female students.

Ho_6 : There is no significant difference in mentoring as perceived by the students in junior high schools and senior high schools.

Ho_7 : There is no significant difference in mentoring as perceived by students in public schools and private schools.

Ho_8 : There is no significant difference in mentoring as perceived by the students and the mentors in science project competition.

RQ-3 : What is the relationship between inventive thinking and mentoring in the context of science project competition?

Ho_9: There is no relationship between inventive thinking and mentoring in the context of science project competition as perceived by the students.

Ho_{10}: There is no relationship between inventive thinking and mentoring in the context of science project competition as perceived by the mentors.

RQ-4 : What are the students' motivations toward science project competition based on the demographic factors?

Ho_{11} : There is no significant difference in motivation toward science project competition as perceived by male and female students.

Ho_{12} : There is no significant difference in motivation toward science project competition as perceived junior and senior high school students.

Ho_{13} : There is no significant difference in motivation toward science project competition as perceived by the students in public and private schools.

Ho_{14} : There is no significant difference in motivation of the students toward science project competition as perceived by the students and the mentors in science project competition.

RQ-5 : What are the students' attitudes toward science project competition based on the demographic factors?

Ho_{15} : There is no significant difference in attitude toward science project competition as perceived by male and female students.

Ho_{16} : There is no significant difference in attitude toward science project competition as perceived by junior and senior high school students.

Ho_{17} : There is no significant difference in attitude toward science project competition as perceived by the students in public and private schools.

Ho_{18} : There is no significant difference in attitude toward science project competition mentoring as perceived by the students and the mentors in science project competition.

RQ-6 : What is the influence of inventive thinking and mentoring toward the achievement in science project competition as perceived by the students?

1.8 Significance of the Study

The purpose of this study was to determine the influence of inventive thinking and mentoring toward the students' achievement in science project competition. The findings of the study are expected to confirm the critical elements of inventive thinking and mentoring. These elements could be made as a guide for science teachers who have the potential to be mentors for students who will compete in future science project competitions. The mentors could use these elements to nurture inventive thinking among their students.

The findings about mentoring traits could also be used to screen future mentors. Only those mentors who possess the designated traits should be allowed to become mentors for students who are going to compete in science project competition. The critical elements of inventive thinking and mentoring found in this study could be used by the stakeholders in schools or in the Ministry of Education to develop new curriculum or standards for training module for teachers and students.

Finding of this study are also expected to support the framework of mentoring model in the preparation of science project competition. This model may not only suitable for mentoring at school, but also for the preparation for international science project competition. The framework of mentoring would be useful for the teachers in supervising student's science project in a way that it would guide teachers to play a role as mentor in the mentoring process. It was very important for teachers to be confident in supervising students' science project in order to maximize students' effort in winning science competition. By raising the awareness of the Indonesian teachers on the importance of developing students' inventive thinking, it would grow students' competitiveness in the global learning, since inventive thinking of students was one component of the 21st century learning.

1.9 Limitations of the Study

This study has several limitations. The science project competitions involved in this study were held in Indonesia. The participants of this study were taken from science competitions in particular areas in Indonesia: Sumatera Utara province, Sumatera

Selatan province, Jawa Barat Province, Jakarta City, Kalimantan Tengah Province, Bali Province, Jawa Tengah Province, Special District of Yogyakarta, Jawa Timur Province, and Surabaya City. The study did not involve students and teachers from other areas.

Each student who involved in this study was aged 13 to 19 years old, meaning that younger students (12 years old and below) and older students (20 years old and above) were not included in this survey. The participants of the science competitions involved in this study were secondary school students. Hence, the respondents of the survey in this study were secondary school students, which means elementary school students and university students were not included. The teachers who were involved in this study were teachers who supervised students in completing science project. The teachers who did not supervise students' science project were excluded from the population.

1.10 Operational Definitions

In order to be concise in the usage of the main constructs in this study, operational definition of each key construct is given.

Achievement

According to Pekrun (2006), achievement is defined as the quality of activities or their outcomes as evaluated by some standards of excellence. In this study, students' achievement in the science project competition was measured by the scores the students gained in the competitions from the judges.

Adaptability

Adaptability is the ability to manage multiple tasks and changes in the environment (Morris et al., 1999). In this study, the indicators of adaptability were ability to handle multiple task of school tasks and the science project, and ability to accommodate changes from the environment related to the substance of the science project.

Attitude

Attitude is a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor (Eagly & Chaiken, 1995). In this study, the particular entity in measuring the attitude was how the students feel about the advantages of participation in a science project competition.

Behaviorism

Behaviorism is a learning theory that asserts the change of behaviors is acquired through an individual's respond to the external stimuli. Behaviorism uses the stimulus and response to intepret exhibited behaviors of an individual (Pavlov, 1941; Watson, 1913).

Coaching

Coaching is process of nurturing a person by using critical strategies such as employing effective listening, asking relevant questions, using feedback, demonstrating, and providing encouragement and support (Canfield & Chee, 2013). In this study, the students were expected to practice effective listening and to ask relevant questions in the discussion with the mentors and other students. The mentor also showed to the students, how to use feedback from the experts and judges. In conducting experiments that were new to the students, the mentors demonstrated them to the students. As a coach, the mentor provided encouragements and supports related to the science project.

Cognitivism

Cognitivism is a learning process that uses information processing as a way to explain how human perceive, remember, and understand the world around them (Atkinson & Shiffrin, 1968).

Communication

Communication is a two-way process to exchange thoughts, ideas, and emotions and to convey and discuss meaning or to provide feedback by using oral, written or gesture to achieve common understanding (Keyton, 2011). In this study, the students and mentors changed thoughts, idea and emotions regarding the science project content in the discussion.

Connectivism

Connectivism views learning as a network phenomenon influenced by technology and socialization (Siemens, 2006).

Constructivism

Constructivism is a learning theory which explains how people acquire knowledge. The theory sugests that humans construct knowledge and meaning from their experiences (Hyslop-Margison & Strobel, 2007; Simpson, 2002).

Creativity

Creativity is the act of bringing something into existence that is genuinely new and original, whether original to the individual, or can be added significantly to a domain of culture as recognized by experts (Burkhardt et al., 2013). In this study, the students were expected to have a new and original idea for the topic of the science project to show their creativity.

Curiosity

Curiosity is a drive to learn and gain knowledge in reaching a goal (Berlyne, 1954). In this study, the students used their curiosity to identify the problems in their surrounding, for the topic of the science project.

Enterprising

Enterprising refers to a quality of a person who is resourceful, confidence, persistent, possess strategic mind to find opportunities and to build network (McClelland,1987). In this study, enterprising was measured by the ability of the students to overcome issues during conducting the science project, and to formulate the future work and recommendations related to the science project. The students have to be persistent in completing the science project, so they would be able to submit the result to the science project competition. When presenting the result of the science project in front of the judges, the students were expected to be confident on the science project they have conducted.

Higher-order thinking

Higher-order thinking is a critical and careful judgment to evaluate, to make inference, to interpret and to solve problem (Conklin, 2011). In this study, higher-order thinking was investigated from the thinking process of the students regarding their science project. In conducting a science project, the students were expected to have the skills of choosing the appropriate theories related to the topic, comparing different theories and models, formulating the hypotheses, interpreting and explaining the result, and making a proper conclusion.

Inventive Thinking

Inventive thinking is the ability to solve problem or create innovative products (Altshuller, 1996). In this study, inventive thinking consists of seven elements, which are adaptability, self-direction, curiosity, creativity, risk-taking, higher-order thinking, and enterprising (Burkhardt et al., 2003; McClelland, 1987).

Junior high school

Junior high school in Indonesia is defined as formal education at one level higher than primary school, which include grades seven, eight, and nine (Ministry of Education of the Republic of Indonesia Regulation no 6, 2019).

Mentor

Mentor is a trusted counselor or guide, tutor, or coach, who has more experience to support, protect, and supervise a less experienced individual (mentee) to facilitate the mentee's growth, both professionally and personally (Armani, 2008; Hill, 2009). In this study, mentor is a teacher who is involved in supervising and coaching students in completing the science projects.

Mentoring

Mentoring is a symbiosis relationship whereby a senior or more experienced person (the mentor) provides psychosocial support, career guidance, role modelling, and coaching to a junior person - the protégé (Bozeman & Feeney, 2007). In this study, mentoring comprised six elements: supervision, relationship, coaching, communication, role model (Lane, 2004), and research skill (Creswell, 2008).

Motivation

Motivation is a theoretical construct used to explain the initiation, direction, intensity, persistence, and quality of behavior, especially goal-directed behavior (Maehr & Meyer, 1997). In this study, the students' motivation toward science project competition was investigated through the intrinsic motivation and extrinsic motivation. The intrinsic motivations were related to curiosity satisfaction, interest in science, interest in the thinking process, the feeling of fulfilled and the happiness. The extrinsic motivations in participating the science project in were looked smart by others, fulfilled in reaching the goal of getting the prizes and travelling.

Private School

Private schools in Indonesia are schools funded by a community or a private entity (Ministry of Education of the Republic of Indonesia Regulation no 48, 2019).

Public School

Public schools in Indonesia are schools funded by the government (Ministry of Education of the Republic of Indonesia Regulation no 48, 2019).

Research skills

Research skills are defined as individual ability to collect and analyze data or information in order to answer the research questions and ultimately to enhance his or her understanding of the subject under study (Creswell, 2008). In this study, research skills were determined from the mentors' side, including providing guidance to the students on searching for information relevant to the problem and research questions, proofreading the students' writing, and making a time line for the science project.

Relationship

Relationship is a process of building by trust, defining roles and responsibilities, and by establishing short and long-term goals and collaborating to solve problem (Byington, 2010). In this study, the relationship between the students and the mentors were measure through the students' judgment on their mentors such as, honesty, ability to make the students feel comfortable during discussion, reducing the students stress, and caring the students' emotion.

Risk-taking

Risk-taking is defined as one's willingness to make mistakes, to advocate unconventional or unpopular positions, or to tackle extremely challenging problems in facing uncertainty (Burkhardt et al., 2013). In this study, risk-taking of the students was measured from several elements such as the response of the students to the mistake they made in conducting a science project. Moreover, risk-taking measured from the courage of the students to go beyond the discipline related to the science project. Finally, risk-taking measured from the willingness of the students to try new things, stay at school late, and go to public institution for the science project purpose.

Role model

Role model is a respected person who could be emulated by others especially by younger generation. Good trait of a role model include confidence, leadership, effective communication, knowledgeable, empathy and being helpful (Zwilling, 2010). In this study, the mentors are the role model to the students in the context of science project competition. The role model was measured from the mentors' willingness to support the students in conducting the science project, including proofreading the students' writing, providing feedback regarding the science project, showing positive respond to the students such as being patient and not being angry. And finally the role model measured from the experience of the mentors in conducting their own research.

Science Project

Science project is an independent science research project conducted by a group of secondary school students (Grote, 1995).

Science Project Competitions

Science project competition or science fair is an event where students present their scientific work based on their research in competition and the project is evaluated by a panel of judges (Tortop, 2013). In this study, science project competition refers to provincial science competition held in Indonesia with the participation of selected secondary school students.

Secondary School

Secondary school is school that houses students in some combination of what traditionally known as grades seven to twelve (Kellough & Kellough, 2003). In Indonesia, junior high school students are those who are seven to nine graders, and senior high school students are ten to twelve graders.

Self-direction

Self-direction is a personality trait of self-determination, self-reliance, self-sufficiency, independence and possession of locus of control (Cloninger et al, 1993). In this study, self-direction measured from the willingness of the students to conduct several things by their own related to science project such as choosing the topic, applying solution to problems occurred, and data analysis. In addition, self-direction also identified from the effort of the students in funding their science project with their own money.

Senior high school

Senior high school in Indonesia is defined as formal education at one level higher than junior high schools, which include grades ten, eleven, and twelve (Ministry of Education of the Republic of Indonesia Regulation no 6, 2019).

Supervision

Supervision is a facilitation process to provide supportive opportunity and conducive environment to guide and nurture supervisees to grow and achieve their potential

(Cooper & Forrest, 2009). In this study, supervision related to conducting a science project at school measured from the mentors' effort to perform positive behaviors to the students such as, not to make fun or make the students feel ridicule, and providing appreciations to the students for their work.

1.11 Summary

The purpose of this study was to determine the influence of inventive thinking and mentoring toward achievement in science project competition. Overview on the inventive thinking as learning skill, and mentoring as developmental process, was discussed in brief. This chapter also discussed about the background of the study, which highlighted the importance of inventive thinking in the 21st century learning. Literature has shown that Indonesia students lacked of creativity in conducting science project, and in science learning. However, there were few studies on the inventive thinking in the context of science project competition.

In the conceptual framework, this study employed enGauge 21st century skills as the main model to derive the key elements of inventive thinking: adaptability, self-direction, curiosity, creativity, risk-taking, higher-order thinking (Burkhardt et al., 2003). One element was added from McClelland (1987), which is enterprising. To determine the mentoring construct, the model by Lane (2004) was used to derive the pertinent elements of mentoring which include relationship, supervision, communication, role-model, and coaching. Research skills was added as an element of mentoring because it is a critical trait of a science project mentor. The achievement in science project competition was measured through the score provided by the judges. Several moderating variables were examined in this study: gender, level and type of school, motivation, and attitude toward science project competition. The participants in this study were limited to the students of Indonesian secondary schools, and the science competitions were selected only in Indonesia. Thus, the generalization of the findings of the study is limited.