A COMPARATIVE-CORRELATIONAL STUDY OF GRADES 7, 8 AND 9 ENGLISH PROGRAM STUDENTS' PERCEPTIONS OF PROJECT BASED LEARNING AND THEIR RELATIONSHIP WITH STUDENTS' INTEREST IN FUTURE STEM CAREERS AT ST. JOSEPH CONVENT SCHOOL, BANGKOK, THAILAND

Giselle Iris M. Alano

I.D. No. 6019504

A Thesis Submitted in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF EDUCATION

in Curriculum and Instruction

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Field of Study: CURRICULUM AND INSTRUCTION

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ABSTRACT

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Key Words: PROJECT BASED LEARNING, STEM JOBS, STEM CAREER, INTEREST IN FUTURE STEM CAREERS, ST. JOSEPH CONVENT SCHOOL, BANGKOK, THAILAND

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In response to the shift in job demands in the 21st century, it is imperative for educators to explore alternative learning methods to better prepare students for future work landscapes. Drawing upon the Social Cognitive Career Theory (Lent et al., 1994) which posits that learning experiences can affect self-efficacy and outcome expectations leading to career choices, this study investigated project based learning as a viable solution to engage students in STEM studies and careers. The research drew on responses from a population sample of 191 Grade 7, 8 and 9 students in order to measure, compare and determine correlation between the research variables. Students participated in one hour of PBL per week for approximately 12 weeks per term. PBL at St. Joseph Convent School implemented seven essential design elements (Larmer & Mergendoller, 2015) and all subject teachers of each grade level acted as mentors and subject experts. At the end of the school year and two terms of PBL, sampling was conducted using Perceptions of PBL and Interest in Future STEM

Careers instruments adopted from LaForce, Noble and Blackwell (2017). Data analysis revealed high levels of perceptions of PBL and interest in future STEM careers. A correlational analysis confirmed a significant relationship between PBL and promoting interest in future STEM careers in Grades 7, 8 and 9 students. Recommendations on successful implementation of PBL elements as well as suggestions for the PBL teacher to assume a role as mentor are discussed by the researcher.

Field of Study: Curriculum and Instruction **Student's signature**……………………

Graduate School of Human Sciences **Advisor's signature** Richard Lynch ……………………

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To my Matthew, for seeing it through to the end, thank you for your endless support and understanding. I would not be where I am today without you.

To Coral and Rocket, Mommy strives even harder because of you.

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PBL Project Based Learning

SCCT Social Cognitive Career Theory

STEM Science, Technology, Engineering and Math

CHAPTER I

INTRODUCTION

Today, more than ever before, humans have in their horizon, the era of extraterrestrial living. Artificial intelligence is learning and computing possibilities faster than any brain and global environmental crises are pushing us to probe life in other, more habitable planets and moons. As humans face new challenges in the 21st century, the value of innovation and the ability to integrate knowledge from different fields of study have become increasingly in demand (White, 2014). The field of education is constantly adapting to these needs and constantly shaping the workforce of the future to achieve these goals. By the definition of genius as 'exceptional intellectual or creative power or other natural ability'-- Steve Jobs, Mark Zuckerberg and Elon Musk are geniuses of this millennium. They employed their design thinking involving various fields of Math, Science, and Technology study to invent the iPhone, Facebook, Tesla and SpaceX, respectively. Integration of the disciplines of science, technology, engineering and math (STEM) is essential in the advancement of human goals and interests in modern day industries. The immediate future holds more STEM jobs than people who can fill them (*STEM 2.0-An Imperative For Our Future Workforce*, 2014).

As an educator dedicated to promoting STEM learning in Thailand, the researcher has been involved in the development and implementation of Project Based Learning in St. Joseph Convent School, an all-girls school in Bangkok, Thailand. This chapter will give an overview of the research into students' perceptions of project based learning and their relationship with students' interest in future STEM careers.

Background of the Study

Historically, mankind has achieved such great feats of discoveries due need or desperation. Inventions such as the automobile, the atomic bomb and Sputnik are attributed to the interlinked use of different disciplines and applied concepts across various fields of study (White, 2014). Integration of the disciplines of science, technology, engineering and math (STEM) has existed for many decades in one form or another. However, it was in the 2011 State of the Union Address when former US president Barrack Obama spoke the words "Science, Technology, Engineering and Math" and the need for more teachers in these fields to build the nation's future (Whitehouse.gov, 2011). Since then, there has been a global push for STEM education by government leaders and school administrators as a response to the growing demand for skilled workers in these fields.

Careers in STEM are considered to be the jobs of the future. In the European Union alone, an estimated 7 million STEM job openings are forecast until 2025 and the current shortage to meet this demand is considered a labor market crisis (Caprile, Palmen, Sanz & Dente, 2015).

STEM is an integrated approach that involves application of the four fields within STEM to solve real-world problems. Similarly, Project-Based Learning(PBL) is pedagogical approach featuring a driving question and extended multidisciplinary task that integrates knowing and doing through real-world challenges (Markham, 2011). This makes PBL an ideal course framework for STEM career preparation.

Thailand's National Education Act (1999) explicitly decreed the promotion and development of training, learning opportunities and resources in the efficient use and production of technologies emphasizing its importance in the quality of life for Thai people. In conjunction, Thailand's current economic model known as Thailand 4.0 also emphasizes the demand for highly skilled workers in 5 technology clusters and targeted future industries namely: (1) food, agriculture and bio-tech, (2) health, wellness and biomedicine, (3) smart devices and robotics, (4) digital, internet of things (IoT), artificial intelligence and embedded technology, (5) creativity, culture and high-value services.

Drawing on the country's pool of knowledge, creativity, innovation, and technology, Thai 4.0 aims to focus on five agendas for integrated research on (1) Food and Agriculture, (2) Energy, (3) Aging Societies, (4) Smart Cities, and (5) Creative Economy to provide possible solutions for these future challenges on both national and global scales ("Thailand 4.0", n.d.).

The venue of this study, St. Joseph Convent School, is one of the most prestigious all-girls schools in Thailand. The school possesses physical, financial and institutional resources necessary to implement a STEM-focused course. Hence, a one-hour per week PBL course was introduced to the students of the English Program in 2016. In this course, students are given a theme or a driving question for one school term and they use the Engineering Design Process to identify a problem, find a solution, implement the solution, iterate the solution for improvement and present their findings. Math, science, English and ICT grade level teachers collaborate to monitor and support their specific components of the project. Students work on this term-long project in small groups of five to 6 students.

Statement of the Problem

Girls are highly marginalized in STEM education and STEM careers (United Nations Educational, Scientific and Cultural Organization, 2017). Thailand's Ministry of Education recognizes this report and has partnered with UNESCO to promote STEM education among girls and young women in the kingdom as part of the 20-year national strategy Thailand 4.0 that aims to "transform the Kingdom into a nation where innovation, creativity, research and development, and green and high-technologies drive the economy" ("Thailand promoting female STEM education with UNESCO", 2017).

Students in the English Program of St. Joseph Convent School, an all-girls school in Bangkok, intensively study science and math at 5 hours per week each subject. However, opportunities to use the knowledge gained in these subjects in real-world situations such as the ones mentioned in Thailand 4.0 are limited. Learning science and math often exists in a vacuum of classroom learning. PBL in St. Joseph Convent aims to provide students exposure to 21st century skills, STEM as well as an edge in future job markets.

Furthermore, levels of students' perceptions of PBL and their interest in future stem careers are unknown.

Research Questions

This study addressed the specific research questions that follow.

1. What are the levels of Grades 7, 8 and 9 English Program students' perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand?
2. What are the levels of Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand?
3. Is there a significant difference among Grades 7, 8 and 9 English Program students' perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand?
4. Is there a significant difference among Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand?
5. Is there a significant relationship between Grades 7, 8 and 9 English Program students' perceptions of project based learning and students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand?

Research Objectives

The following objectives guide the direction of this research and what it intends to achieve.

1. To determine the levels of Grades 7, 8 and 9 English Program students' perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand.
2. To determine the levels of Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.
3. To determine if there is a significant difference among Grades 7, 8 and 9 English Program students' perceptions of project based learning.
4. To determine if there is a significant difference among Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.
5. To determine if there is a significant relationship between Grades 7, 8 and 9 English Program students' perceptions of project based learning and students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.

Research Hypotheses

1. There is a significant difference among Grades 7, 8 and 9 English Program students' perceptions of project based learning.
2. There is a significant difference among Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.
3. There is a significant relationship between Grades 7, 8 and 9 English Program students' perceptions of project based learning and students' interest in future

STEM careers at St. Joseph Convent School, Bangkok, Thailand, at a significance level of .05.

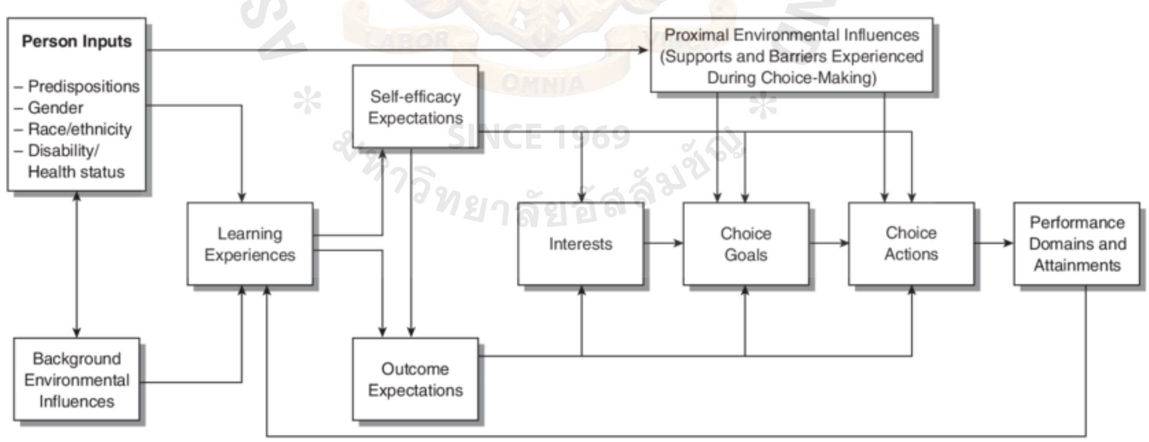
Theoretical Framework

It is the researcher's belief that PBL provides the contextualized, authentic experiences necessary for students build positive self-efficacy and outcome expectations related to STEM studies and careers.

This study draws on Social Cognitive Career Theory (SCCT) developed by Lent, Brown and Hackett (1994) which emphasizes experiential factors such as learning experiences to predict future career choices. According to this theory, learning experiences affect an individual's self-efficacy and outcome expectations which in turn, impact their future choices in interests, goals and actions including career paths they choose in the future. Figure 1 illustrates a view of how career interest and choices develop over time.

Figure 1

A Simplified View of How Career-Related Interests and Choices Develop Over Time



Note. From "Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance", by R.W. Lent, S.D. Brown, and G. Hackett, 1994, *Journal of Vocational Behavior 45*(1), p.93

SCCT is based on Albert Bandura's earlier work on social cognitive theory with constructs such as self-efficacy, outcome expectations and personal goals. These constructs are factors that are argued to determine people's career-related interests, choices and performance.

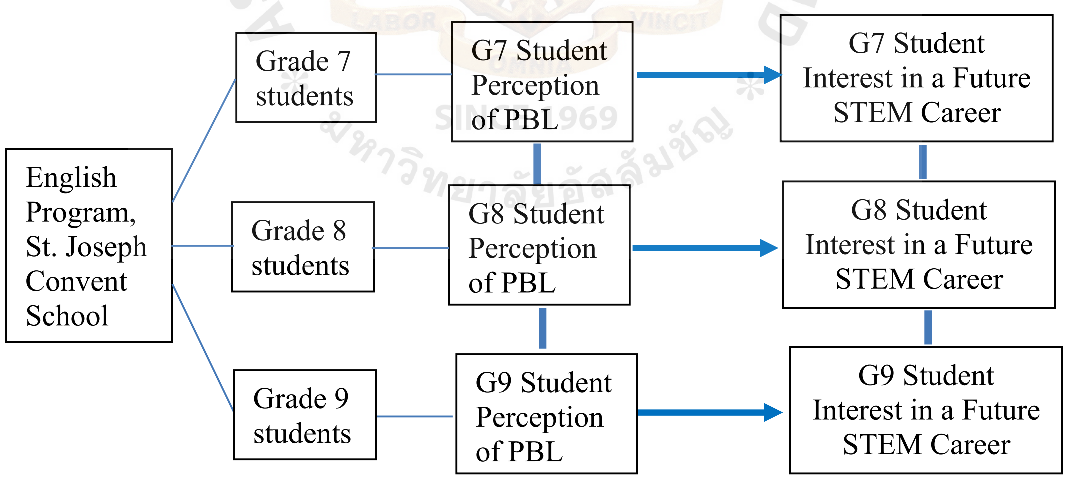
The central learning experience of this study is PBL and perceptions of PBL held by Grades 7, 8 and 9 English Program students at St. Joseph Convent School were examined to determine if they can predict a student's interest in future STEM careers. A recent study by Laforce, Noble and Blackwell (2017) indicated that PBL is one instructional approach that can increase students' interest in STEM careers. Analyses from this study also indicated that students' perceptions of PBL significantly predicted students' interest in pursuing STEM careers.

Conceptual Framework

To determine the relationships between students' perceptions of PBL and students' interest in future STEM careers, the conceptual framework below will be applied.

Figure 2

Conceptual framework of this study.



Scope of the Study

The scope of the study is limited to St. Joseph Convent School in Bangkok, Thailand. A population sample of 56 Grade 7 students, 72 Grade 8 students and 63 Grade 9 students in the English Program participated in the study for a total population sample size of 191 students. Students' perceptions of PBL, the independent variable, was measured using an instrument called Perceptions of PBL Questionnaire. Students' interest in future STEM careers, the independent variable, was measured by a questionnaire called Interest in Future STEM Careers (IFSTEMC). Both instruments were developed by LaForce, Noble and Blackwell (2017). The theoretical scope of this study was limited to Social Cognitive Career Theory (Lent et al., 1994).

Definitions of Terms

Interest in Future STEM careers

This refers to students' current interest to pursue a STEM career in the future as measured by items 1 to 4 of IFSTEMC Questionnaire.

Perceptions of PBL

These are students' perceptions of their PBL learning experience as measured by items 1 to 12 of Perceptions of PBL Questionnaire

Project Based Learning

This refers to an experiential learning approach that allows students to investigate a topic of their interest in order to find solutions over an extended period of time.

STEM Careers

These refer to jobs that integrate at least two or more of the four disciplines of science, technology, engineering and math.

Students

This constitutes a population sample of 191 students from Grades 7, 8 and 9 in the English Program in St. Joseph Convent School during the school year of 2020-2021.

Significance of the Study

The significance of this study applies to four identified groups namely students, teachers, school administrators, policy makers and future researchers.

This study can be a tool to assist students to develop positive perceptions toward PBL and give them an advantage in future job markets that focus on STEM.

It can also serve the same purpose for teachers to develop positive perceptions toward PBL and continue to improve its implementation. In addition, this paper offers guidance to teachers regarding their crucial role in the PBL process.

As for school administrators, the results of this study may be used as justification for allocation of resources to further PBL and STEM-related activities as well as push for parental and institutional support to continue PBL.

Policy makers may also use this study to promote PBL activities across the country to increase interest in STEM careers. The may also be inspired to create policies to reduce gender bias and increase girls' chances in STEM studies and careers.

Future researchers may use the information provided on PBL as well as data for cross-validation of students' perceptions of PBL and interests in future STEM careers.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter will review available literature related to the research study. First, the underpinning theories of project based learning (PBL) with a focus on constructivism will be discussed. Second, PBL and its distinction from other associated pedagogies, its key features, implementation essentials and critique will be reviewed. Third, the researcher will synthesize various implementations of STEM curriculum and instruction to offer a unified picture of existing prominent assumptions. Fourth, STEM careers will be discussed in terms of what qualify as such followed by the current and projected demands in global workforce trends. Social cognitive career theory is central to this study's theoretical framework and will be discussed in relation to PBL learning experiences and its effects on future career choices. Previous research on PBL will be discussed to illuminate its value as an effective pedagogical approach to integrate STEM and increase interest in STEM careers. Lastly, the researcher will review the participating school's background.

Constructivist Learning Theory

Constructivism is one of the most established learning theories in education. It is a theory that focuses on how cognition works. It states that through an individual's personal experiences and subsequent reflection on them, they construct their own understanding and knowledge of the world (Bereiter, 1994). At the core of this theory is the principle that students create their own understanding of the world by linking what they already know from previous experiences to the new information that is being presented. Through this process, students construct their own meaning and understanding of the world.

Constructivism posits that students play an active role in the process of learning and knowledge acquisition. The learner needs to discover new information, check it against previous knowledge and transform the information into relevant knowledge they can then use as a basis for action (Phillips, 1995).

Early theorists of constructivism include John Dewey, Lev Vygotsky, Jean Piaget, and Jerome Bruner. Von Glasersfeld (1995) posited that learning is not a matter feeding the student information and expecting learning as the outcome. On the contrary, learning is largely a self-managed process wherein the learner develops ideas and makes connections through thoughtful reflection and extraction of meaning.

Constructivism is based on the idea that learning happens as the result of mental construction. Learners acquire new knowledge by putting together what they already know with new information and experiences. In this sense, a student's learning is affected not only by the student's beliefs and attitudes but also by the context in which a concept is taught. The theory suggests that the human mind constructs knowledge and meaning from a person's experiences. Hence, the whole experience including the idea and the conditions during which it was learned are crucial to learning. When learners are faced with something new, they have to relate it to previous beliefs and ideas resulting in a change of current beliefs or a decision to discard the new information. In this sense, learners play an active role in the creation of their own knowledge. Learners ask questions, explore ideas, and evaluate what they know and need to know (Bada, 2015).

Constructivism is not a specific pedagogy. However, the constructivist view of learning can manifest in the classroom through different teaching practices that encourage students to engage in active learning. It is important to note that constructivism is interpreted in many different ways, with varying offshoots of the main theory (Oliver, 2000). These varying embodiments share common characteristics and major overlaps but also contain significant differences. Activities such as experiments, inquiry learning, and problem-solving allow students to generate more knowledge and then to reflect and discuss their own understanding of the matter. The role of the teacher is to ensure that students are guided through the activities, addressing their preexisting conceptions and building on them towards new knowledge (Oliver, 2000).

According to Driscoll (2000), constructivist learning theory is a philosophy which enhances a student's logical and conceptual growth. As the theory is based on how an individual constructs new knowledge, two key concepts from Piaget's theory of cognitive development need to be briefly discussed: assimilation and accommodation (Wadsworth, 2004) . Assimilation occurs when a learner incorporates new experiences into the old experiences and existing schema. This particular path to knowledge construction necessitates the learner to evaluate how the new information can fit into what is already known- a schema. Accommodation, on the other hand, occurs when the new information does not fit into the present knowledge and so necessitates the learner to restructure or modify what is previously known, essentially reframing what is known about the world and how it works so that this new information can be accommodated (Wadsworth, 2004).

To sum up constructivism, new knowledge is constructed by learners by connecting new experiences to previous knowledge. In this process, the learners must be actively involved in the learning process and not simply passive observers.

Theory of Experience

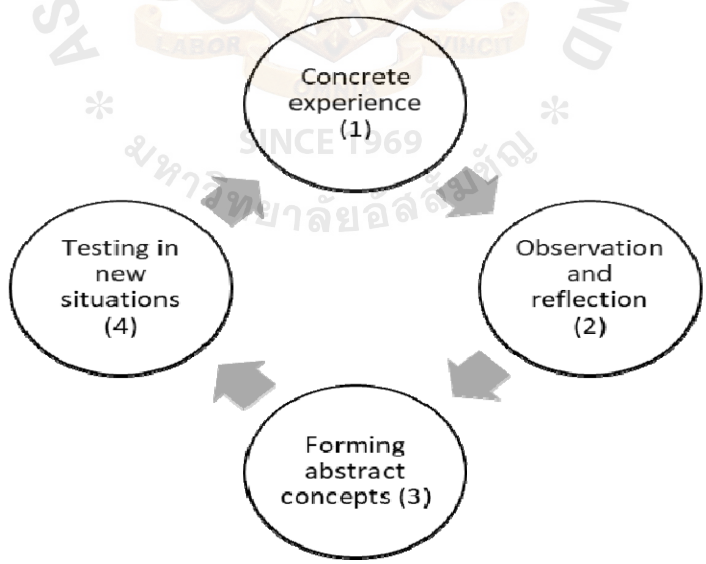
Under the broader umbrella of the constructivist learning theory wherein learners are offered authentic tasks to construct knowledge and meaning for learning, Dewey's theory of experience is one of the earliest theories that have implications in problem based learning as a pedagogical approach and STEM education as a whole. Dewey posited that education is based on real-world experiences and that students learn based on meaningful experiences, hence the phrase learning by doing. This is not to say that all experiences are educative, in fact Dewey argues that some schooling experiences are mis-educative[sic]. Dewey's principles of continuity and interaction can aid educators to assess their 'planned experiences' to create and simulate real-world experiences that promote positive outcomes for their students, not only in the present but also in the future (Dewey, 1938).

Project Based Learning

Building upon Dewey's work, Kolb (1984) developed the experiential learning theory which presents a cyclical model of learning, consisting of four stages. The theory posits that learning starts with a concrete experience which the individual observes and reflects on in order for them to construct their own concepts. These new concepts are then tested in other situations. The theory is illustrated in figure 3.

Figure 3

Kolb's Experiential Learning Cycle



Note. Adapted from Experiential Learning: Experience as The Source of Learning and Development (p.21), by D. Kolb, 1984, Prentice Hall.

The term project learning is deeply rooted in Dewey's constructivist learning theory and dates back to William Kilpatrick, who coined the term in 1918(Beckett & Slater, 2019). Despite surfacing roughly a century ago, most of the research on PBL started only in the 1990's (Thomas, 2000) and it is still very much considered a non-traditional and progressive teaching strategy. Of the earlier authors on PBL, Blumenfeld et al. (1991) defined it as a teaching and learning approach that was designed to engage students in investigation of authentic problems.

In a nutshell, Project Based Learning (PBL) is an extended learning task based on a simulated or authentic real-world challenge that requires deep inquiry, collaborative work, reflection and iteration to produce a tangible product, performance or event.

To better understand PBL, the terms project and problem based learning need to be defined in order to dispel some of the most popular misconceptions about PBL. While creating projects can be done at practically any time during the curriculum for any subject as a formative or summative assessment, not all projects are products of PBL. A project is typically defined as an output-based assignment, usually performed at the end of a unit to synthesize or apply the concepts learned. The focus is on the final output. In this sense, educators use the analogy of a *dessert project* which happens at the end of learning. In PBL, a greater importance is placed on the process itself, the guiding framework of the teaching method and the way that learning occurs. Using the same analogy, PBL is the *main course* or the meal itself wherein the actual learning occurs while the project is being done. Projects are usually teacher-directed with the same expected output for all students. On the other hand, PBL emphasizes student voice and student choice which makes the final product highly dependent on the path the students decide to take. In addition, projects can be done alone and possibly within a short timeframe. PBL, however, requires collaboration and a lengthier period to allow for deep inquiry, problem solving, reflection, and iteration. Finally, PBL requires the design task to be real-world challenge that is authentic and relevant to students. This is not a fundamental requirement for all projects. To sum up the comparison between projects and PBL, both require a culminating product; however, projects are usually treated as summative assessments which occur at the end of learning while with PBL, the bulk of learning is expected to occur during PBL.

Another problematic matter is the confusion between project based learning and problem based learning. All forms of PBL use problem based learning and may in fact have several problems within the PBL. However, PBL is broader and spans over an extended period of time. Problem based learning can be shorter and only require a solution or explanation rather than an actual public product or artifact.

Problem based learning usually involves the following aspects:

1. present an open-ended or "ill-structured" problem,
2. define or identify a specific problem to be solved,
3. research, review and inventory of related literature,
4. propose possible solutions,
5. identify issues found and rework the solution with self and guided, direction
6. present findings and solutions

On the other hand, Project Based Learning or PBL as defined by Grant (2002) included the following features:

- setting the stage as an introduction or context for the task,
- a task or a driving question,
- collaborative elements as a result of research,
- content and resources which can include textbooks, experts in the field of study, and internet-based references,
- a framework for student-teacher and/or teacher-teacher collaboration,

- peer groups of specialists,
- Opportunities to reflect, present and showcase findings

Although the researcher agrees that Grant's Anatomy of PBL has listed key elements of PBL that are seen in various applications, the researcher disagrees that all seven elements must be present to qualify one's application as PBL. More specifically, peer groups of specialists are not always mentioned in many other applications of PBL.

To offer a more inclusive definition of PBL, Thomas (2000) offered five criteria that a project must have to be considered as PBL. The five criteria are centrality, driving question, constructive investigations, autonomy and realism. Centrality means that the PBL project is at the core of the curriculum. The project itself drives the curriculum and learning. It is not a supplementary requirement as it is usually seen in a typical subject curriculum. A driving question is one element that is seen in all forms of project and problem-based learning It is arguably the most important aspect of PBL as it sets the parameters and goals of the activity. Without a relevant or challenging driving question, students will become disengaged. Constructive investigation or research is a key learning activity wherein students make an inventory of what they already know and what they need to know. Afterward, they find information and make connections to their existing ideas to be able to complete their task. Autonomy means that PBL allows for student choice and student voice in decision-making. Real-world problems and simulation of real-world environments are essential to PBL. They give students critical problem solving skills via hands-on experience related to the subject. Completing projects immerses the student in a problematic situation in constructive ways. The learning experience becomes outward from the students' perspective. Projects offer real world experience (Thomas, 2000).

Larmer and Mergendoller (2015) offered further clarification and guidance to educators who want to implement true and effective PBL by identifying seven design elements of PBL:

- challenging problem or question
- sustained inquiry
- authenticity
- student voice and choice
- reflection
- critique and revision
- public product

These seven design elements will later be used by the researcher to assess the validity of PBL in St. Joseph Convent's English Program.

Failure of Constructivism and PBL

Kirschner, Sweller and Clark (2006) argued that learning and teaching approaches such as problem-based learning and project based learning that offer minimal guidance from teachers are not supported by evidence and that research does not support these techniques. From what can be determined from controlled studies, the evidence shows that lower level to intermediate learners need direct and strong instruction rather than constructivist-based guidance which is typically minimal. Moreover, even for more advanced students, direct and strong guidance was most often found to be equally effective as minimally guided approaches. Self-direction was found to be less effective, and more alarmingly, the evidence also suggests that it may be detrimental to students' learning as they may come across concepts that are confusing. Without guidance, they may acquire misconceptions and store incorrect or disorganized knowledge. Furthermore, the importance of direct guidance is only minimized when learners are already highly proficient in the necessary prior knowledge (Kirschner et al., 2006).

Unguided or minimally guided instructional approaches founded on constructivist learning views are widely popular and possess an appeal to a wide range of educators and learners. However, Kirschner et.al. (2006) noted that these approaches ignore what is already known about the structures of human cognitive architecture. In addition, they argued that constructivist approaches such as problem-based and project based learning are not supported by empirical evidence that state that minimally guided instruction is less effective than pedagogies that promote strong teacher guidance throughout the learning process.

STEM Education

STEM is an education concept that has proven difficult to define precisely in terms of both its meaning and its application. Opinions vary as to whether it needs to be taught as an integrated subject or as an approach to teaching science, technology, engineering and mathematics. There is also no clear consensus on what progression should be followed in STEM education along with the assessments that can be used for it (Pitt, 2009; Williams, 2011). This section provides a synthesis of prominent contemporary STEM concepts and principles to give a better understanding of STEM and its implementation in education.

Curriculum development in STEM requires teachers to set up a problem or design task. There are two criteria necessary in order to do this effectively. First, the task must be engaging and applicable to students' everyday lives. Utilizing a task that the students are interested in and can relate to will increase student engagement and involvement. Second, STEM educators must implement the engineering design process (EDP), necessitating the creation of artifacts, prototypes and/or working models (Apedoe et al., 2008). Centered on an engineering design, there are two main types of STEM curriculum integration: content integration and context integration (Moore et al., 2014a; Moore et al., 2014b). The concept of content integration sees multiple content fields being integrated into one curriculum in order to meet over-arching learning goals, emerging from the content in each subject, and utilizing the engineering design process. Context integration, on the other hand, focuses on the content of one discipline and uses contexts from supporting disciplines to provide depth, interest, relevance and real-word simulation.

Content integration features a curriculum that merges content from varying subjects, in this case, a combination of science, technology, engineering and mathematics. This type of STEM integration sees the concurrent learning of a combination of disciplines (Moore et al., 2014a). In STEM content integrations, learning objectives from the individual STEM disciplines are learned simultaneously. For example, a design task that requires students to devise a way to clean up polluted water in ponds will necessitate the application of learning objectives from multiple subjects. Biology concepts such as ecosystem relationships and biomes can be introduced. Earth science can also be applied in terms of the water cycle. For mathematics, students can measure variable factors such as pH levels over time and perform subsequent data analysis for statistics (Moore et al., 2014c). This kind of design task, when performed using the engineering design process, is a good example of STEM content integration.

On the other hand, context integration focuses on one discipline at a time while using a second one to play a supporting role in framing the lesson content to create a meaningful and relevant task (Moore et al., 2014a). This type of STEM curriculum integration focuses on one discipline above others while secondary subject matters supplement the primary content to provide a setting or context (Moore et al., 2014c). In this particular set up, students are expected to make connections between disciplines and experience the task in a more meaningful manner. However, the learning objectives addressed belong only to the primary discipline (Moore et al., 2014b). For example, a task can be designed in the context of engineering a vehicle but the learning objectives are focused on mathematics.

Whether implementing STEM via content or context integration, merging subject matter from various disciplines can prove to be challenging. Great consideration must be placed on ensuring that essential aspects of each discipline are not lost in the process of integration (Glancy, Moore, Guzey, Mathis & Tank, 2014). Williams (2011) proposed that, rather than integration, a more practical approach may be to develop interaction between STEM subjects by fostering interdisciplinary linkages. This way, the integrity of each subject is preserved. Interaction, as opposed to integration, means that students will be establishing connections between subjects to arrive at the targeted learning objectives (Williams, 2011). Meanwhile, the important role that teachers play in this process cannot be discounted. Teachers of different subjects must collaborate with each other to ensure meaningful interaction between subjects that will allow students to make connections for an enhanced learning experience. A critical factor for meaningful STEM links in schools is collaboration which requires partnerships between teachers with a shared vision (Barlex, 2007; Williams, 2011).

Finally, it is important to recognize the requirements of STEM curricula (Moore et al., 2014a):

- the context must be relevant and motivating so students develop personal connections to the learning
- students must work in the higher order thinking skills of Bloom's taxonomy within the engineering design process framework
- students should have space to design and recognize the failures of their design, improve upon them and make iterations while meeting important math and/or science objectives

- the lessons that incorporate non-STEM content, such as reading or social studies, are suggested
- the lessons must incorporate and emphasize teamwork and communication.

When the STEM curricula follow the above requirements, it is expected that the learning practices will (1) increase student interest in STEM disciplines, (2) create meaningful learning in individual disciplines by providing context for the subject matter, (3) increase student understanding of STEM disciplines through relevant, authentic, real-world tasks and (4) encourage students to pursue careers in STEM fields (Moore et al., 2014a).

STEM in Thailand

STEM education in Thailand is officially spearheaded by the Institute for the Promotion of Teaching Science and Technology (IPST). It is an arm of the Thai Ministry of Education tasked to promote and improve the learning processes involved in science, mathematics, and technology. IPST is responsible for the creation of Thailand's STEM education network which includes 13 regional centers in 12 different provinces across the country. The network consisted of leader teachers in each center whom were expected to execute STEM approaches in their classrooms to serve as models to other teachers in the regions. Leader teachers were trained by IPST at least once a year (The Institute for the Promotion of Teaching Science and Technology, 2014).

In a study of 114 leader teachers in Thailand's STEM education network, it was found that teachers, students, learning management, tools of learning management, and school management were the factors that supported the STEM education learning management of leader teachers. It was noted that amongst these factors, the sub-item with the highest level of impact was the leader teacher's own subject knowledge. On the other hand, the item that supported STEM education learning management the least was support from external agencies (Painprasert & Jeerungsuwan, 2015).

It should be noted that the study was originally conducted due to observed problems in that the centers failed to achieve their objectives. The study's outcome is that teachers, students, learning management, tools of learning management, and school management were the factors that supported the STEM education learning management of leader teachers.

There is a need for more research in STEM education in Thailand to better understand its current status and implementations.

STEM Careers

Similar to *STEM education,* the term *STEM career* is not clearly defined as of yet and different organizations will have their own occupations list that are inconsistent with others. All definitions of STEM jobs, however, recognize occupations in the hard sciences, engineering, and mathematics. It is not clear, however, whether STEM careers encompass teachers, managers, lab technicians, nurses, health care workers or social scientists.

The 2018 Standard Occupational Classification (SOC) system is used by U.S. federal agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data. There are 867 detailed occupations in this system and all US workers are classified into one of them according to their occupational definition. Using this system, U.S. Bureau of Labor and Statistics have defined STEM careers as the list of jobs included in Appendix A consisting of 100 occupations, including jobs in computing, mathematics, architecture, engineering, life and physical science occupations. Interestingly, this list also includes managers, university teachers and sales occupations requiring scientific or technical knowledge at the postsecondary level (www.bls.gov/SOC).

The largest group of STEM jobs in the US is within the computer and mathematics fields. These fields account for nearly half of all STEM jobs. Engineering and surveying occupations come second with 30 percent. Next are jobs in physical and life sciences with 12 percent. At the bottom, management jobs in STEM fields hold only 9% of all STEM employment (Noonan, 2017).

Appendix B provides the List of STEM occupations as recognized by the U.S. Department of Commerce whose report is also used in this literature review. As previously mentioned, inconsistencies can be noted in various lists of STEM jobs even under the same government. The U.S. Department of Commerce's definition of STEM occupations, which includes professional and technical support jobs in the fields of computer science and mathematics, engineering, and life and physical sciences, is slightly different when compared to the Census Bureau's definition. U.S. Department of Commerce's STEM occupations list includes more management occupations because they are considered clearly relevant to STEM. This list does not include STEM educators. Finally, one difference between the U.S. Department of Commerce's definition and the Census Bureau's definition is that the former does not recognize social scientists as STEM careers (Noonan, 2017).

Future Labor Markets

STEM education is important because of the future demands of the evolving society. According to The Future of Jobs Report 2018, we are in the midst of the Fourth Industrial Revolution which is shaping a new labor market. Rapid technological advancements continue to shift job roles and transform the demand for skills at a faster pace than ever before. There is an urgent need to address the effects of automation and new technologies on current industries. The recommended response to this need is to upgrade education policies and programs to hone STEM skills across all levels (World Economic Forum, 2018).

According to the report, new technologies and trends are shifting the way businesses are dividing the work between workers and machines. Employers surveyed for this report expect that, between 2018 to 2022, there will be a decline in demand for skills such as manual dexterity, precision, memory, verbal, auditory and visual abilities, quality control and management of personnel and resources. On the other hand, analytical and innovation thinking, complex problem-solving, creativity, originality and leadership will grow as desirable skills that employers seek.

These skills also correspond to the emerging job profiles in the next few years. New types of jobs will gain importance in the coming years while some existing jobs will become redundant. Across all industries, by 2022, the expectation is that the decline of certain types of jobs which account for 10% of all jobs will be offset by the creation of new roles. About 50% of current professions will remain somewhat stable.

Existing jobs such as data analysts, scientists, programmers, applications developers, and e-entrepreneurs and social media specialists that require advanced skills in technology are among the emerging roles that are set to experience an increase in labor market demand in the period up to 2022. These fall under the category of stable jobs joined by higher management officers, sales and marketing professionals, human resources specialists, financial advisers and post-secondary teachers.

Moreover, the report's analysis notes that due to the proliferation of technology in the classroom that there is a growing need for educators who are experienced in this area of learning: AI and machine learning professionals, big data and data security experts, process automation and robotics specialists, end to end user experience consultants and blockchain developers.

Office workers and routine-based jobs are easy targets for automation with the new technologies available. Jobs in data entry, accounting and banking are becoming increasingly redundant with continuing developments in automated banking and intelligent scanning.

Over in Europe, a similar trend is forecasted by the European Commission. Despite the economic crisis faced by several countries in the European Union, demand for workers with STEM skills is still expected to grow. Around 7 million job openings are forecast until 2025 - two-thirds for replacing retiring workers (Caprile et al., 2015).

Current shortages appear to be more pronounced for technological fields such as engineering and information communication technology. Among the 20 European countries surveyed, over two-thirds reported that there are difficulties with labor supply in the sectors of engineering, science and ICT. This is consistent with recent employment trends in these occupations (Caprile et al., 2015).

Osborne and Dillon (2008) noted that there was not significant enough support from educational institutions to include STEM learning as a requirement for young learners to engage with. From a different perspective, Craig et al. (2011) suggested that the problem is not one of shortages. Instead, the problem is one of location mismatch. Skilled and talented individuals are being produced but they are not available where they are needed. For example, the three largest emerging economies (Brazil, India, China) already produce more STEM talent than three of the world's largest developed economies (US, UK, Japan) claiming a higher percentage every year. Essential mechanisms and information to match the supply and demand of talented workers are lacking in the global job market (Craig et al., 2011).

Women in STEM Careers

According to the U.S. Department of Commerce, women filled nearly half of all U.S. jobs in 2015 but held only a quarter of all the STEM jobs in the same year. In the same manner, about half of college educated workers are made up of women yet only a 25% held jobs amongst college educated STEM workers. The Census Bureau's American Community Survey (ACS) data show the same findings (Noonan, 2017). In other words, women were less likely to be STEM workers in America even if they were STEM educated.

The lack of equal gender distribution in STEM careers is not only a gender issue. It is a systemic issue caused by layers of socio-economic, cultural and educational factors (Caprile et al, 2012). The literature emphasizes the role of gender association and biases to explain the disparity in gender distribution across fields of study. Traditional gender roles are first and foremost perpetuated and by family members, especially parents. Schooling reinforces these stereotypes, often limiting or encouraging choices on studies and careers based on gender (Sáinz, Palmén, & Garcia, 2012). Research suggests a correlation regarding gender bias against females over the entire range of scientific fields of study that exists at all levels of institutional education. This leads to women having a disadvantage when they reach graduate level studies and in the workforce.

Gender discrimination is still a prominent issue in modern day society despite more efforts to eradicate it. Biases and social norms usually affect girls negatively in the quality and access they have in STEM studies and careers. Girls are highly underrepresented in STEM because science, technology, engineering and mathematics are historically male-oriented subjects. This is a deep rooted problem in education which hinders progress towards sustainable development.

Research by Sáinz et al. (2012). has shown that girls' self-efficacy and attitudes related to STEM are significantly affected by their parents' support and encouragement as well as the community. Parents' own beliefs, attitudes and expectations are also strongly influenced by traditional gender expectations and stereotypes, which can result in a disparity in pastoral care, play and learning experiences. For female children who come from families with higher educations and socio-economic backgrounds, STEM is more widely available and encouraged as a key educational element to their personal development. This tends to not be true for families from lower socio-economic and educational standing including immigrants, single parent households and minorities. Representation of women in media as well as the wider society's treatment of women also strongly influence the participation of women in STEM occupations (Sáinz et al., 2012).

The gender gap widens as students progress through secondary and post-secondary education. Late adolescence and early adulthood are stages when individuals have enough exposure in different activities to start developing specialization in certain interests. Here students start to make decisions such as to what academic path they would like to pursue (Van Langen, Bosker, & Dekkers, 2006).

Moreover, evidence shows that girls continually lose interest in STEM fields as they grow older. This is not the case with boys. A study from the United Kingdom reported that early adolescent girls and boys aged 10-11 years did not differ so much in their levels of interest in engaging in STEM. About 75% of boys and 72% of girls reported that they were interested in studying matters of science. This dramatically changes as they turned into young adults. At age 18, levels of interest in STEM fell to 33% for boys and 19% for girls. A similar trend was observed in America. Boys started to lose interest in STEM subjects as they entered advanced level studies while girls lose interest at lower secondary (Sáinz, et al., 2012).

In Thailand, 44% of employment or approximately 17 million jobs are at risk of automation over the next two decades according to the International Labour Organization. Women take a larger portion of these at-risk jobs requiring low STEM skills and will most likely be negatively impacted by this shift towards automation (https://www.ilo.org/).

Social Cognitive Career Theory

Social cognitive career theory (SCCT) is a relatively new theory that aims to explain three interrelated aspects of career development: (1) how basic academic and career interests develop, (2) how educational and career choices are made, and (3) how academic and career success is obtained. This theory considers different factors such as interests, abilities and environmental factors which also appear in more earlier career theories supported by evidence to affect career choice. Developed by Robert W. Lent, Steven D. Brown, and Gail Hackett in 1994, SCCT is based on Albert Bandura's general social cognitive theory, an established theory of cognitive and motivational processes which has been used in countless other studies and theoretical development related to academic achievement, pedagogical development, psychosocial functions and behavior (LaForce, Noble, & Blackwell, 2017).

The SCCT framework looks at the individual's decision-making process leading to career choices, as well as other factors that promote or limit personal choice and agency. Specifically, the theory focuses on the following variables: self-efficacy, expected outcomes, goals, contextual factors and experiential learning factors (Lent, Brown, & Hackett, 1994).

Self-efficacy refers to an individual's beliefs about his or her own abilities and capacity to achieve certain tasks or to succeed in a particular avenue (Bandura, 1986). Self-esteem is not synonymous to self-efficacy. Whereas self-esteem or confidence refer to a person's overall sense of self-worth, self-efficacy are more specific and usually pertain to a particular domain. For example, a person's self-efficacy might be very high in accomplishing tasks related to face-to-face sales but feel much less confident about online marketing. SCCT assumes that there is a likelihood for people to pursue careers that have occupational domains in which they have strong self-efficacy beliefs (Lent et al.,1994).

Outcome expectations refer to a person's evaluation of particular outcomes resulting from their performance in specific domains or activities. Individuals make decisions regarding activities they will invest energy and effort into by evaluating their perceived outcomes. For example, a person who pursues an intensive workout regimen perceives a positive outcome of weight loss and improved fitness which is most likely a priority to the individual. Similar to self-efficacy, an individual's expected outcomes can determine his or her level the level of engagement, effort and persistence in a particular activity (Lent et al.,1994).

Personal goals can be understood as a person's own intentions to engage in an activity and to what degree or level they will perform to, for example, pursue a particular bachelor's degree or to graduate summa cum laude. SCCT further classifies personal goals into two categories: choice goals and performance goals. Choosing a field of study or career is a choice goal. Aiming to complete a course with high honors is considered a performance goal which indicates the degree of success which an individual targets as a goal. Setting goals allows people to organize themselves and to self-regulate over long periods of time especially in the absence of external motivation. Individuals tend to have goal systems that are in line with their beliefs of their personal capabilities and their outcome expectations. Goals are generally implicit in career development and choice theories. Social cognitive career theory posits important reciprocal relationships among self-efficacy, expected outcomes and personal goals (Lent et al.,1994).

Self-efficacy, outcome expectations, and goal systems play important roles in SCCT's models of career interest development, choice making, and performance attainment. A student's interest in career-forming activities is a result of self-efficacy and outcome expectations. As an individual matures, he or she is exposed to various career-relevant activities in school, at home and in their communities. The context and culture of their development also reinforce their interest to pursue certain activities and hone skills in particular domains. In many cultures, for example, gender affects the type of exposure and encouragement an individual receives toward engaging in different types of activities (Lent et al.,1994).

Through engagement in various educational and occupational activities, individuals practice skills and develop the concept of performance attainment or standards. If they excel at a particular task, their self-efficacy in the relevant domain increases. They also learn about possible outcomes and what to expect. Individuals tend to pursue interests and activities when they perceive themselves as fully-capable to complete the tasks most relevant to the particular activity. It is also highly likely that an individual pursues the activity because of expected positive outcomes. When people believe they can accomplish a goal, they involve themselves in more, invest time and effort into the chosen academic or vocational activity. This then leads to more experiences that allow mastery or failure which feedbacks to an individual's self-efficacy and expected outcomes what is truly a constant cycle (Lent et al.,1994).

A young person's interest development is highly malleable and dynamic up until late adolescence when interests become more definitive and stable. This is not to say that people do not change their interests in adulthood. As a matter of fact, data shows that it does. SCCT assumes that when these latter changes in interest occur, they can be explained in self-efficacy beliefs or outcome expectations or both. This usually happens when the individual is exposed to a major learning experience in recent time that changes their career or academic direction (LaForce et al., 2017).

Interests can greatly affect academic and occupational choice when individuals are supported and enabled to pursue these interests. Unfortunately, many young adults are not able to follow their interests because of constraints labeled as "environmental influences" in SCCT. These factors can be financial, cultural, educational, and racial. In these cases, the individual will have to compromise and make pragmatic choices based on considerations of the opportunities available, self-efficacy beliefs and expected outcomes.

To sum up SCCT, the theory assumes that people are likely to form career and academic interests when they perceive themselves as competent at the required tasks involved and when they value the outcomes that follow. Furthermore, SCCT posits that for interests to grow in a particular occupation or educational area, individuals must be in environments that expose them to compelling learning experiences that can encourage the formation of strong self-efficacy beliefs and positive outcome expectations. In short, a person's interest in an academic or career path blossoms when he or she has high levels of self-efficacy in the activities involved and when the expected outcome beliefs are positive (LaForce et al., 2017)

Previous Research

In recent years, policy-makers, researchers and educators alike have been taking greater interest in studying and implementing strategies for engaging students in STEM and cultivating their interest to pursue STEM studies and careers.

Evidence from prior research indicates that intrinsic motivation and self-efficacy beliefs affect student success (Wang, 2013). Hence, educators and policy-makers encourage instructional strategies that can promote positive motivation and ability beliefs.

Perceptions of PBL

Based on a 2017 study by LaForce, Noble and Blackwell, it can be hypothesized that PBL may be a viable strategy for increasing students' interest in STEM fields. The study drew upon survey responses from 3,852 high school students at 17 inclusive STEM high schools across the United States and examined the use of project based learning to increase interest in STEM careers. La Force et al.(2017) measured perceptions of PBL on a 12-item PBL scale. The scale captured the frequency with which students reported experiencing various aspects of PBL at their school, with each item measured on a 6-point Likert scale anchored by never and always.

Research findings from LaForce et al. (2017) showed that PBL has a direct effect on interest in a future STEM career (IFSTEMC); when controlling for STEM attitudes, PBL had a reduced but still significant effect on IFSTEMC.

Interest in Future STEM Careers

In the study by Laforce et al.(2017), students' interest in a future STEM career was measured on a scale which consisted of the following four items: (a) I see myself pursuing a career in STEM; (b) I expect to take a lot of STEM courses in college; (c) A career in STEM sounds exciting to me; and (d) If I had to pick a college major right now, it would be in a STEM field. Each item was measured on a 6-point Likert scale anchored by strongly disagree and strongly agree and the scale achieved high reliability ($\alpha = 0.97$). The findings suggest that higher ratings for students' perception of PBL predict higher IFSTEMC.

In another study conducted in a vocational high school in Turkey, Çevik (2018), the relationship between PBL STEM education and students' academic achievement and career interest was confirmed. The study measured students' interest in future STEM careers on a STEM career interest scale following the application of PBL to a sample of 18 students in the 11th grade. It was found at the end of the study that students improved significantly in their academic achievement and developed STEM career interests in a positive direction.

Several other studies show evidence that engagement in PBL activities can increase self-efficacy and confidence in STEM disciplines (Baran & Maskan, 2010; Cerezo, 2015) which, consequentially, could lead to more positive attitudes toward STEM studies and later on a career in STEM fields.

Research findings have shown that PBLs not only improve students' conceptual knowledge but also their intrinsic motivation and self-efficacy (Massa, Dischino, Donnelly &

Hanes, 2009). This is also supported by Cerezo (2015), who showed that PBLs were particularly effective in enhancing STEM self-efficacy in middle school girls. Berk et al. (2014) showed that learners who had experienced PBL were more inclined to also engage positively with STEM which resulted in them considering careers in STEM-related fields. So, it can be surmised that experience with PBL and STEM may be a key path for students to pursue higher education and careers related to STEM.

LaForce et al.(2017) found that gender had no significant effects on PBL ratings or career interest although further research was recommended.

Strong evidence shows that STEM courses and careers are growing in interest and given that it promotes the development of key life skill of self-sufficiency, and the educational benefits of PBL in developing social-cognitive factors, this study seeks to examine how PBL learning experiences can encourage students to seek out STEM-related fields.

Background of the School

Saint Joseph Convent School is an all-girls private school located in Central Bangkok founded in 1904. It is a Catholic school catering to Thai students in primary and secondary levels. Saint Joseph Convent School is considered to be a prestigious and conservative institution. At its inception, the school had mostly European students who came from families temporarily staying in Thailand. The Thai Ministry of Education officially approved Saint Joseph Convent School as an academic institution in 1936, and has since received four Royal awards for the best Elementary and Secondary School.

The English Program was created in 1997 as a response to the demand for English language instruction of content subjects such as math, science and English. The English Program caters to students from Grades 1 to 12.

This study focuses only on Grades 7, 8 and 9 in the English Program. There are 3 classes in each grade level. Each class learns 5 hours of English, 5 hours of Science, 5 hours of Math and 1 hour of ICT with foreign teachers. Teachers of each grade level work together to implement a term-long project for PBL wherein students spend 1 hour each week consulting with the different subject teachers.

CHAPTER III

RESEARCH METHODOLOGY

In the previous chapter, the researcher presented the theories and literature related to the study. Literature related to PBL, perceptions of learning experiences, career choice, and previous research related to the study have been reviewed. This chapter will provide the procedures that will be used in the research process of this study. Included in this chapter are the research design, population sample, information on the research instruments, collection of data timeline, and the data analysis methods.

Research Design

This study is a comparative-correlational quantitative data analysis that measured and compared Grades 7, 8 and 9 students' perceptions of PBL as well as their interests in future STEM careers. This study aimed to investigate the relationship between Grades 7, 8 and 9 English program students' perceptions of PBL and their interest in future STEM careers. The researcher utilized two instruments to measure the two variables mentioned: Perceptions of PBL Questionnaire and Interest in Future STEM Careers (IFSTEMC) Questionnaire.

Descriptive statistics, means, standard deviations, one-way analysis of variance(ANOVA), and correlational analysis using Pearson Product-Moment Correlation were used to analyze the data gathered.

Population Sample

The population of this study included Grades 7, 8 and 9 English Program students at St. Joseph Convent School, Bangkok, Thailand, during the academic year 2020-2021. All the students were Thai and female.

There was a population of 234 students in Grades 7, 8 and 9 of the English Program. There were 80 students in Grade 7, 80 students in Grade 8 and 74 students in Grade 9. Due to the Covid-19 pandemic, there was a high rate of absent students. Only 191 out of 234 students participated in the survey. Forty-three students were absent due to illness or their family's preference to stay home due to concerns regarding Covid-19 infection. The sample consists of 56 students in Grade 7, 72 students in Grade 8 and 63 students in Grade 9. There were 191 respondents in total. Table 1 presents the number of students in each grade.

Table 1

Total 191 Grades 7, 8 and 9 English Program Students at St. Joseph Convent School, Bangkok, Thailand (Academic School Year 2020 – 2021)

Grade	Total Number of Students	Sample Size
7	80	56
8	80	72
9	74	63
Total	234	191

Research Instruments

Two instruments were used in this study. Both questionnaires were adopted from a study by LaForce et al.(2017) in Chicago, supported by a grant from the National Science Foundation to investigate how PBL may address the growing demand in STEM workforce. The two instruments are called Perceptions of PBL and Interest in Future STEM Careers. The questionnaires were originally administered to 20 selected inclusive STEM schools in seven states in America.

Perceptions of PBL Questionnaire

The first instrument called Perceptions of PBL questionnaire measured the independent variable of the study: Grade 7 to 9 students' perceptions of PBL. It is a 12-item questionnaire scored on a 6-point Likert-type anchored by never and always. All items were used in this study to determine the levels of Grades 7, 8 and 9 English Program students' perceptions of project based learning. Exploratory factor analyses were conducted to investigate construct validity. Reliability was measured at α = 0.96. This instrument can be found in Appendix C. Table 2 presents the interpretation scale of the perceptions of PBL questionnaire used in this study.

Table 2

Scores and Interpretation of the Perceptions of PBL

Agreement level	Score	Mean score	Motivation interpretation level
Always	6	5.15 - 6.00	Very high
Very Frequently	5	4.32 - 5.14	High
Frequently	4	3.49 - 4.31	Slightly high
Occasionally	3	2.66 - 3.48	Slightly low
Rarely	2	1.83 - 2.65	Low
Never	1	1.00 - 1.82	Very low

Interest in Future STEM Careers(IFSTEMC) Questionnaire

The second instrument called Interest in Future STEM Careers(IFSTEMC) measured the dependent variable. Hence, it was used to determine the levels of Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School. This scale was developed for the same study as the perceptions of PBL questionnaire. Each item was measured on a 6-point Likert scale anchored by strongly disagree and strongly agree. Exploratory factor analyses were conducted to investigate construct validity. The scale achieved high reliability α = 0.97. The instrument can be found in Appendix C.

Table 3 presents scale interpretation scale of the IFSTEMC questionnaire used in this study.

Table 3

Scores and Interpretation of the Interest in Future STEM Careers

Agreement level	Score	Mean score	IFSTEMC Interpretation level
Strongly agree	6	5.15 - 6.00	Very high
Agree	5	4.32 - 5.14	High
Slightly agree	4	3.49 - 4.31	Slightly high
Slightly disagree	3	2.66 - 3.48	Slightly low
Disagree	2	1.83 - 2.65	Low
Strongly disagree	1	1.00 - 1.82	Very low

Correlation of Perceptions of PBL and IFSTEMC

The correlation between the students' perceptions of PBL and their interest in future STEM careers will be analyzed using Pearson's Product-Moment Correlation. Table 4 offers the interpretation scale for the correlation coefficient of this study (Selvanathan et al., 2020).

Table 4

Scale of Correlation Coefficient and Their Interpretations

Scale of Correlation Coefficient	Interpretation
$0 < r \leq 0.19$	Very low correlation
$0.2 \leq r \leq 0.39$	Low correlation
$0.4 \leq r \leq 0.59$	Moderate correlation
$0.6 \leq r \leq 0.79$	High correlation
$0.8 \leq r \leq 1.0$	Very high correlation

Collection of Data

The researcher administered the questionnaires to Grades 7, 8 and 9 students in the English program in March 2021 at the end of the second semester of the 2020-2021 academic school year. Students were given 20 minutes during the class period to complete the survey.

There was a return rate of 100% as all questionnaire responses were useable. Table 5 below outlines the data collection process.

Table 5

Research Timeline for This Study

Date	Task
December 2020	Official permission from school to conduct research
March 2021	Thesis proposal examination
March 2021	Data collection
March 2022	Final thesis examination

Data Analysis

The researcher used descriptive statistics to include frequencies, means, and standard deviations for research objectives 1 and 2. One-way ANOVA was used to measure objectives 3 and 4. Lastly, a correlational analysis using Pearson product–moment correlation was employed for objective 5. The summary of the research process follows in Table 6.

Summary of the Research Process

The research process of this study is summarized in Table 6.

Table 6

Summary of the Research Process

Research objective	Source of Data or Sample	Data Collection Method or Research Instrument	Method of Data Analysis
1. To determine the levels of Grades 7, 8 and 9 English Program students' perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand.	A population sample of 191 Grades 7, 8 and 9 English Program students at St. Joseph Convent School, Bangkok, Thailand	Perceptions of PBL Questionnaire	Descriptive statistics (frequencies, means, and standard deviations)
2. To determine the levels of Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.	A population sample of 191 Grades 7, 8 and 9 English Program students at St. Joseph Convent School, Bangkok, Thailand	IFSTEMC Questionnaire	Descriptive statistics (frequencies, means, and standard deviations)

(continued)

(continued)

Research objective	Source of Data or Sample	Data Collection Method or Research Instrument	Method of Data Analysis
3. To determine if there is a significant difference among Grades 7, 8 and 9 English Program students' perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand.	A population sample of 191 Grades 7, 8 and 9 English Program students at St. Joseph Convent School, Bangkok, Thailand	Perceptions of PBL Questionnaire	One-way ANOVA
4. To determine if there is a significant difference among Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.	A population sample of 191 Grades 7, 8 and 9 English Program students at St. Joseph Convent School, Bangkok, Thailand	IFSTEMC Questionnaire	One-way ANOVA
5. To determine if there is a significant relationship between Grades 7, 8 and 9 English Program students' perceptions of project based learning and students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.	A population sample of 191 Grades 7, 8 and 9 English Program students at St. Joseph Convent School, Bangkok, Thailand	Perceptions of PBL Questionnaire and IFSTEMC Questionnaire	Correlational analysis using Pearson Product-Moment Correlation

In this chapter, the researcher presented the research design, population, sample, research instrument, data collection, data analysis, and the summary of the research process of this study. The next chapter presents the findings of the current comparative-correlational study of Grades 7, 8 and 9 English program students' perceptions of PBL and their interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.

CHAPTER IV

RESEARCH FINDINGS

This chapter presents the findings from the research. The data was collected from 191 students at the end of the academic year 2020-2021, at St. Joseph Convent School in Bangkok.

The researcher measured the students' perceptions of project based learning and their interest in future STEM careers. The relationship between the two variables was also analyzed. The students had attended a PBL course for an hour each week during the school year.

The research objectives and findings are as follows.

Research Objective 1

Research Objective 1 was to determine the levels of Grades 7, 8 and 9 English Program students' perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand.

Table 7 shows frequency distribution of the students' perceptions of PBL mean scores including their interpretations.

Table 7

The Frequency Distribution of Students' Perceptions of PBL and their Interpretations

Grade	Interpretation	Number of students
7	Very high	22
	High	19
	Slightly high	11
	Slightly low	3
	Low	1
	Very Low	0

(continued)

(continued)

8	Very high	29
	High	19
	Slightly high	11
	Slightly low	7
	Low	5
	Very Low	1
9	Very high	28
	High	13
	Slightly high	14
	Slightly low	6
	Low	2
	Very Low	0
Overall	High	191

The data in Table 7 show that across all grade levels, only 1 student had very low perceptions of PBL. Eight students had low PBL ratings between 1.83 and 2.65. About 8% of the respondents at a quantity of 16 students had slightly low ratings of PBL. The trend continues upward with 36 and 51 students having slightly high and high perceptions of PBL, respectively. Lastly, 79 students rated their perceptions of PBL as very high between 5.15 and the maximum score of 6.00.

Table 8 below highlights the mean per grade level, the overall mean score for perceptions of PBL, and their interpretations. The Perceptions of PBL questionnaire measured Grades 7, 8 and 9 students' perceived quality of their learning experience during the PBL course. Table 8 also shows the standard deviation of the reported mean scores.

Table 8

Grade Level Means, Standard Deviations and Interpretations for Students' Perceptions of PBL

	N	*M*	*SD*	Interpretation
Grade 7	56	4.79	.85	High
Grade 8	72	4.58	1.17	High
Grade 9	63	4.76	1.03	High
Total	191	4.70	1.04	High

The data in Table 8 show that the mean rating for the whole sample was 4.70. According to Table 2 in Chapter III and Table 6 in this chapter, the variable's mean falls under the category of high level of perception of PBL.

Research Objective 2

Research Objective 2 was to determine the levels of Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.

Table 9 presents the frequency distribution of mean scores of Grades 7, 8 and 9 students' interest in future STEM careers and their interpretation.

Table 9

The Frequency Distribution and Interpretation of Students' Interest in Future STEM Careers

Grade	Interpretation	Number of students
7	Very high	14
	High	19
	Slightly high	16
	Slightly low	4
	Low	2
	Very Low	1
8	Very high	24
	High	15
	Slightly high	15
	Slightly low	9
	Low	4
	Very Low	5
9	Very high	27
	High	9
	Slightly high	13
	Slightly low	8
	Low	4
	Very Low	2
Overall	High	191

The data in Table 9 shows an ascending trend in students' interest in future STEM careers. Across all grade levels, only eight students had very low interest in future STEM careers with mean scores between 1.00 and 1.82. Ten students rated their IFSTEMC between

1.83 to 2.65 which is considered low. Twenty-one students had mean ratings between 2.66 and 3.48 which is interpreted as slightly low. The majority of the students' IFSTEMC ratings fell under slightly high to very high. Forty-four students rated IFSTEMC between 3.49 and 4.31 which is considered slightly high. Similarly, 43 students responded with high ratings of PBL between 4.32 to 5.14. Finally, 65 students had very high mean ratings between 5.15 and 6.00.

Table 10 shows the mean score and standard deviation of interest in future STEM careers of Grades 7, 8 and 9 English program students at St. Joseph Convent School.

Table 10

Grade Level Means, Standard Deviations and Interpretations for Students' Interest in Future STEM Careers

	N	*M*	*SD*	Interpretation
Grade 7	56	4.54	1.02	High
Grade 8	72	4.38	1.35	High
Grade 9	63	4.61	1.39	High
Total	191	4.51	1.25	High

The data in Table 10 above show that the mean score of IFSTEMC for the whole sample was 4.51. Table 3 in Chapter III and Table 8 in this chapter, this value is considered as high interest in future STEM careers amongst the respondents.

Research Objective 3

Research Objective 3 was to determine if there was a significant difference among Grades 7, 8 and 9 English Program students' perceptions of project based learning. A one-way analysis of variance was conducted to compare the effect of the students' grade levels on students' perceptions of PBL. ANOVA results are shown in Table 11.

Table 11

ANOVA Results for Students' Perceptions of PBL Using Grade Level (7 to 9) as the Criterion

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.77	2	0.89	0.82	0.443
Within Groups	203.44	188	1.08		
Total	205.21	190			

The one-way ANOVA showed that the effect of students' grade level on their perceptions of PBL was insignificant ($F_{2, 188} = .82, p > .05$). Therefore, there was no significant difference in the students' perceptions of PBL in Grades 7, 8 and 9.

Research Objective 4

Research Objective 4 was to determine if there was a significant difference among Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand. A one-way analysis of variance was conducted to compare the effect of the students' grade levels on students' interest in future STEM careers. ANOVA results are shown in Table 12.

Table 12

ANOVA Results for Students' Interest in Future STEM Careers

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.78	2	0.89	0.54	0.582
Within Groups	307.87	188	1.64		
Total	309.65	190			

The one-way ANOVA showed that the effect of students' grade level on their interest in future STEM careers was insignificant at ($F_{2, 188} = .54, p > .05$). Therefore, there was no significant difference in the students' interest in future STEM careers in Grades 7, 8 and 9.

Research Objective 5

Research Objective 5 was to determine if there was a significant relationship between Grades 7, 8 and 9 English Program students' perceptions of project based learning and students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.

Table 13 shows the Pearson Product-Moment correlation between students' perception of PBL and students' interest in future STEM careers.

Table 13

Pearson Product-Moment Correlation Between Perceptions of PBL and Interest in Future STEM Careers (N = 191)

	Interest in Future STEM Careers
Perceptions of PBL	.73** (< .001)

Note. **. indicates a statistically significant relationship (statistical significance level at *p*= .05, two-tailed) while *p*-value appears within parentheses below the correlation coefficients.

Table 13 indicates a significant relationship between Grades 7, 8 and 9 English Program students' perceptions of project based learning and students' interest in future STEM careers at St. Joseph Convent School at .05 level. Table 12 shows a strong linear relationship of students' perceptions of project based learning and their interest in future STEM careers (r = .73, p < .001).

In this chapter, the researcher presented the study findings of the relationship of students' perceptions of project based learning and students' interest in future STEM careers of Grades 7, 8 and 9 students at St. Joseph Convent School. In Chapter V, the researcher will summarize the major findings presented above, present the conclusions from those findings, discuss the findings in relation to previous research, and provide recommendations for teachers, future researchers, school administrators, and policy-makers.

CHAPTER V

CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

The previous chapter presented findings from the data collected for this comparative-correlational study of Grades 7, 8 and 9 English program students' perceptions of project based learning and their interests in future stem careers at St. Joseph Convent School, Bangkok, Thailand. This chapter presents a summary of the study, the research findings, and the conclusions drawn from each research objective's findings. Moreover, a discussion of the reseach literature will be presented in relation to the findings. Finally, the chapter will present recommendations to teachers, students, administrators, and future researchers.

Summary of the Study

The main purpose of this study was to determine if there was a significant relationship among Grades 7, 8 and 9 English Program students' perceptions of project based learning and students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand. To examine these variables, a comparative-correlational research was designed to study a total of 191 students in Grades 7, 8 and 9 (56 students from grade 7, 72 students from grade 8, and 63 students from grade 9) of the English Program at St. Joseph Convent School, Bangkok, Thailand.

Furthermore, this study was guided by the following research objectives.

1. To determine the levels of Grades 7, 8 and 9 English Program students' perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand.

2. To determine the levels of Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.
3. To determine if there is a significant difference among Grades 7, 8 and 9 English Program students' perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand.
4. To determine if there is a significant difference among Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.
5. To determine if there is a significant relationship between Grades 7, 8 and 9 English Program students' perceptions of project based learning and students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.

Students' perceptions of PBL were measured by an instrument called Perceptions of PBL Questionnaire while the dependent variable was measured by the Interest in Future STEM Careers(IFSTEMC) Questionnaire. The focal hypothesis of the study was based on the last objective.

The current study confirmed that there is a significant relationship between Grades 7, 8 and 9 English Program students' perceptions of project based learning and students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand, at a significance level of .05.

Summary of the Findings

This section presents a summary of findings obtained from the data collection and analysis. The research findings are presented in relation to the objectives.

Research Objective 1

According to the data gathered from the Perceptions of PBL Questionnaire, Grades 7, 8 and 9 English Program students had high levels of perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand. The overall rating based on students' responses were interpreted as high perceptions of their PBL learning experience based on Table 3 in Chapter III.

Research Objective 2

Based on the evidence obtained from IFSTEMC Questionnaire responses, the researcher found that Grades 7, 8 and 9 English Program students at St. Joseph Convent School, Bangkok, Thailand had high levels of interest in future STEM careers with an overall mean rating of 4.51 based on Table 4 in Chapter III.

Research Objective 3

Regarding Research objective 3, there was no significant difference in the levels of Grades 7, 8 and 9 English Program students' perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand.

Research Objective 4

Similarly, the researcher found that there was no significant difference in the levels of interest in future STEM careers among Grades 7, 8 and 9 English Program students at St. Joseph Convent School, Bangkok, Thailand.

Research Objective 5

Most importantly, the researcher found a significant relationship between the Grades 7, 8 and 9 English Programs students' perceptions of project based learning and their interests in future STEM careers at St. Joseph Convent School, Bangkok, Thailand. A Pearson correlation coefficient was computed to assess the linear relationship between students' perceptions of project based learning and their interests in future STEM careers. It was found that there was a strong significant correlation between the two variables.

Conclusions

From the research findings, the following conclusions were drawn.

Research Objective 1

The findings of Research Objective 1 indicated the following results about the students' perceptions of project based learning.

The high levels of students' perceptions of project based learning in Grades 7, 8 and 9 English Program at St. Joseph Convent School, Bangkok, Thailand indicated that students had a positive learning experience in their 1-hour per week project based learning. Students found that project based learning offered student-led activities which allowed them to relate previous knowledge in multiple subjects to real-world problems. The process of inquiry, collaboration and resolution had a positive effect on the student's perceptions of project based learning.

Research Objective 2

The findings of Research Objective 2 have the following implications about students' interest in future STEM careers.

The high levels of students' interest in future STEM careers in Grades 7, 8 and 9 English Program at St. Joseph Convent School, Bangkok, Thailand, indicate that the students are likely to consider pursuing a degree in STEM in university. Further, the researcher can also conclude that the students are interested in future STEM careers.

Research Objective 3

The findings from Research Objective 3 revealed that there was no significant difference between Grades 7, 8 and 9 English Program students' perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand. The researcher can conclude that the students across all three grade levels in the study had positive perceptions of their PBL learning experience.

Research Objective 4

The findings from Research Objective 4 revealed that there was no significant difference between Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand. The researcher can conclude that the students across all three grade levels in the study had high levels of interest in pursuing further studies as well as a career in STEM.

Research Objective 5

The most clinically relevant finding is related to Research Objective 4. The current study found that there was a significant strong, positive and linear relationship among Grades 7, 8 and 9 English Program students' perceptions of project based learning and their interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand. A conclusion can be drawn that the students' positive perceptions of PBL correlated with their desire to pursue STEM studies and careers in the future.

Discussion

This section presents discussion on the research findings in relation to the previous research and literature. The discussion that follows is organized based on the variables in the current study.

Perceptions of Project Based Learning

The results of the study showed that Grades 7, 8 and 9 English Program students had positive perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand. It also showed that there was no significant difference between Grades 7, 8 and 9 English Program perceptions of project based learning at St. Joseph Convent School, Bangkok, Thailand.

It is important to note that the PBL model implemented in the English Program at St. Joseph Convent School employs seven design elements of PBL (Larmer & Mergendoller, 2015). These include a challenging problem or question, sustained inquiry, authenticity, student voice and choice, reflection, critique and revision, and a public product. The program aimed to engage students in discussion, research, student-led collaboration, prototyping, iteration and presentation. These elements can offer an explanation regarding the students' positive perceptions of these learning experiences.

As discussed in the literature review, PBL tasks can result in positive results if they are relevant, real-world problems (Baran & Maskan, 2010; Cerezo, 2015; Çevik, 2018; LaForce et al., 2017). The driving question is arguably the most important aspect of PBL. Examples of PBL driving questions or challenging problems that were given to the Grades 7, 8 and 9 English Program students at St. Joseph Convent School are as follows.

- What will the sustainable home of the future look like?
- Create a technological solution for an issue or problem that you care about.
- Identify a problem relating to Covid-19 and create a product or service that helps to solve the problem.

For each project, Grades 7, 8 and 9 students were given one hour per week for approximately twelve weeks. Under the supervision of their mentors which comprised of their English, math, science and technology teachers, Grades 7, 8 and 9 students worked in small teams of five to six students to brainstorm, research, plan and eventually, build their prototypes or artifacts. The students received expert advice from their mentors for the various subject components utilized in their project.

To illustrate the PBL elements present in the implementation of PBL in Grades 7, 8 and 9 English Program at St. Joseph Convent School, the researcher will draw examples from PBL in the first term of the academic year 2020 to 2021. Grades 7, 8 and 9 teachers agreed on an overarching challenge which asked the students to identify a problem relating to Covid-19 and create a product or service that helps solve the problem. Each grade level was given a specific sector to focus on. All teachers collaborated on the PBL brief and had uniform delivery of the instructions and expectations. The PBL brief is attached in Appendix D.

The overarching theme, the standard PBL brief and the consistent structure across the grade levels in this study offer a possible explanation as to why there was no significant difference in the students' perceptions of PBL Grades 7, 8 and 9 English Program students at St. Joseph Convent School, Bangkok, Thailand.

In response to criticism on PBL and its ineffectiveness due to minimal guidance (Kirschner et al., 2006), this researcher argues that guidance can be strong and consistent during PBL while still respecting the students' choices. Grades 7, 8 and 9 teachers acted as mentors who approved the students' proposals, offered advice and conducted regular follow-ups. Grades 7, 8 and 9 teachers implemented weekly check-ins and used mentor checklists to guide students toward successful completion of their projects. Examples of the mentor checklists can be found in Appendix E. The findings suggest that consistent and strong guidance during PBL produce positive perceptions of PBL. Appendix F offers an example of students Grade 7 students' work and anecdotal evidence that strong guidance contributes to high perceptions of PBL.

In reviewing the literature, the criticism from Kirschner et.al. (2006) was not unfounded. Earlier versions of PBL focused on experiential learning or learning by doing. Constructivists argued that meaningful learning is a largely self-managed process wherein the individual draws on previous knowledge, reflects and construct new knowledge (Bereiter, 1994; Von Glasersfeld, 1995). Dewey's theory of experience saw the teacher as a facilitator of the stimuli, creating planned experiences for students in order to simulate real-world situations (Dewey, 1938). Kolb's (1984) experiential learning theory offered a cycle with four stages: concrete experience, observation and reflection, forming abstract concepts, and testing in new situations. Teacher feedback, advice, mentorship and guidance are not mentioned as a crucial element. However, latter implementations of PBL including the one used for this current study, involved critique and guidance from teachers (Larmer and Mergendoller, 2015).

An implication of the findings related to the perceptions of PBL variable is the possibility that ensuring proper implementation of the seven design elements of PBL can result in positive learning experiences and successful project based learning. Appendix H shows examples of students' work during PBL in the first term of 2020.

Interest in Future STEM Careers

The research findings show that Grades 7, 8 and 9 English Program students have high levels of interest in future STEM careers. There are several possible explanations for this result. First, previous research indicated that one of the factors that determine career interest is the quality of a student's learning experience in a particular domain. Social Cognitive Career Theory (Lent et al.,1994) posits that when individuals develop positive outcome expectations and self-efficacy related to activities in a domain: for example STEM, those individuals become more likely to pursue studies and later on, careers in STEM. Second, environmental and socio-economic factors play an undeniable role in career and academic choices (Caprile et al, 2012). Grades 7, 8 and 9 English Program students at St. Joseph Convent School, Bangkok, Thailand have access to facilities such as a modern laboratory, a state-of-the-art computer room, access to the internet and well-appointed classrooms. In addition, most Grades 7, 8 and 9 English Program students come from families with higher educations and socio-economic backgrounds. STEM activities and studies are available and encouraged. Third, the recent years have offered more media representation of women in STEM careers. This generation of students are seeing more female doctors, engineers, programmers and other STEM professions than ever before. Not only is it more common, it is also seen by society as a desirable career path. As mentioned in the literature, the representation of media and society's treatment of women strongly influence the participation of women in STEM (Sáinz et al., 2012).

It is interesting to note that there was no significant difference in the levels of Grades 7, 8 and 9 English Program students' interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand. It can thus be suggested that Grades 7, 8 and 9 students at St. Joseph Convent School, Bangkok, Thailand have similar access to learning opportunities and exposure to STEM. This finding can also be explained by the fact that St. Joseph Convent School, Bangkok, Thailand is an all-girls school. Although gender bias in STEM careers was discussed in the literature, it was not relevant in the data obtained from the current study.

Perceptions of Project Based Learning and Promoting Interest in Future STEM Careers

The most important clinically relevant finding was the significant strong and positive correlation between Grades 7, 8 and 9 English Program students' perceptions of project based learning and their interest in future STEM careers at St. Joseph Convent School, Bangkok, Thailand.

This study supports evidence from previous research (e.g. LaForce et al., 2000; Baran & Maskan, 2010; Cerezo, 2015; Çevik 2018) which have found positive relationships beteen engagement in PBL activities and STEM career interest.

The observed correlation between perceptions of PBL and interest in future STEM careers might be explained in this way: PBL offers a viable avenue for students to experience STEM interactions so that they may pursue it in further studies and eventually, a career in STEM. When PBL is executed with proper planning and implementation, students are given an opportunity to tap into various subject areas while gaining experience in skills required for STEM jobs. PBL can offer a healthy environment which exposes students to compelling learning experiences that can encourage the formation of strong self-efficacy beliefs and positive outcome expectations in STEM studies and acitivites. Therefore, positive learning experiences, strong self-efficacy belief and positive outcome expectations related to STEM during PBL will most likely lead to positive interest in future STEM careers.

Recommendations

The researcher would like to provide the following recommendations for teachers, students, school administrators, and future researchers according to the findings of the current study of Grades 7, 8 and 9 English Program students' perceptions of project based learning and their interests in future stem careers at St. Joseph Convent School, Bangkok, Thailand.

Recommendations for Teachers

The findings of this research study confirm that PBL is a viable avenue for students to gain exposure to STEM. The researcher recommends that teachers design their PBL based Larmer and Mergendoller's (2015) 7 elements of PBL . These include a challenging problem or question, sustained inquiry, authenticity, student voice and choice, reflection, critique and revision, and a public product. It is recommended that students be given an extended period of time to immerse themselves in PBL. Moreover, teachers must strive to collaborate with other subject teachers so that students can have a more dynamic experience in applying knowledge across multiple subjects. Lastly, teachers are advised to act as mentors and consultants, offering strong guidance and consistent follow-up during PBL while respecting the students' choices.

Recommendations for Students

Job market forecasts have reported an increased demand for workers in STEM fields. It would be advantageous for students to gain exposure to STEM studies and to practice skills such as collaboration, creativity, critical thinking, and communication. Participating in PBL provides real-world simulation of actual processes that exist in STEM fields today. Taking full advantage of such an opportunity will give students a competitive advantage in the future job markets.

Recommendations for Administrators and Ministry of Education (Thailand)

This research has confirmed previous findings that PBL is a powerful tool in honing higher order thinking skills and promoting interest in STEM studies and careers. Therefore, the school administrators and the Ministry of Education (Thailand) should support teachers by offering training workshops and PBL resources for successful planning and implementation. It is also recommended to have dedicated school hours for PBL as it is most effective when students engage in sustained research, discussions, prototyping and iterations. Furthermore, PBL should be cross-curricular and involve learning experiences in various subjects. In preparing students for the real world, PBL tasks should be authentic in the sense that real-world problems and their possible solutions do not exist in a vacuum of only one field of knowledge. Exposing students to STEM integration during PBL is highly recommended in order to promote interest in further STEM studies and careers.

Recommendations for Future Researchers

The current research study was a quantitative correlational research design which was developed to find the relationship between Grades 7, 8 and 9 English Program students' perceptions of project based learning and their interests in future stem careers at St. Joseph Convent School, Bangkok, Thailand.

The data of this study were collected only focusing on the Grades 7, 8 and 9 English program students at St. Joseph Convent School in Bangkok, Thailand. Due to the access limitations, the researcher would recommend the future researcher to collect more data on the variables of perceptions of PBL and interest in future STEM careers to increase the reliability and validity of this study's results.

Future researchers should pay close attention to the structure and delivery of PBL during the study as there are many interpretations of PBL. For example, the interpretation of the PBL teacher's role and guidance during the constructivist learning experience could negatively affect the effectiveness of PBL.

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APPENDICES

APPENDIX A

U.S. Bureau of Labor and Statistics STEM Occupations List

OCC_CODE	OCC_TITLE
11-3021	Computer and Information Systems Managers
11-9041	Architectural and Engineering Managers
11-9121	Natural Sciences Managers
15-1111	Computer and Information Research Scientists
15-1121	Computer Systems Analysts
15-1122	Information Security Analysts
15-1131	Computer Programmers
15-1132	Software Developers, Applications
15-1133	Software Developers, Systems Software
15-1134	Web Developers
15-1141	Database Administrators
15-1142	Network and Computer Systems Administrators
15-1143	Computer Network Architects
15-1151	Computer User Support Specialists
15-1152	Computer Network Support Specialists
15-1199	Computer Occupations, All Other
15-2011	Actuaries
15-2021	Mathematicians
15-2031	Operations Research Analysts
15-2041	Statisticians
15-2091	Mathematical Technicians
15-2099	Mathematical Science Occupations, All Other
17-1011	Architects, Except Landscape and Naval
17-1012	Landscape Architects
17-1021	Cartographers and Photogrammetrists
17-1022	Surveyors
17-2011	Aerospace Engineers
17-2021	Agricultural Engineers
17-2031	Biomedical Engineers
17-2041	Chemical Engineers
17-2051	Civil Engineers
17-2061	Computer Hardware Engineers
17-2071	Electrical Engineers
17-2072	Electronics Engineers, Except Computer
17-2081	Environmental Engineers
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors
17-2112	Industrial Engineers
17-2121	Marine Engineers and Naval Architects
17-2131	Materials Engineers
17-2141	Mechanical Engineers
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers
17-2161	Nuclear Engineers
17-2171	Petroleum Engineers
17-2199	Engineers, All Other
17-3011	Architectural and Civil Drafters
17-3012	Electrical and Electronics Drafters
17-3013	Mechanical Drafters
17-3019	Drafters, All Other
17-3021	Aerospace Engineering and Operations Technicians
17-3022	Civil Engineering Technicians
17-3023	Electrical and Electronics Engineering Technicians
17-3024	Electro-Mechanical Technicians
17-3025	Environmental Engineering Technicians
17-3026	Industrial Engineering Technicians

17-3027	Mechanical Engineering Technicians
17-3029	Engineering Technicians, Except Drafters, All Other
17-3031	Surveying and Mapping Technicians
19-1011	Animal Scientists
19-1012	Food Scientists and Technologists
19-1013	Soil and Plant Scientists
19-1021	Biochemists and Biophysicists
19-1022	Microbiologists
19-1023	Zoologists and Wildlife Biologists
19-1029	Biological Scientists, All Other
19-1031	Conservation Scientists
19-1032	Foresters
19-1041	Epidemiologists
19-1042	Medical Scientists, Except Epidemiologists
19-1099	Life Scientists, All Other
19-2011	Astronomers
19-2012	Physicists
19-2021	Atmospheric and Space Scientists
19-2031	Chemists
19-2032	Materials Scientists
19-2041	Environmental Scientists and Specialists, Including Health
19-2042	Geoscientists, Except Hydrologists and Geographers
19-2043	Hydrologists
19-2099	Physical Scientists, All Other
19-4011	Agricultural and Food Science Technicians
19-4021	Biological Technicians
19-4031	Chemical Technicians
19-4041	Geological and Petroleum Technicians
19-4051	Nuclear Technicians
19-4091	Environmental Science and Protection Technicians, Including Health
19-4092	Forensic Science Technicians
19-4093	Forest and Conservation Technicians
19-4099	Life, Physical, and Social Science Technicians, All Other
25-1021	Computer Science Teachers, Postsecondary
25-1022	Mathematical Science Teachers, Postsecondary
25-1031	Architecture Teachers, Postsecondary
25-1032	Engineering Teachers, Postsecondary
25-1041	Agricultural Sciences Teachers, Postsecondary
25-1042	Biological Science Teachers, Postsecondary
25-1043	Forestry and Conservation Science Teachers, Postsecondary
25-1051	Atmospheric, Earth, Marine, and Space Sciences Teachers, Postsecondary
25-1052	Chemistry Teachers, Postsecondary
25-1053	Environmental Science Teachers, Postsecondary
25-1054	Physics Teachers, Postsecondary
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products
41-9031	Sales Engineers

APPENDIX B

STEM Occupations and Standard Occupational Classification(SOC) Codes

Occupation	SOC code	Occupation	SOC code
Computer and math occupations			
• Computer scientists and systems analysts	15-10XX	• Network systems and data communications analysts	15-1081
• Computer programmers	15-1021	• Actuaries	15-2011
• Computer software engineers	15-1030	• Mathematicians	15-2021
• Computer support specialists	15-1041	• Operations research analysts	15-2031
• Database administrators	15-1061	• Statisticians	15-2041
• Network and computer systems administrators	15-1071	• Miscellaneous mathematical science occupations	15-2090
Engineering and surveying occupations			
• Surveyors, cartographers, and photogrammetrists	17-1020	• Materials engineers	17-2131
• Aerospace engineers	17-2011	• Mechanical engineers	17-2141
• Agricultural engineers	17-2021	• Mining and geological engineers, including mining safety engineers	17-2151
• Biomedical engineers	17-2031	• Nuclear engineers	17-2161
• Chemical engineers	17-2041	• Petroleum engineers	17-2171
• Civil engineers	17-2051	• Engineers, all other	17-2199
• Computer hardware engineers	17-2061	• Drafters	17-3010
• Electrical and electronic engineers	17-2070	• Engineering technicians, except drafters	17-3020
• Environmental engineers	17-2081	• Surveying and mapping technicians	17-3031
• Industrial engineers, including health and safety	17-2110	• Sales engineers	41-9031
• Marine engineers and naval architects	17-2121		
Physical and life sciences occupations			
• Agricultural and food scientists	19-1010	• Physical scientists, all other	19-2099
• Biological scientists	19-1020	• Agricultural and food science technicians	19-4011
• Conservation scientists and foresters	19-1030	• Biological technicians	19-4021
• Medical scientists	19-1040	• Chemical technicians	19-4031
• Astronomers and physicists	19-2010	• Geological and petroleum technicians	19-4041
• Atmospheric and space scientists	19-2021	• Nuclear technicians	19-4051
• Chemists and materials scientists	19-2030	• Other life, physical, and social science technicians	19-40XX
• Environmental scientists and geoscientists	19-2040		
STEM managerial occupations			
• Computer and information systems managers	11-3021	• Natural sciences managers	11-9121
• Engineering managers	11-9041		

APPENDIX C

Perceptions of PBL and Interest in Future STEM Careers Questionnaire

Dear Students,

The main objective of this study is to have more understanding on your perceptions of project based learning(PBL) in your school and your interest in pursuing a career in science, technology, engineering and mathematics(STEM). The questionnaire has three parts. Part I is for the information of your grade level. Part II is the questionnaire asking your perceptions of PBL. Part III is a scale of your interest in future STEM careers.

The data collected from your responses in this questionnaire are considered as very important results for improving project based learning and for promoting STEM in the school. Consequently, please ensure that all your responses of each questionnaire item truly reflect your perceptions and interest.

Your kind participation in this study is highly appreciated. Thank you for your cooperation.

Yours Sincerely,

Giselle Iris Alano

Graduate School of Human Sciences

Assumption University of Thailand

Part I. Demographic Information

Grade Level:

Grade 7 ☐

Grade 8 ☐

Grade 9 ☐

Part II. Perceptions of PBL Questionnaire

Directions: Please accurately answer based on your true feelings and perceptions. There is no right or wrong answer and all your answers will be respected. Put a check (✓) in the box that describes how often you feel the statement is true.

How Often Is the Following True?

Items	1 Never	2 Rarely	3 Occasionally	4 Frequently	5 Very Frequently	6 Always
1. PBL projects get students to discuss ideas in class.						
2. PBL projects do a good job of getting students to do research to look for background information.						
3. PBL projects draw from multiple courses or subjects.						
4. PBL projects are interesting and fun.						
5. PBL projects are relevant to students' daily lives.						
6. PBL projects give students a chance to think about future careers.						
7. PBL projects help students to better understand current events and/or environmental issues.						
8. PBL projects draw on things students have learned previously.						

9. PBL projects require students to apply knowledge learned in the classroom to a real-life event.						
10. PBL projects are central to the curriculum.						
11. PBL projects require a thorough process of inquiry, knowledge building and resolution						
12. PBL projects are more student-led than teacher-led.						

Part III. Interest in Future STEM Careers Questionnaire

Directions: Please accurately answer based on your true feelings. There is no right or wrong answer and all your answers will be respected. Put a check (✓) in the box that describes how strongly you agree or disagree with the statement.

Items	1 Strongly disagree	2 Disagree	3 Slightly disagree	4 Slightly agree	5 Agree	6 Strongly agree
1. I see myself pursuing a career in STEM.						
2. I expect to take a lot of STEM courses in college.						
3. A career in STEM sounds exciting to me.						
4. If I had to pick a college major right now, it would be in a STEM field.						

APPENDIX D

PBL Brief for Term 1/2020

PBL Brief

Purpose

Brief students on PBL Project for Term 1 of the 2020/2021 School Year

Theme

The ongoing pandemic has been a human, economic, and social crisis. In this time of COVID-19, we as a society must adjust our work, school, and social lives. Facing these new problems, what are some solutions that we can come up with to make adjusting to the new normal an easier process for us as a society?

What are the impacts of COVID-19?

Educational impact, Coronavirus and Inequality, Religious Impact, Psychological Impact, Social Impact, Work Impact, Healthcare Impact, Economic Impact, Day-to-day Impact, Transportation Impact, Environmental Impact

- *G7 - Social and Day to day Impact*
    - Psychological Impact, Religious Impact, Environmental Impact
- *G8 - Educational and Work Impact*
- *G9 - Economic Impact*
    - Transportation, Tourism, Healthcare Impact, Inequality

Learning Goals vs. Subject Components

Learning Goals:

The goals of High-Quality Project-Based Learning are to:

- Teach academic content knowledge and skills, and develop a deeper understanding.
- Build 21st-century success skills such as critical thinking, problem-solving, communication, collaboration and creativity/innovation.
- Help students become aware of their own academic, personal and social development.
- Help students gain confidence in meeting new challenges in school and in life

Subject Components

- English Portion - Design Brief, Branding, Presentation
- Math & Science Portion - Engineering process - Design, Building, Testing

Process

Define

- *Brainstorm & Research*
    - o Identify the problem relating to COVID-19 and create a product or service that helps to solve the problem
    - o Write a design brief for your product
    - o Brainstorm with your partners different ideas
    - o Evaluate all of the ideas and as a team decide which approach is the best
    - o Get teacher approval for your idea

- *Design*
  - Work with your group to develop design sketches
  - Share your sketches or outlines with another group
  - Critique each other's designs
  - List the materials, tools, and equipment necessary

Build

- *Development*
  - Collect the necessary materials, tools, and equipment necessary to create a prototype
  - Create a model, prototype, or detailed schematic of your product
- *Testing & Evaluation*
  - Finish prototype testing plan sheet
  - Prototype Testing Plan
- *Branding*
  - Create a company to produce and sell your product. Include a company name, product name logo, and slogan for your company. You may also include an advertisement and sample packaging.

Present

- *Presentation*
  - Create presentations which include a video
  - Present

Limitations

- Ideas should be grounded in reality, feasible with current technology
- Students unhappy with being unable to work in groups
- Possibility of further lockdown
- Making time for classes with mentors
- Technological limitations
- Using new software could be difficult for the students to learn (Trello is too confusing)
- Overwhelming students with new information
- Figuring out how to do presentations

Timing

- PBL Kickoff Week of July 13
- Brainstorm & Research - Week 1 - 2 July 13 - 24
- Design - Week 3 - 4 July 27 - August 7
- Development - Week 5 - 7 August 10 - 28
- Testing and Evaluation - Week 8 - 10 August 31 - 18
- Branding - Week 11 September 21
- Presentation - Week 12 September 28

Extra Details

- 5 groups per class, maximum of 6 members per group
- Mentor led, 1 teacher per class to help guide groups
- Trello for group collaboration
- What is Trello?
- How are we going to use it?
- How are we going to teach the students how to use it?

Teacher Trello -

Join Trello

Join Trello PBL Team

Reference Docs

G7 PBL Brief for Term 1 2019/2020

G8 PBL Brief for Term 1 2019/2020

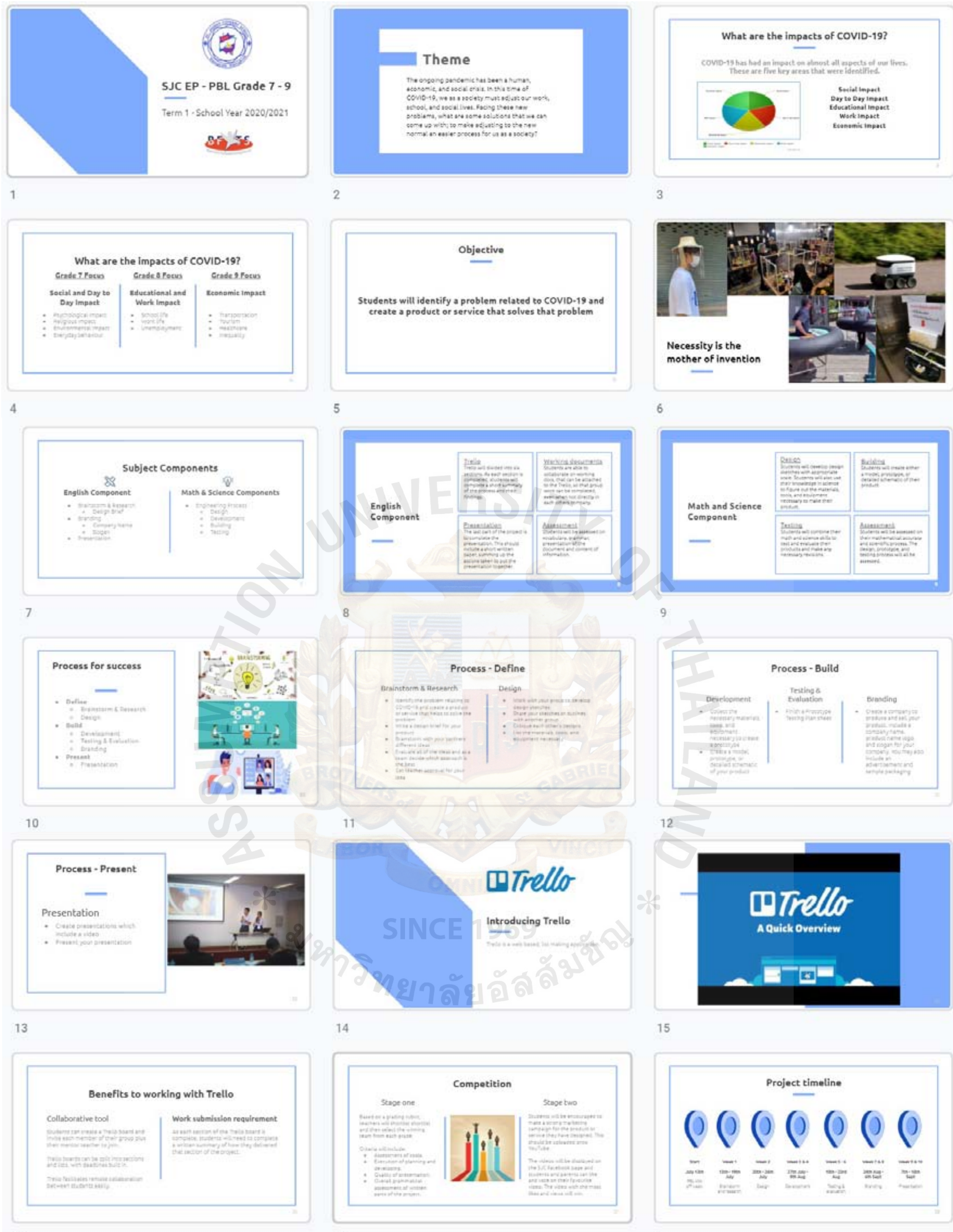
G9 PBL Brief for Term 1 2019/2020

G7-9 PBL Brief for Term 2 2019/2020

G7 PBL Summary for Term 2 2019/2020

G7 PBL Ideas and Teams for Term 2 2019/2020

PBL Trello Board


SJC EP - PBL Grade 7 - 9
Term 1 - School Year 2020/2021
1
Theme
2
What are the impacts of COVID-19?
Social Impact
Day to Day Impact
Educational Impact
Work Impact
Economic Impact
3
What are the impacts of COVID-19?
Grade 7 Focus
Grade 8 Focus
Grade 9 Focus
Social and Day to Day Impact
Educational and Work Impact
Economic Impact
4
Objective
Students will identify a problem related to COVID-19 and create a product or service that solves that problem
5
Necessity is the mother of invention
6
Subject Components
English Component
Math & Science Components
7
English Component
8
Math and Science Component
9
Process for success
10
Process - Define
11
Process - Build
12
Process - Present
Presentation
13
Trello
Introducing Trello
14
Trello
A Quick Overview
15
Benefits to working with Trello
Collaborative tool
Work submission requirement
16
Competition
Stage one
Stage two
17
Project timeline
18

APPENDIX E

Examples of Mentor's Checklist

PBL Mentor Checklist for Week of August 3rd - 7th

Mentor Goals:
Ensure teams are on track and documenting their progress on Trello
Ensure teams are prepared for the Development stage
Guide teams if they are having difficulty

Checklist for Brainstorm and Research List and Design List Completion on Trello:
Brainstorm & Research List
1. Identify the problem
2. Brainstorm
3. Evaluate
4. Write Design Brief
5. Gain teacher approval

Design List
1. Design sketch
2. List of materials, tools, and equipment

Questions for student teams:

1. Is the idea grounded in reality and feasible with current technology?

2. Will the students be able to produce a prototype?

3. Is the group using Trello as they should be?

4. What improvements can be made to the team's idea?

5. Are all the students contributing?

6. Are the cards on Trello fleshed out and written properly?

Notes:

For the presentation, students will make a packet/brochure out of their Trello boards so the content on the Trello cards should be grammatically correct and contain more than just a few words.

PBL Mentor Checklist for Week of August 9th - 14th

Mentor Goals:
Ensure teams are on track and documenting their progress on Trello
Teams should be ready to begin Development next week
Up to the Design list has to be finished by Wednesday, August 19th
Push teams if they are behind, Lists must be completed
Guide teams if they are having difficulty

Checklist for Brainstorm and Research List and Design List Completion on Trello:
Brainstorm & Research List
1. Identify the problem
2. Brainstorm
3. Evaluate
4. Write Design Brief
5. Gain teacher approval

Design List
1. Design sketch
2. List of materials, tools, and equipment

Development
1. Collect the necessary materials, tools, and equipment necessary to create a prototype.
2. Create a model, prototype, or detailed schematic of your product.

Questions for student teams:

1. Will the students be able to produce a prototype?

2. Is the group using Trello as they should be?

3. Are all the students contributing?

4. Are the cards on Trello fleshed out and written properly?

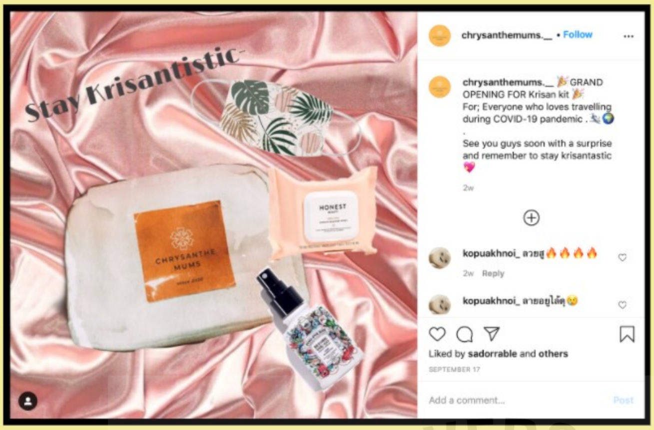
Notes:

For the presentation, students will make a packet/brochure out of their Trello boards so the content on the Trello cards should be grammatically correct and contain more than just a few words.

APPENDIX F

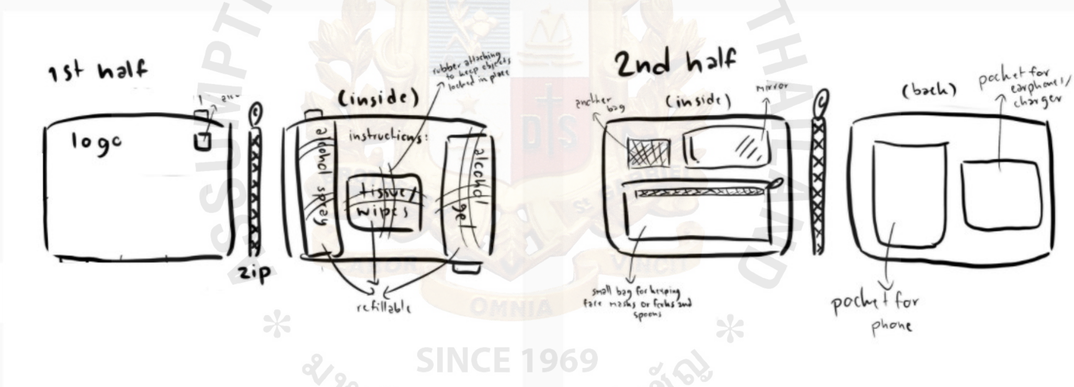
Excerpts from a Grade 7 PBL Presentation with Anecdotal Evidence in Support of Strong Guidance

Group 1 - Chrysanthemums (Krisan)



Amotang	14
Petch	17
Jeans	26
Winnie	7
Sheen	15
In	28

DEVELOPMENT PROCESS



CONCLUSIONS

Teamwork is important for creating a project because brainstorming and other great ideas won't happen if there isn't a team. Having a great team helps us achieve a great deal of success.

Creating a product takes hard work. Being diligent and in time made our product better in quality and got our jobs done in the time required.

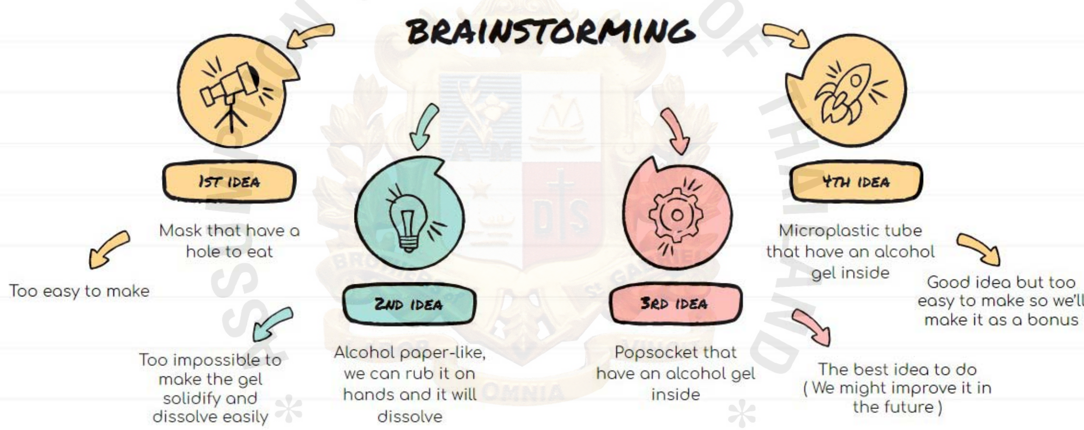
None of this could have been done without support and advice from our teachers. This product showed us that in order to be ready, you need to be prepared.

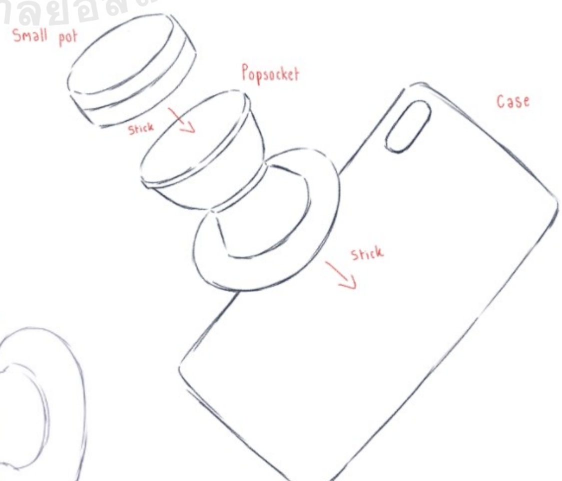
APPENDIX G

Examples of Grades 7, 8 and 9 Students' Work during PBL in Term 1/2020

Group 2 - Poppie Gel

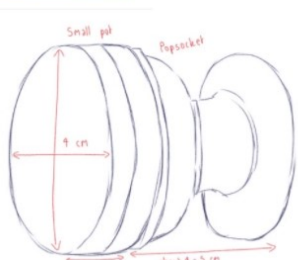
Namo	18
Chom	11
Miu	9
Mei	6
Palm	20
Tutu	29





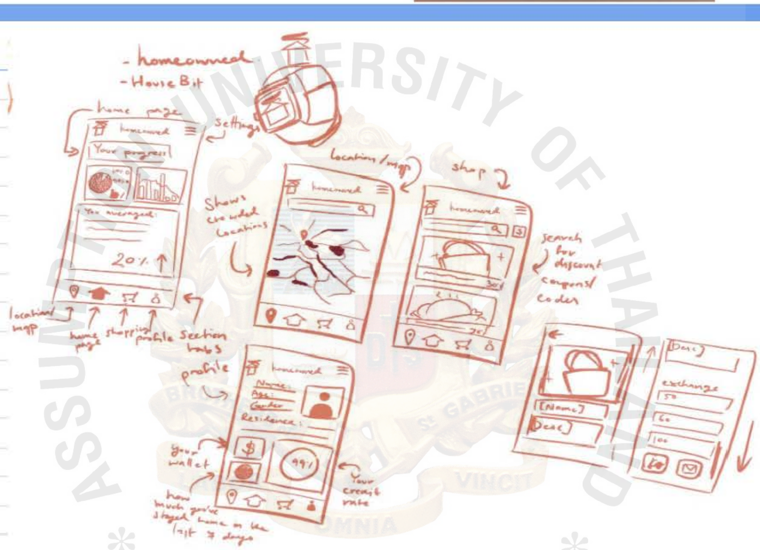
Design Process

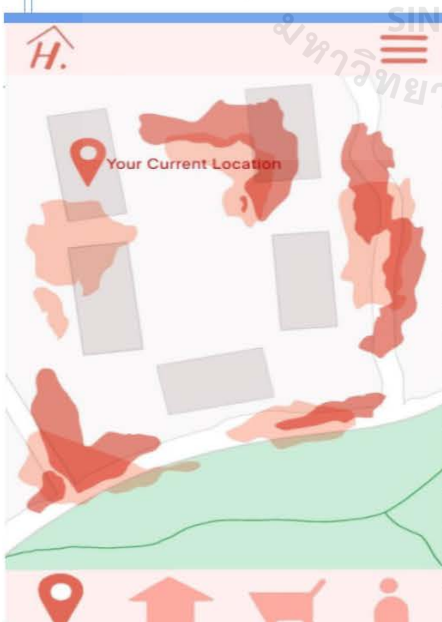
Development Process

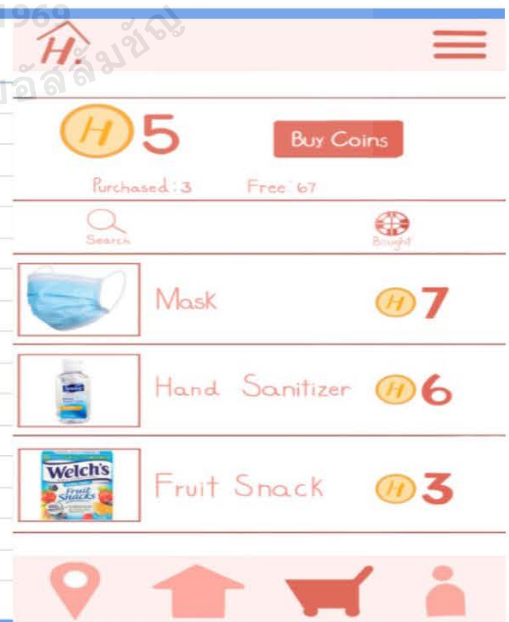


Homie! - A Virtual App

That rewards people
for social distancing



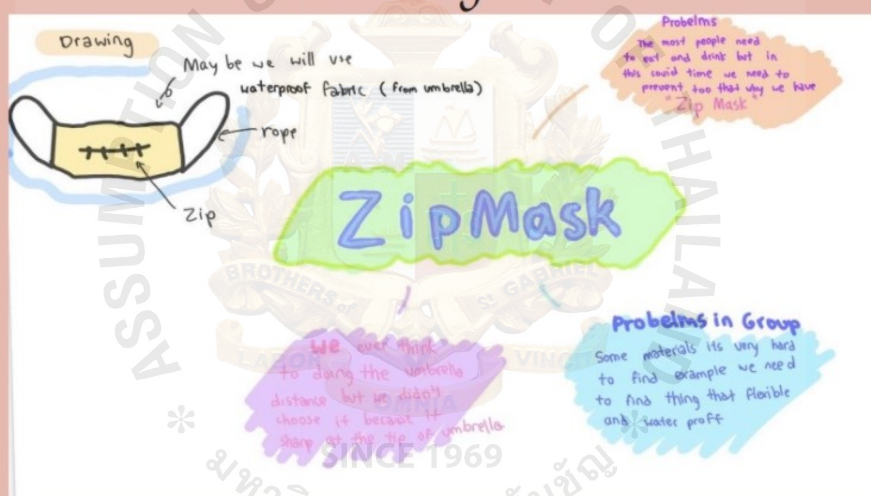




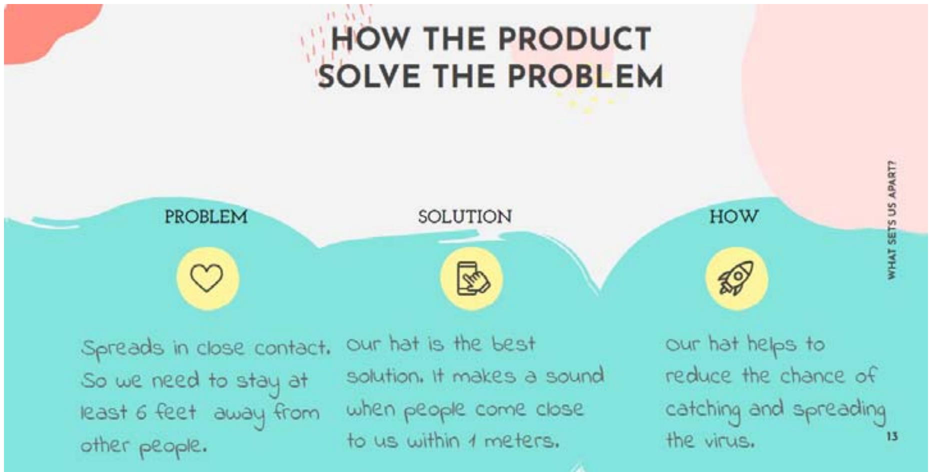
Describe the product you created to solve the problem.

Our group thinks to make this product for when consumers want to eat or drink we don't need to put the mask down you just open the zip. And this product can prevent the covid - 19 virus from infecting more people.

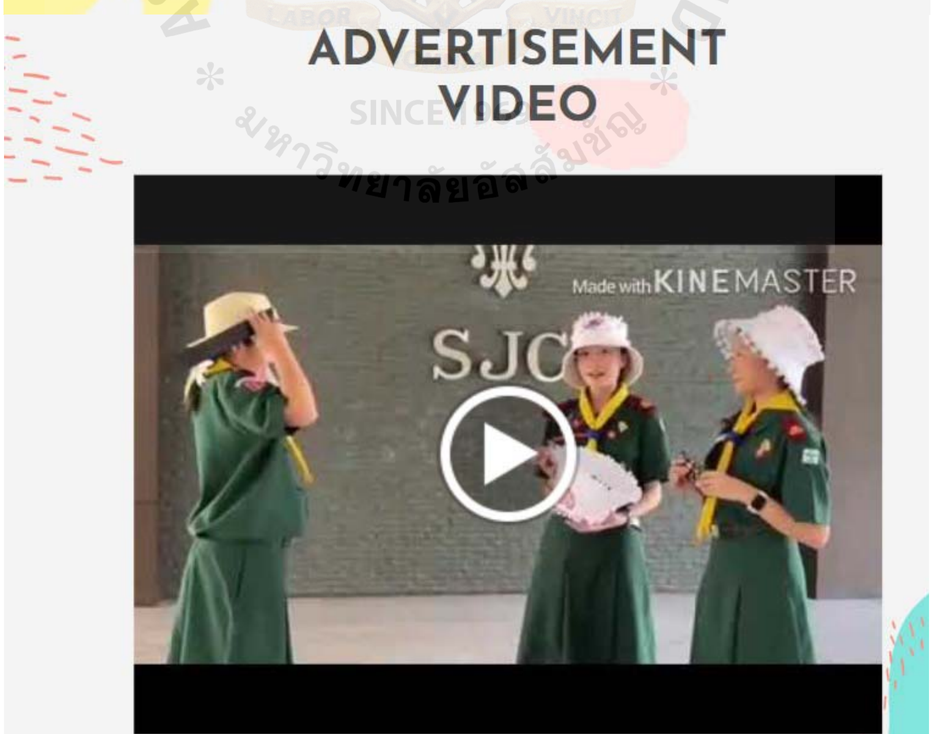
Brainstorming Process

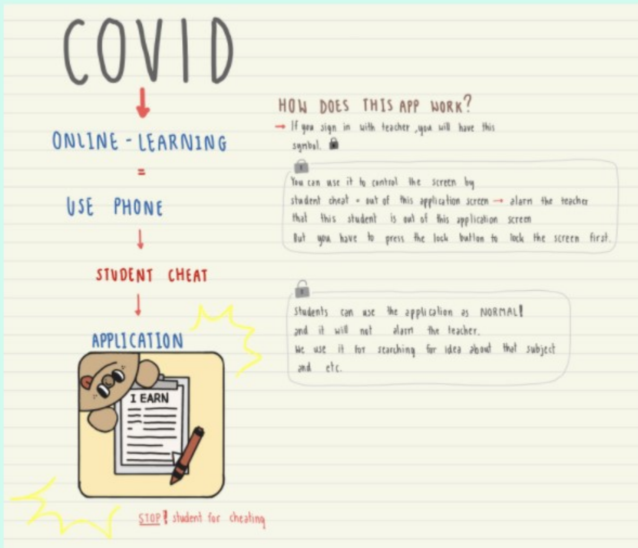


Design Process


HOW THE PRODUCT
SOLVE THE PROBLEM
PROBLEM
SOLUTION
HOW
Spreads in close contact. So we need to stay at least 6 feet away from other people.
our hat is the best solution. It makes a sound when people come close to us within 1 meters.
our hat helps to reduce the chance of catching and spreading the virus.
WHAT SETS US APART?
13


DESIGN AND
DEVELOPMENT PROCESS
It has a sensor.
It also has cute and cool decorations.
-front-
-B a c K-
The hat is made of cotton.
14


ADVERTISEMENT
VIDEO
Made with KINEMASTER
SJC



Team 1 - iEarn

Gift - 17
Pang - 4
Tonliew - 15
Ajay - 16
Googoo - 20
Nana - 28

Team 1 - iEarn

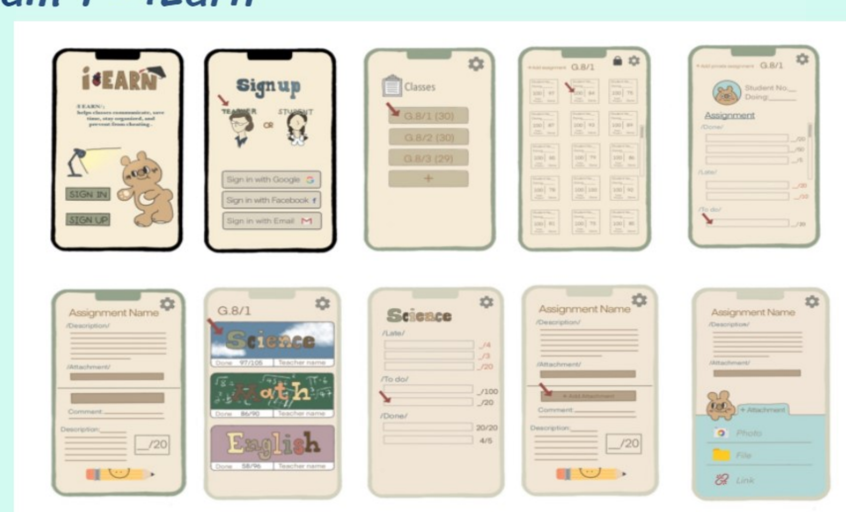
Identifying the problem and brainstorming a solution.

Due to COVID situation, We have to learn and do every in our phone, so our group have an idea about creating an application that suit the teacher and student.

Students can't cheat or leave the screen until the the unlocked.

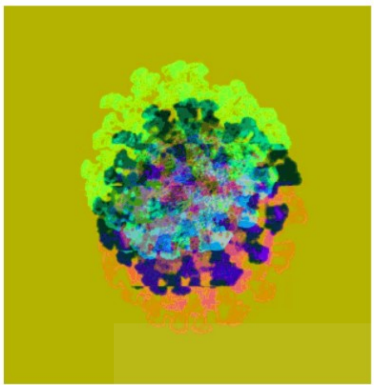
This app is both convince for teacher and student.

Team 1 - iEarn

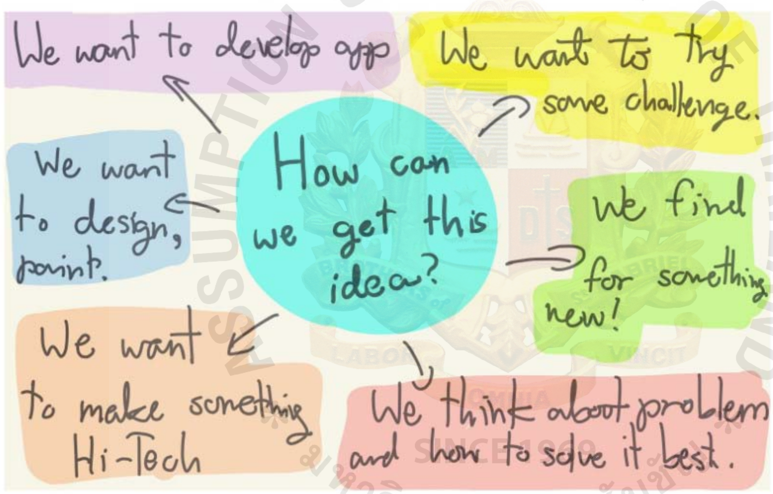


RESEARCH - What's Covid-19?

Virus Covid19 is Positive Ions - *Harmful* to People Health



Brainstorming the problem and some solutions



This group looked at the technology of using crushed Tourmaline, positive ions, to coat their clothes to help prevent the virus.

Products the team designed

The team designed a tee shirt, a jacket and a face mask.

- All were coated with Tourmaline.
- All had a hand stitched logo on it.

Group 4 - SPC 19

Focus	5
Noodee	4
Grace	3
Prae	27
Pink	22
Jan	24

Design process

Install Uv light bulbs in the aluminum foil box. Put the things that you want to sterilize into the box for 15 minutes.

Development Process

Ultraviolet (uv) is a form of electromagnetic radiation The effects of are greater than simple heating effect .uv light damage DNA and sterilize surfaces with which comes into contact.

our design brief is uv light bulbs installed in aluminium foil box.


Sensore Shoes
Poolto
only 800.-!
Group 1 - Poolto Flamingo
RongKhaw 5
PinPin 1
Kowpan 10
Pat 12
Jeeja 17


Trello board
7/2 Team 1
Brainstorm & Research
1. Identify the problem relating to COVID-19 and create a product or service that helps to solve the problem.
2. Brainstorm with your partners different design ideas.
3. Evaluate all of the ideas and as a team decide which approach is the best.
4. Write a design brief for your product.
Design
6. Work with your group to develop design sketches.
7. List the materials, tools, and equipment necessary.
Development
8. Collect the necessary materials, tools, and equipment necessary to create a prototype.
9. Create a model, prototype, or detailed schematic of your product.
+ Add card
Testing & E


Last, we decided to do sensor shoes. It will blink when we are close to each other about 0.5 meters so when we are in skytrain it will blinks and can reduce the chance of infection of Covid-19.
CLOSE