STEAMing the Ships for the Great Voyage: Design and Evaluation of a Technology-integrated Maker Game

Ju-Ling Shih*, Shu-Hsien Huang, Chang-Hsin Lin, Chia-Chun Tseng

Department of Information and Learning Technology, Natioanl Univeristy of Tainan
33, Sec. 2, Shu-Lin St. 70005 Tainan, Taiwan
*juling@mail.nutn.edu.tw

Abstract. This study presents an interdisciplinary learning model that puts students in a historical context, in which they have to apply their knowledge of history, geography, math, physics, mechanics and natural sciences to achieve the goal of the game. In the learning scenario, students' critical thinking, creative thinking, computational thinking, and problem-solving abilities, as well as cooperative and competitive gaming strategies are used and enhanced. From the research results, it is evident that the "Maker Game for Great Voyage" has succeeded in the instructional design of technology-integrated game-based learning with STEAM and maker, and with the rich historical context of the Age of Discovery. Also, from pre-test and post-test evaluations and questionnaires, this research looks into students' learning effectiveness; and through qualitative research methods, students' group cooperative styles and competitive gaming strategies are analyzed in terms of students' personality traits.

Keywords: Interdisciplinary learning, STEAM, Maker, Game-based Learning, Great Voyage, personality traits.

1 Introduction

As human society advances culturally and technologically in both localized and globalized form, human lives are getting more complex than ever, which require critical thinking and innovative thinking for complex problem solving. The abilities to understand interdisciplinary concepts and master its applications have become essential for us and our next generation. Environmental issues, gender issues, or social-historical issues, just to name a few, all relate to human science, natural science, and social science in an inter-related form. Providing cross-subjects and interdisciplinary learning for our students are not only a trend, but also a must.

In Taiwan, departmental teaching is still the major practice of current formal education that causes theme-based learning to be impeded in the real life classrooms. Theme-based teaching requires more class time and synchronized teaching progress of many teachers in various subjects; it also imposes high standard requirements for students since they need to have better understanding to all learning concepts to succeed in the theme-based tasks. It often becomes a challenge to the teachers to properly provide assistance to heterogeneous students. Having this said, wouldn't there be a way to not only give high learning achievement students more opportunities to reach excellency but also provide low achievement students chances to succeed in a non-traditional paper-and-pencil assessment, or at least enjoy the learning process? The answer might be an innovative instructional design that can meet the expectation.

This study is one that endeavors to provide a teaching and learning model of such. The initial attempt is to create an extra-curricular activity that students get a chance to try out an interdisciplinary task. The goal of this paper is to showcase the creation, implementation, and evaluation of the instructional model.

This study presents an interdisciplinary learning model that puts students in a cultural historical context, in which they would apply their knowledge of history, geography, math, physics, mechanics and natural sciences to work cooperatively and competitively to achieve the goal of the game. In the learning scenario, students' critical thinking, creative thinking, computational thinking, and problem-solving abilities, as well as cooperative and competitive gaming strategies would be used and enhanced. These abilities are the 21st century abilities students should have, that encourage students to transform crystal learning contents into fluent ones, so they would apply them in their future lives.

In recent years, Taiwan has been promoting information technology-integrated education such as innovative teaching, mobile learning, extensive reading, etc., in all levels of schools, from primary to higher secondary schools; all are encouraging schools to integrate technological equipment in creating seamless digital learning and enhancing students' learning effectiveness [1], [2], [3], [4]. Nevertheless, it is to our curiosity that players of different characteristics would conduct different gaming strategies which would influence the overall gaming strategies. Therefore, by identifying players' personality traits to observe their behaviors in the games would contribute to our understanding to human psychologies and behaviors.

From pre-test and post-test evaluations and questionnaires, this research would look into students' learning effectiveness; and through qualitative research methods, students' group cooperative styles and competitive gaming strategies would be analyzed in terms of students' members' personality traits.

In the study, both quantitative and qualitative data were collected for analysis in order to answer the following three research questions:

1. What is students' performance in the "Maker Game for Great Voyage" course in terms of STEAM and context aspects?

2. What is the influence of students' personality traits to their group dynamics in the "Maker Game for Great Voyage" course?

3. What is students' overall satisfaction to the "Maker Game for Great Voyage" course?

2 Literature Review

2.1 From STEM to STEAM

United States government launched "Educate to Innovate" initiative in 2009 to support STEM educational movement which nurture students to reach excellence in subject areas of science, technology, engineering, and mathematics, thus enhancing science literacy. By situating students on collaborative hands-on tasks, they are more immersed in complex problem-solving process and learning by trials, designs, discovers, and experimentations. Students would be motivated to expand their knowledge in the wide array of learning content, discuss with peers, take multiple perspectives, and try to use the knowledge in any way they can to resolve the given issues.

In the aspect of educational policy, STEM education normally benefits to talent education; in the aspect of teaching, STEM course focuses on improving K-12 STEM course design, teaching strategies, and teaching practices in order to allow students to synthesize what they have learned [5].

According to United States Department of Education, job opportunities are STEM related in the future decade. Becker and Park's [6] research shows STEM interdisciplinary teaching has positive influence to students' learning achievement. And Chang and Yang [7] mentioned that the influence of STEM to younger students were larger than the older students so that it is concluded that early STEM education would stimulate students' learning interests in science, and increase the opportunities they choose technology and engineering related majors.

In terms of STEM instructional design, the science construction that PISA suggested in 2006 [8] can be a good reference. Teaching activities can be organized into three stages: (A) Confirming issues, perspectives, and core concepts. (B) Describing perspectives, explaining phenomenon, and predicting changes. (C) Using information to do hypothesis, finding evidence, generating conclusions, and having reflections. Through the three stages, STEM issues should be closely related to real-life practices. It is to increase students' sensibility to phenomenon, descriptions to content, and learning from reflections.

The 6E learning model proposed by Burke and Barry [9] is a student-centered learning model which can be used when designing a STEM instruction. It includes: (A) Engage: Define related questions, attract students' attention, enhance students' learning interests, and help students to make mental links to their prior knowledge, so that they have curiosity to the course and increase their participations to the course. (B) Explore: Search information and make course plans. Students can collect materials according to the issues, and do group discussions. (C) Explain: Allow students to explain their collected materials, and summarize for the best solutions. (D) Engineer: Use technologies to produce prototype, and then test and conduct evaluation before doing the group reports. (E) Enrich: Finish solving defined questions, and improve design plans so that students can investigate more complex problems. (F) Evaluate: Examine and evaluate whether they have reached the preset course plan.

Petrina [10] proposed authentic assessments to evaluate students learning process as well as outcome. The evaluation methods include portfolio assessment, performance assessment and criterion-referenced assessment. Portfolio assessment is used for process records of the learning stages. Performance assessment is used to evaluate the completeness and creativities of students' projects; at the same time, observe students' learning motivation, critical thinking, and presentation abilities. Criterion-referenced assessment is used to evaluate students' other abilities with preset standard; for example, problem-solving abilities, and skill masteries, etc. These three evaluation methods are useful for the assessment of STEM learning activities.

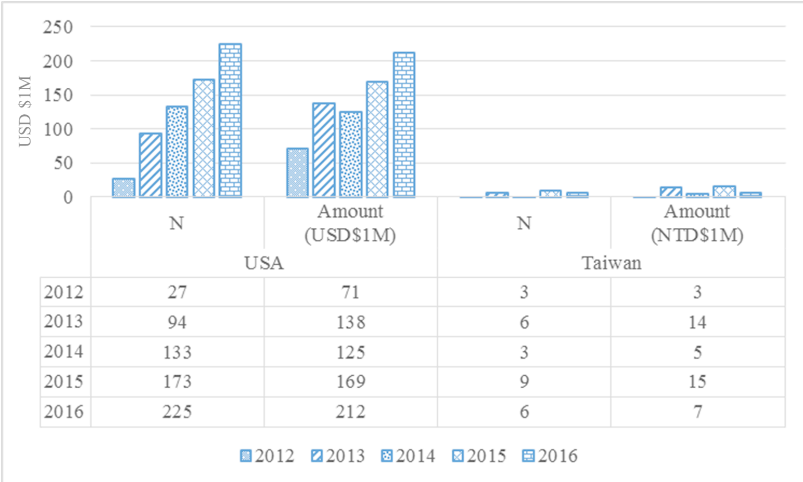
In Taiwan, there are wide spreading STEM educational practices in all levels of schools, especially with robots and 3D printings. Chang and Yang [7] used hydraulic arms to imitate human arms to extend, bend, and snap objects. Students use injection syringe and plastic pipes to understand its mechanism. The research use science concepts such as Pascal and lever principles to show hydraulic pressure, air pressure, and to construct engineering designs; and use math concepts to design arm size and mechanics. Also, Tsai and Wu [11] guided the students to use daily necessities and eggs to design airdrops which use parachutes concepts to make accurate aiming for the landing.

In Hong Kong, STEM has been the top educational policies since 2015. It aims to reinforce students' science, technologies, and math education to nurture multiple talents with computational thinking and international competences. It a learning model that is learner-centered, emphasizes on learning process, allow students to makes different goals, and reaches balance between opinions and interests. So far, Hong Kong's STEM teaching is used on smart robots, biological science, geographical and technological agricultures in primary school STEM education. Many of the applications are single subject, for example: science with technologies to design instruments with different sounds; or math science to imitate animals in adopting cold weathers. There are also interdisciplinary teachings, such as integrating science, technologies and math content to design maglev train or sound insulation walls.

Overall speaking, STEM education has received attentions in most countries. Grant projects executed in United States and Taiwan in the recent five years (2012-2016) are listed as follows (Fig. 1). United States is the pioneer of STEM education; from 27 projects in 2012 to 225 projects in 2016, which has grown tenfold in five years. The grant amount has tripled from 71 million US dollars to 212 million US dollars. On the other hand, Taiwan STEM education research has no stable growth along the time. Lin [12] mentioned that Taiwan current education system is over emphasizing on learning science and acquisition of related knowledge, but lack of practical applications of science knowledge abilities. STEM interdisciplinary education is to integrate theories and practices, and allow learners to do hands-on manipulations, so there is still a need to continue the work in promoting STEM in Taiwan.

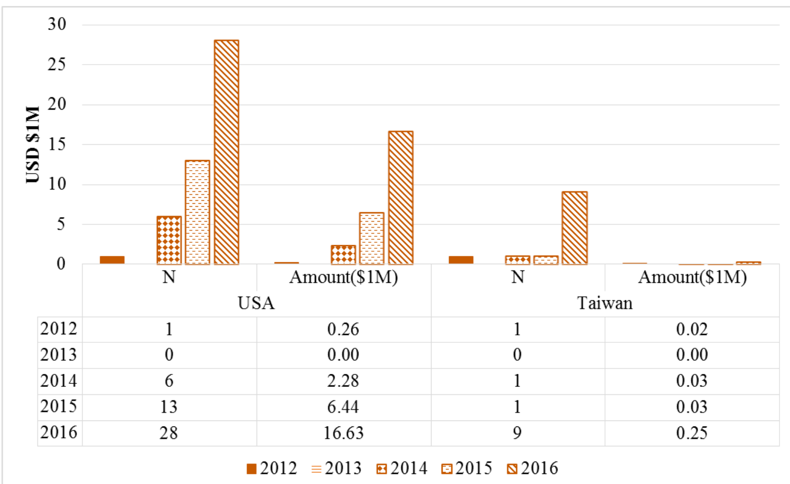
Nevertheless, STEM has grown into STEAM a few years back. Element of "arts" has gain increasing attention since creativity is another important aspect of learning other than science [13]. There are many benefits in adding arts into STEM [14]. Ghanbari [15] mentioned that STEAM is established on the basis of STEM and art. Art is a humanistic subject who strengthens the cross-disciplinary links with STEM

[16], and enhances students' learning of STEM [17], [18] as well as their problem-solving skills [19].



	USA N	USA Amount (USD$1M)	Taiwan N	Taiwan Amount (NTD$1M)
2012	27	71	3	3
2013	94	138	6	14
2014	133	125	3	5
2015	173	169	9	15
2016	225	212	6	7

Fig. 1. Grant projects on STEM executed in United States and Taiwan in the recent five years



	USA N	USA Amount($1M)	Taiwan N	Taiwan Amount($1M)
2012	1	0.26	1	0.02
2013	0	0.00	0	0.00
2014	6	2.28	1	0.03
2015	13	6.44	1	0.03
2016	28	16.63	9	0.25

Fig. 2. Grant projects on STEAM executed in United States and Taiwan in the recent five years

Grants devoted into the studies on STEAM have grown in the last five years (Fig. 2). In United States, it is grown from 0.26 million US dollars in 2012 to 16.63 million in 2016; it is 63 times of growth. Grant projects were also increased from 1 to 28. In

Taiwan, Also, funds were in much smaller size, the growth within the five years was 12 times, from 0.02 million in 2012 to 0.25 million in 2016. Grant projects were also increased from 1 to 9. The research on educational applications of STEAM has the trend of increase.

In the aspects of educational applications, Quigley and Herro [20] pointed out that teachers who conducted STEAM instruction should provide authentic learning environment to assess students' learning, and make appropriate adjustments to the class. The study of Connor, Karmokar, & Whittington [19] shown that after ten-weeks of STEAM course to college students, the students placed more considerations on people in solving environmental problems than before, and were able to design products for their solutions [18]. The positive teaching outcome can also be seen int eh elementary schools. For example, Oh, Lee and Kim [21] conducted the STEAM education to the 6th graders with Scratch, and found the students' creativity is increased. In similar manner, Oner, Nite, Capraro, and Capraro [13] created an informal learning environment in a summer camp, in which middle and highs school students were involved in the project-based learning. Their art creativity abilities were shown in the STEAM activities. Just like many other school applications, Kang, Jang, and Kim [22] had conducted STEAM through 3D models and robotics. Nevertheless, although such educational practices are everywhere, there are limited literatures about them since teachers in the primary and secondary schools would share their experiences in the educational fairs than in the form of academic papers.

Among all the found literatures, most of the studies discuss instructional theories or analyze perspectives of teachers and pre-service teachers to STEAM [19], [20], [23], [24], [25], mostly using traditional computer-assisted learning methods [21]. There is a big gap between explaining how theoretical frameworks can be transformed into instructional design, and further to the analysis of how students interact in the STEAM that affect how much they learn. Therefore, this research attempts to provide students artistic space to design their own ships for the Great Voyage, transform STEM into STEAM; and offer an instructional model for the instructional design.

2.2 Maker Movement

The maker movement has transformed classroom lecture to hands-on experience. It encourages multiple perspectives, conducts strategic competitions in the physical classrooms, and use game to activate learning conditions to promote students' interpersonal interactions. In recent years, as Taiwan educators and scholars place their attentions on flipped classrooms, it corresponds to the concept of maker movement which emphasizes on students having hands-on experiences; both hope to nurture students' creative thinking, critical thinking, problem-solving, cooperative skills, and communicative skills in the process. There is no limitation for the students to the creation of the objects in the maker projects, including interactive technologies, robots, crafts, wood carvings, etc. In the current practices, many educational activities have used robots in the maker practices, in high schools, technical schools, universities, as well as in research institutes. Students' motivation is stimulated from discovering the theories from their practices and encouraging autonomous learning, so they are happy to share.

Maker movement concepts started in the Make Magazine of United States and the Maker Faire in 2006. In the past research, it is evident that making, playing, building, and interacting are valuable learning methods [26]. Martin [27] proposed three key elements of the integration of maker movement to education: (A) Tools: Materials that are used in the design activities; (B) Events: Activities that on the web or in the authentic teaching scenarios; (C) Value: Beliefs that connect with the learning environment which enrich cultural creations. Maker movement can be used in both formal and informal teaching. Its core spirit is to allow students to gain skills in the making process, but also to obtain deep learning in knowledge building [27], [28], [29], [30].

There are also studies about the integration of maker movement and games. Khalili et al. [31] developed game for the concepts of neuroscience, in which students learned about neuros and molecular structure as they played. This research had also been proved that games can improve students' learning effectiveness. However, Papavlasopoulou, Giannakos, and Jaccheri [30] also found that although there were fair amounts of research concerning about the maker movement but still little with the integration of STEM course.

The applications of robots have brought to the students high sense of achievement. This research attempts to integrate STEAM with maker movement in the interdisciplinary course.

2.3 Game-based Learning

Prensky [32] said that game is the learning mechanism the brain likes the most. The six features of games have made game an intriguing human activity which includes: (1) stimulate intrinsic motivation; (2) focus more on the process than the results; (3) self-intrigued and active; (4) provides open choices; (5) positive and entertaining; and (6) dynamic. Through game, human build knowledge and skills and have fun in the process of learning.

Digital game-based learning (DGBL) has become a popular means and tool in the recent decades. It is known to provide experiences beyond class teaching, and its instant feedback can increase the enjoyment and make learning more challenging [33]. Thus, it effectively intrigues learners' motivation and promotes active participation to learners that are proved by research [34], [35], [36], just to name a few. It further improves students' learning abilities, effectiveness, problem-solving skills, and interpersonal interactions [37], [38], and enhances students' self-directed learning and problem-solving abilities at the same time [39].

Students can learn problem-solving abilities, critical thinking, and cooperation through digital game as well as in the physical form [35]. Problems happen when students encounter situations that were different from expectations, and then take actions to reach the status of completion or success [42]. Madden, et al. [43] proposed a curriculum that engaged learners in team-based multidisciplinary problem solving through mentoring, learning communities, research projects, and partnerships with outside agencies. In problem solving, students go through stages such as identifying problems, defining problems, searching for resources, deciding solutions, taking actions, and evaluating results in real life and in game-based learning. Therefore, rather than being an intellectually lazy pursuit, students need to use high level of skills to meet increasing challenges.

In the pre-designed context of instructional games that involve skill, knowledge, and chance, players follow guided rules to solve a problem or complete a task, in which students explore, think, and make decisions in the competitions [40], [41]. Competition and cooperation are two major social interaction types that are important learning incentives [33], [44]. In competitive learning situations, students attempt to reach their learning goals by defeating others in which learners exhibit a more aggressive attitude to reach a higher status or obtain better resources. Johnson and Johnson [33] encouraged teachers to emphasize on the learning process instead of the gaming outcomes, and to design for group competitions instead of individual competitions to avoid classroom atmosphere turning sour. On the other hand, cooperative learning has been another popular teaching strategy which encourages students' interdependency that they share works and information with peers in order to reach common goals. It effectively allows students to be involved in discussions [45]. When learning in group or working in team, students would become an united learning body within which the members depend on each other and take individual responsibilities so learners can effectively take part of the learning process [46]. Students become active thinkers, and students help each other to enhance overall learning achievements of all. Lin, Huang, Shih, Covaci, and Ghinea [47] in their computer-based table game proved that both competitive and cooperative games can effectively intrigue students in learning and encourage them to use critical thinking for gaming strategies.

However, different student backgrounds and personalities can cause cooperative learning to fail. Group discussions and decisions can be dominated by certain students, and other students would take free rides in the group assignments [48]. Therefore, it is also one of the research aims of this study to investigate how individual differences influence group dynamics and their gaming strategies.

With previously investigated game factors and game-based learning design model [49], this study made an instructional design for the interdisciplinary game-based learning course for the "Maker Game for Great Voyage" which let students participate in the individual and group competitions; at the same time, to immerse students in the social cultural course in which enrich robot activities with learning context and learning content.

3 Course Design

3.1 Interdisciplinary Course Design

This study was a cooperated project with a 7-day summer camp in a local primary school in Taiwan. It is a small school with one class in every school year with around 20 students in one class. The summer camp welcomed students in all school years.

Other than two teachers from the primary schools, a mentoring teacher and an art teacher, two teachers with digital learning background from the university were involved in the course with two teaching assistants for helping students. Each teacher takes a part of the course that requires specific knowledge and expertise. For example, the art teacher is responsible for day 5 and day 6 for the crafting and maker classes; and the computer teacher is responsible for the unplugged and computer coding classes in day 2; and the game teacher is responsible for the "Maker Game for Great Voyage" competition.

The course encompassed interdisciplinary learning contents aiming to the final "Maker Game for Great Voyage". The course content for the seven days is described as follows (Fig. 3).

Day 1: Mobile Game of "Fragrance Channel". Use mobile version of the game, to attract students' attention, and help them to understand the gaming process.

Day 2: Unplugged and Computer Coding. First, use the unplugged coding lessons to help students understand the logistics. Then, use the web-based studio code to help students understand the concept of block coding.

Day 3~4: Coding mBot. Use mBlock Coding software to control robot mBot. Obstacle race and track-finding race are conducted to check students' understanding.

Day 5~6: Maker. Students handcraft mBot as ships using art supplies and robot parts.

Day 7: The "Maker Game for Great Voyage" Competition. Students enter the maker game competition with mBot ships.

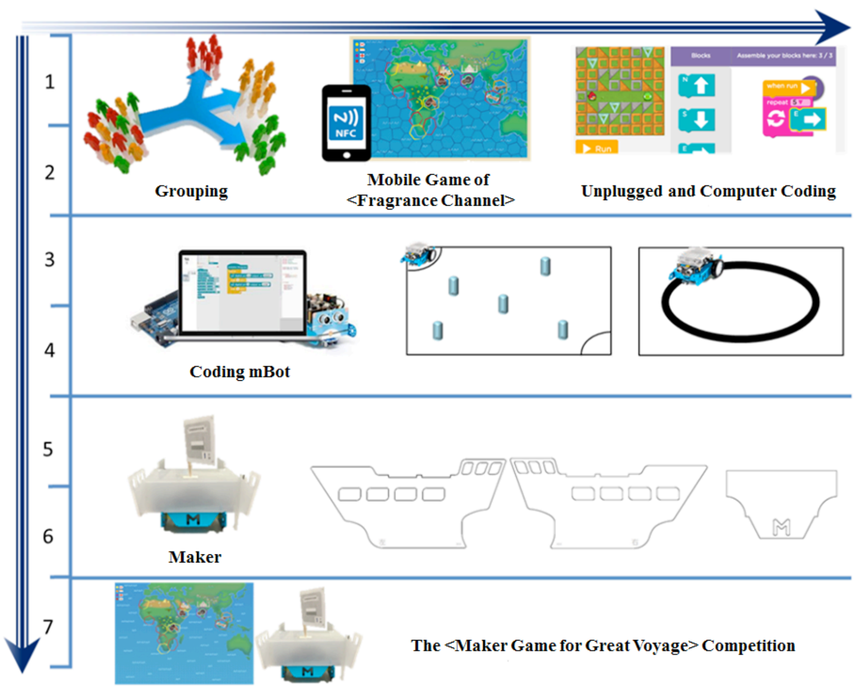


Fig. 3. The activity process of "Maker Game for Great Voyage"

The course includes STEAM elements including:
Science: Robot movement competition with obstacles and its tracking functions.
Technology: Use of mobile game of great voyage, computer coding.
Engineering: The construction of mBot and its weapons.
Art: Painting and crafting the boat in the maker class.
Math: Calculation of boat movement distance, angle, direction, space, speed.
Humanity: The history of the Age of Discovery, global geography, location of colonies and spice productions, and international relations and conflicts.

Overall competencies including students' group collaboration and communication skills with peers, and critical thinking on gaming strategies.

3.2 Game Design of the "Maker Game for Great Voyage"

This project aims to design an interdisciplinary maker game that has STEAM values in it. "Maker Game for Great Voyage" is a game based on the historical period of time, the Age of Discovery, also called the Great Voyage. Because the whole course has a large portion of the hands-on maker process, therefore, it is also called the maker game.

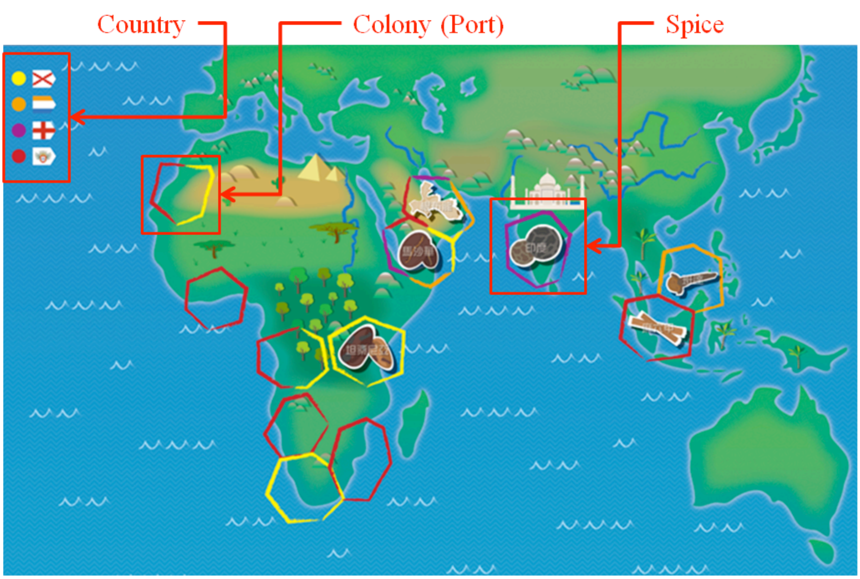


Fig. 4. Game map of "Maker Game for Great Voyage"

In the classroom, a world map in the form of matt with the size of 600*400 cm is placed on the floor so that the classroom is transformed into the earth where students can be immersed in the context. Map is no longer an abstract and distant object on the textbook or on the table, but a space where the students are situated in. The map can also give students the sense of direction and have more authentic sense to the natural science. On the map, it is marked in colors with places that were ever colonized by the major European countries involved in the Great Voyage; the ports are also marked with the corresponding spices that are produced in the area (Fig. 4).

On the map, 4 mBot robot ships are place on the top left corner of the map as the starting point. All game cards are placed on a table to begin with.

Five players are grouped as a team, in which every player is assigned with a role, namely planner, navigator, coder, attacker, and trader. The navigator is the one who can physically go onto the map, count steps for the movements, and provide accurate directions to the planner. The planner is responsible for writing down the coding plans for the mBot ship so the coder knows what to put into the codes; for example, if they want to move the robot forward with 12 points, they might plan to use 3 points to move forward, 4 points to turn left for 40 degrees, and 3 points to move forward, 1 point to get inbound to the port, and 1 point to trade for spice. Then the trader would keep records of each country's spice types and amounts they obtained, and then offer information to their group for next movement decisions. The attacker is responsible for the robot's keyboard-control movements when the ships get into battles. In this way, all members in the group have to work closely to each other and contribute to their group decisions.

There are 4 teams in total and each take the role as one of the major countries in the Age of Discovery, including United Kingdom, Netherland, Spain, and Portugal. Each team has one laptop for coding the mBot ship.

Then, each team randomly chooses a task card (Fig. 5), which indicates the amount of spices they should obtain to win. They would conceal their cards from other teams. Their goal is to use their robots to sail to the ports to trade for the spices and carry the spices back to the starting point.

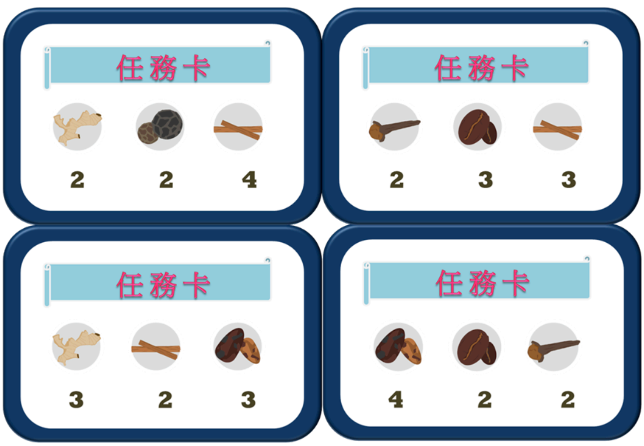


Fig. 5. Task cards denoting spices produced in the Age of Discovery

After knowing what spices they would need, the team rolls the dice to decide who choose countries first. Since the countries have different strengths and weaknesses in terms of their economic and military powers, all the ships have different pre-set parameters to represent their country powers. Therefore, the teams would decide which country to choose to get the best advantages according to the tasks. In this stage, players gain the knowledge about the historical background of the countries and their international relationships at that time.

After that, all countries start to build their ships by choosing ship parts cards including hull, oar, mast, and weapons (Fig. 6). All the ship parts would influence their game parameters, including Propulsion Power, Cargo Capacity, Deceleration, Firing Distance, Arm Force, and Sailing Duration. The students then calculate their total ship powers and discuss about the strategies, routes, and targeted spices to get in order to win the game.

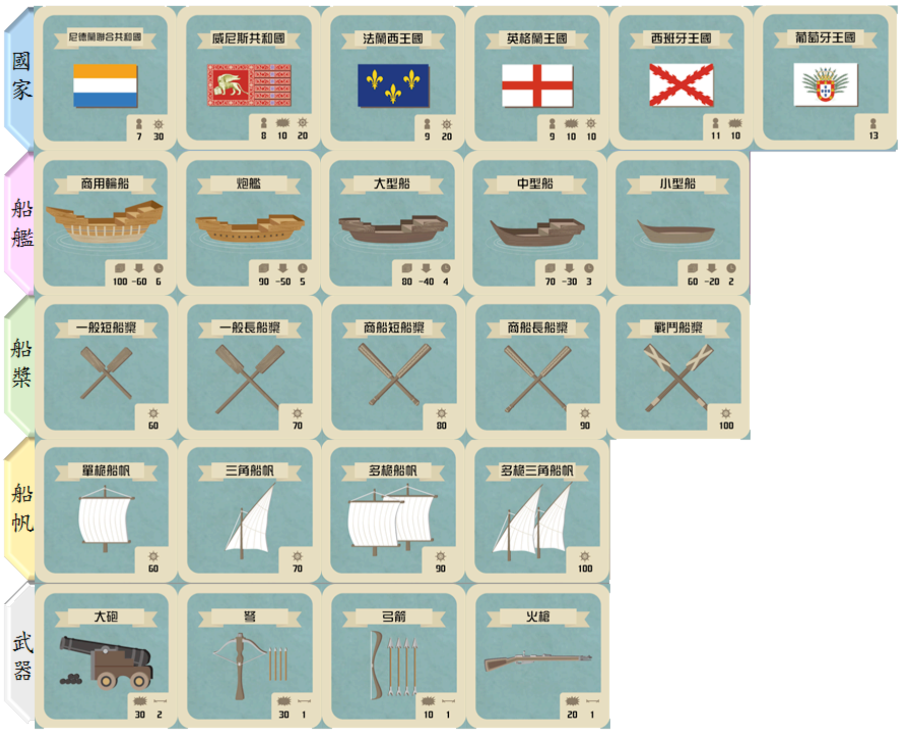


Fig. 6. Cards of the ship parts for "Maker Game for Great Voyage"

In this stage, players enter hands-on maker stage. In order to protect the robot chips from accidents, the research team used 3D printing technology to create a plastic shell in ship shape. Students painted mBot ships and used robot parts to assemble for the arm forces (Fig. 7).

Fig. 7. The mBot ships decorated for "Maker Game for Great Voyage"

In the game, students used the points of their sailing power to move, attack, inbound and outbound of ports, trade for spices, collect black tapes, and upgrade their ships for weapons. Every point can trade for 2 seconds of ship movements. For example, if the Spanish ship has 10 points sailing power, they can use 5 points (10 seconds) to move forward, 2 points (4 seconds) to turn right, 1 point to go inbound to port, 2 points to trade for spices. Students program their mBot by the movement plan, and execute the robot to sail to the designated direction. Since the sailing plan is a guess-estimation, the fun occurs whether the actual sailing destination is the same with their prediction. If the team has collected sufficient length of black tapes in the game, they can also use robot's tracking function to move the ship to ensure the sailing direction and increase the sailing distance.

If they have the target spices in their colonies, they can simply sail into the port and trade for it. If they do not have the spices in their colonies, they have to fight with other ships to get it, or return to the starting point to trade for it. Once the attack is requested by any country, the two teams use their keyboard to control their robot ships to fight with each other until whichever loses as its balloon is poked. Finally the game would continue until one of the countries has completed their tasks.

4 Research Design

The student participants of this instructional experiment were 20 students in grade 2 to 5, aged between 8 and 11. Among them, there were 7 fifth graders, 3 fourth graders, 2 third graders, and 8 second graders. They were randomly distributed into 4 groups of 5 people. Every group was assigned with at least one older high-achievement student (Learning attitude =5) selected by the school teacher who knew them from the in-semester learning. It is reported as learning attitude levels in Table 6 to Table 9; among them, there were many mid-achievement students (Learning attitude =3). Since the younger kids had no experience in working with computers, it is necessary to assign older kids in every group to provide peer support. Most students (85%) had experiences playing digital games and table games, but only less than half of the students (40%) had coding experiences (Table 1).

Table 1. Students' gaming experience

Experience	Table Game	Digital Game	Coding
No experience	3(15%)	3(15%)	12(60%)
Less than 1 year	8(40%)	8(40%)	6(30%)
Between 1 and 3 years	1(5%)	1(5%)	2(10%)
Between 3 and 5 years	1(5%)	1(5%)	N/A
More than 5 years	7(35%)	7(35%)	N/A
Total	20(100%)	20(100%)	20(100%)

In this research, not only students' cognitive learning outcomes are analyzed, the gaming process are also documented and observed (Fig. 8).

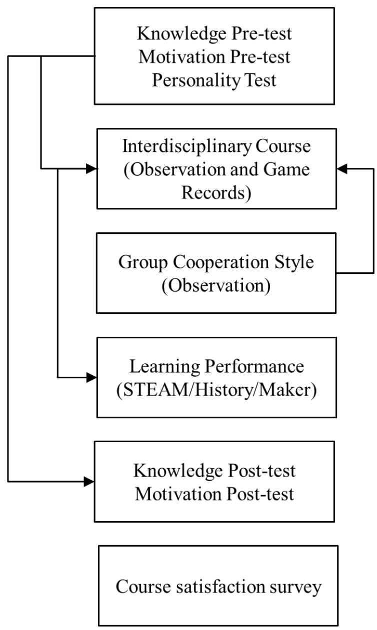


Fig. 8. Research Process

Before the class started, a set of questionnaire were distributed. Besides students' background, a personality trait test was conducted using Professional Dynamitic Program (PDP) scales proposed by McCrae and Costa [50]. Just like DISC theory that categorize people into four types, including dominance, influence, steadiness, and conscientiousness, both tests oriented from the theory of William Moulton Marston developed in 1920 [51]. PDP uses personal behaviors, reactions to the environments, and predictable behavior models to identify personal traits, and is widely used in enterprises, human resources institutes, and governments [51], [52], [53] even today. Personality traits test is different from personality categorization. It is used to identify traits of personal behaviors and reactions instead of naming people to a certain type. Since people with different ways of thinking, ways of talking, and use of strategies, everyone would influence the dynamic of the group and the game. From the anthropological and educational perspectives, it is important to know how technology, game, and certain instructional design would affect the learning dynamics and further affect learning results.

Nevertheless, there is no literature that uses PDP to analyze students, and look into how individuals influence group dynamics. It is certainly not the goal of this study nor the nature of educational to conduct experimental research to it.

With students reacting to 30 adjectives on five-point Likert Scale, students' personality tendencies were assessed and defined as one of the five types of personalities including Tiger-Driven, Peacock-Expressive, Koala-Amiable, Owl-Analytical, and Chameleon-Comprehensive. Instead of identifying students as specific types of persons, the tests is to know what personality traits were shown on which students which allow us to understand how individual behaviors influence group dynamics.

Tiger-Driven persons are those who have highly dominating traits. They prefer to adventure, evaluate, make decisions, and are confidence, positive, competitive, and ambitious. The Peacock-Expressive persons are good at interpersonal relationship building. Those persons are compassionate, optimistic, and sociable; they have great sympathy, enjoy communication, and like exposure. The Koala-Amiable persons own honest, steady, gentle and kind characteristics. They don't like to make trouble with others, and can work steadily. The Owl-Analytical persons are conservative, down-to-earth, and methodical. They pay attention to details and have strong analysis and responsibility. Finally, The Chameleon-Comprehensive persons are fickle, moderate, tough, and good at communication. They are a born negotiator as well as have high resilience [54].

Then, students' knowledge about the Age of Discovery was evaluated as the pre-test and post-test. Ten questions in multiple choices, fill-in blanks, and short answers were included to verify their knowledge in various cognitive levels.

In the course, authentic assessments as Petrina [10] proposed were used, such as process records of learning stages, completeness of students' projects, and abilities assessments. A set of STEAM interdisciplinary evaluations were done in the corresponding stages, namely science (physics, natural science), technology (coding and logistics), engineering (spatial concept and ship assembly), arts (maker and painting), and math (calculation, angle, distance, shape, time, area, capacity).

All the learning process throughout the whole 7-days was observed, and the gaming process was documented. Students' learning behaviors were recorded for group cooperation analysis. These data were cross-analyzed with students' personality traits and group gaming strategies.

At last, reflection sessions and group interviews also provided students' internal thoughts, expectations, and feedbacks to the course.

Course satisfaction survey was to know students' feedback to the course, "Maker Game for Great Voyage", robots and coding, and maker projects.

5 Research Results

5.1 Learning Assessments and STEAM performance

From the results of pre-test and post-test comparison, the overall learning performance of the 20 students have reached significant improvements (t=4.66, p<.05) (Table 2). It is shown that the “Maker Game for Great Voyage” can effectively enhance students’ interdisciplinary learning. It is to the nature of the instructional design that the conjunction of everything, including the elements of STEAM, game, and curriculum design, brings the students to the productive outcome. Selective variable with experimental tests that contribute to the learning is not the claim of this study. In the following paragraph, the paper presents students’ learning performances in the various aspects of STEAM course.

Table 2. Paired-samples t-test of the pre-test and post-test of students’ overall learning achievements

Subject	Test	N	Mean	SD	t
All	Pre-test	20	44.25	18.94	4.66***
	Post-test	20	19.25	15.92	

***p<.001

In the social science aspect of STEAM, this research uses the Age of Discovery history as the game context, therefore, students’ understanding to the related learning content have reached significant improvements (t=4.80, p<.001)(Table 3). It is evident that the game has let the students obtained the learning content effectively without needing the teacher to give lectures.

Table 3. Paired-samples t-test of the pre-test and post-test of history learning

Subject	Test	N	Mean	SD	t
History	Pre-test	20	68.95	29.64	4.80***
	Post-test	20	22.63	31.75	

***p<.001

The technology aspect of STEAM was the core of this course in which students learn about programming and use programming skills to move robots. There are three stages of the technology instruction (Fig. 9), including unplugged coding activity, coding with block editor on computer, and coding to move mBot. Students’ coding concept has significant improvement (t=3.73, p<.05)(Table 4) showing that the course can effectively provide learning scaffolds no matter how old the students are or whether they have coding experience or not. The standard deviation was enlarged due to older students had greater improvements than younger students.

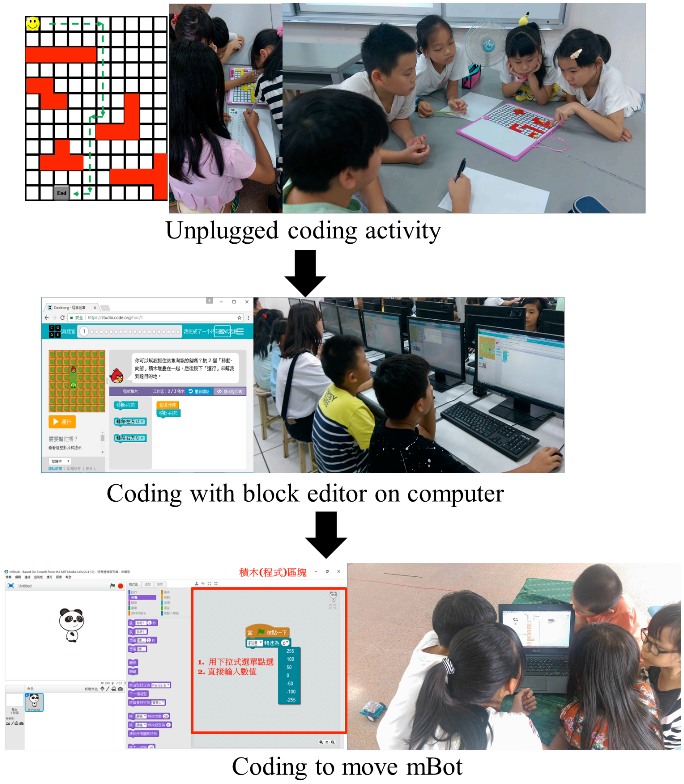


Fig. 9. Coding instruction stages for the course

Table 4. Paired-samples t-test of the pre-test and post-test of programming learning

Subject	Test	N	Mean	SD	*t*
Programming	Pre-test	20	4	10.46	3.73**
	Post-test	20	24	28.72	

**$p<.01$

In the engineering aspect of STEAM, all the students have the chance to transform their mBot into ships (Fig. 10). They were curious and excited about the hands-on experience, and were creative in assembling ships and their weapons. In the process, the groups would discuss, interact, make adjustments to designs, and enjoy the process of have ship battles to see the results of their creations. They can all created different and functional weapons along with their specific strategies. They were all devoted in the making, and all satisfied with their products regardless of their ships won or lost.

Fig. 10. Students' weapon design as in engineering presentation

In the art aspect of STEAM, all the student groups have done artistic creations to the boat in terms of painting the boat in the maker production (Fig. 11). According to the art teacher, their painting were related to their imagined world or related to stories they know; and most of them were colorful. With longer course time, students can be involved in a lot more modifications to the boat including construction of boat from scratch, combing engineering skills with artistic expression to the design.

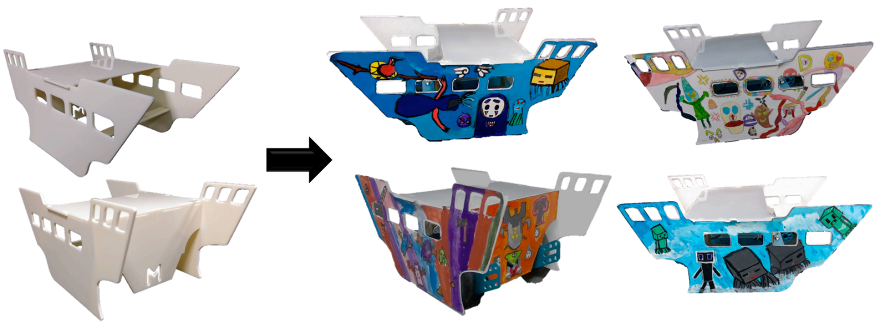


Fig. 11. Students' maker production and artistic creations

In terms of mathematics, the students' pre-test and post-test on angle and distance calculation have some improvements but have not reached significant differences (t=-.15) (Table 5). It is supposed that math tests on the paper were 2D concepts, and in the maker game, students need spatial concept to solve the angle problems. Therefore, it might be the difference that caused their translation confusion. It is also a reminder to us that the flat and dimensional concepts were to be verified to the students in the lesson.

Table 5. Paired-samples t-test of the pre-test and post-test of mathematic learning

Subject	Test	N	Mean	SD	*t*
Mathematic	Pre-test	20	51.25	27.48	-.15
	Post-test	20	52.50	30.24	

5.2 Personalities, Group Cooperation Styles and Gaming Strategies

In order to understand students' gaming experience, individual students' personality traits and their respective roles in the group would influence their decisions on gaming strategies, which are retrieved by their gaming records and interviews.

Fig. 12 Student interactions in the Maker Game for Great Voyage (up left: set up the weapon tool; up right: groups battle; down left: group members discuss their strategies; down right: control the mBot)

In general, players with specific PDP personality traits showed certain gaming strategies and behavior patterns. General tendencies and behaviors were analyzed as follows.

Tigers: In this instructional experiment, there was no student who is with this trait.

Peacocks: Students with Peacocks traits were more active, outgoing, talkative, and sometimes brighten up the group atmosphere. Those with prosocial tendencies used peaceful gaming strategies, tended to give suggestions to others to complete their tasks step by steps. On the other hand, peacocks with aggressive tendencies led the groups to use more conflict-oriented strategies, and encouraged others to make alliance, weaken targeted players, and compete to win.

Koalas: They were conservative and rigid. Once they had decided on a strategy, they did not change their minds. They did not like to attack others, or be attacked. They were passive players and avoid initiating battles. They tended to be prosocial and preferred to keep the game atmosphere peaceful.

Owls: They were with delicate minds, and followed the game rules. They calculated in detail to decide on movement distance and predict locations. They thought about

their next step while it was others' turns, and protected themselves by getting inbound to ports or quickly sailed back to the starting points to complete the tasks. They tended to play safe, and maximized the effects of action points.
Chameleons: They liked to go with the flow, and changed their strategies as the game progresses. They were goal-oriented, and wanted to complete game tasks in their first priority. They liked to take aggressive actions such as attack or persuade others to make alliance to attack the same target which strengthened his own country's power. He may or may not betray his alliance after achieving his goals depending on personal choices.

Since students were groups with mixed year age, students with better abilities were assigned by their group members to take more difficult roles while younger ones take the easier ones. On the other hand, group members with different personality traits who took different roles in a group would also greatly influence the groups' gaming strategies. The following paragraphs would report on each individual group and see their dynamic interactions (Fig 12).

Table 6. Personality traits and learning improvement of students in group 1

Year Level	Learning Achievements	Learning Attitude	PDP	Role	Pre-test	Post-test	Improvement
5	High	3	Owl	Attacker	NA	60	+60
4	High	5	Peacock	Coder	NA	40	+40
3	Low	4	Peacock	Planner	10	45	+35
2	Low	3	Chameleon	Trader	15	25	+10
2	Low	4	Peacock	Navigator	5	25	+20

The personality traits and learning improvement of students in group 1 is as Table 6. In group 1, there were three older kids who took the major roles of the groups. They are all peacocks who are prosocial and talkative, and would give command and guide the group forward. One of the third grader is an owl who also took the role as the attacker. He paid much attention on details and can provide accurate information to the group. His learning improvements are the most among the group.

Group 1

The group's cooperation level was high and interaction was smooth. The older kid led the group in the beginning of the game, and as they worked toward the end, they would make decisions based on group consensus.

In terms of group gaming strategies, it is from observation that the attack of this group did not happen until later. The fifth year student would take the lead for the group gaming strategy. The fourth year coder would allow the older kid to do his job since he was more capable member than himself. In the beginning of the game, the group leader would do the decision on his personal will, and would not consider others' thoughts. Especially when the recorder found that mBot could be diverged, no one would listen to him since he was only a third grader. But when the leader realized that his prediction was inaccurate, he would start to listen to others. At the second half of the game, the group worked toward better landings, all group members would share the joy and sense of coherence. Since it was a group work, younger kids had little chance to take control; therefore, they felt more left alone in the game.

Group 2

Table 7. Personality traits and learning improvement of students in group 2

Year Level	Learning Achievements	Learning Attitude	PDP	Role	Pre-test	Post-test	Improvement
5	High	4	Chameleon	Attacker	15	40	+25
5	Low	3	Tiger/ Chameleon	Planner	45	25	+20
4	Low	3	Tiger	Coder	20	55	+35
2	Low	3	Peacock	Trader	15	35	+20
2	Low	4	Chameleon	Navigator	5	55	+50

The personality traits and learning improvement of students in group 2 is as Table 7. In group 2, there were many chameleons who had good abilities in making adjustments according to the circumstances. However, in the group, there was a fourth grade tiger kid who was very dominant, ambitious, and liked to boss others around. Regardless of his grade level, he took the role as the coder, neglected navigator and planner, and many times yelled at younger kids; therefore, this group had worst communication and interaction between members.

Their cooperation style was always dominant control from the beginning of the game to the end. Even though the teacher had several times reminded them to put group benefit in front of personal will, it was not easy to alter a tiger kid to use his emotions and strong commands to dominant the group.

In terms of group gaming strategies, it is from observation that the group atmosphere was not good. The dominant student tended to blame group members by yelling. Although he was a low learning achievement and low learning attitude student, he was the most active student in the whole course. Lower graders were bored in the whole gaming process since they could not have a say or do anything. Therefore, the whole group was dominated and not cooperative at all.

Group 3

Table 8. Personality traits and learning improvement of students in group 3

Year Level	Learning Achievements	Learning Attitude	PDP	Role	Pre-test	Post-test	Improvement
5	High	5	Peacock	Planner	35	70	+35
5	High	4	Peacock/ Chameleon	Coder	20	75	+55
4	Low	4	Chameleon	Attacker	45	NA	
2	High	5	Owl/ Chameleon	Trader	10	40	+30
2	Low	3	Chameleon	Navigator	10	25	+15

The personality traits and learning improvement of students in group 3 is as Table 8. This group had many chameleons, and with a mix with peacock and owl. These personal traits tended to communicate and were flexible to change as the conditions change. Older peacocks were prosocial, and younger owl could provide appropriate information to the group, therefore, their group work was effective.

The group members would project their ideas and opinions and then the group would make decisions based on consensus. The group cooperation was high and the interaction was good.

In terms of group gaming strategies, it is from observation that the fourth grader was taking the lead because he had taken coding class before. He had poor attitude to younger students, and would not teach. However, whenever there was a need to complete a group goal that requires all members to participate, he would offer his support. In the mBot game, the group had very good cooperation between members. Their interactions were well.

Group 4

Table 9. Personality traits and learning improvement of students in group 4

Year Level	Learning Achievements	Learning Attitude	PDP	Role	Pre-test	Post-test	Improvement
5	Low	4	Chameleon	Planner	50	65	+15
5	High	4	Tiger/ Koala	Coder	40	70	+30
3	Low	3	Chameleon	Navigator	10	45	+35
2	Low	3	Chameleon	Trader	5	40	+35
2	High	5	Chameleon	Attacker	30	50	+20

The personality traits and learning improvement of students in group 4 is as Table 9. This group had four chameleons who were flexible with strategies, and one older kid with tiger/koala traits. Although tiger was supposed to be dominant, his koala trait had put him into more rational state, and would listen and cooperate with others in a more communicative way. The group cooperation style was mild, and group decisions were reached through consensus.

In terms of group gaming strategies, it is from observation that in the beginning, all group members would participate in the game. In the middle of the process, the coder and recorder would take the lead more. It was when lower graders had different opinions from the higher graders, or when the lower graders had nothing else to do, they would lose their focus to the game. Also, when the attacker wanted to fight, since the higher graders were girls and more shy to battles, the democratic process would lead the strategies to less aggressive. The lower grade boys were ignored sometimes.

5.3 Satisfaction

The satisfaction survey include total of 36 questions with 12 of them as reverse checks. Questions include whether the course can draw their attentions, can motivate them to participate for more learning, increase their curiosity, have confidence to learn, and give them the sense of achievements.

From the results of the survey accompanied with student interviews, students said that they generally like the course, especially satisfied with the “Maker Game for Great Voyage” (Table 10). The course can intrigue their interests and attract their attention so they were focused and immersed in the game. They can relate to the STEAM learning content and make connections to their life experiences which allow them to generate strategies in playing the game. Other than that, students share works in the groups so most of them have personal tasks to fulfill so that they can make group progress in the game and the course. To conclude, they think the course is well-designed, instructionally meaningful, in which they gain the sense of achievement and are confident to learn what is embedded inside the course.

Table 10. Paired sample t-test of pre-test and post-test of course satisfaction

Satisfaction	Test	N	Mean	SD	*t*
Satisfaction	Post-test	20	3.939	.797	4.302***
	Pre-test	20	3.249	.500	

****p*<.001

The game ended with a big battle between group 1 and 3. The two chameleon attackers compete with each other and had fun while all group members cheer for them, win or lose. Group 2 and 4, instead, with aggressive coders without willing to listen to other members in the whole gaming process, did not succeed to finish the trading tasks, and did not get the chance to involve in the ship battles. The game did not progress as they wished. Cooperation skills and manners between group members were strengthened again at the end of the camp to remind students of the importance of communication and cooperation with others.

6 Conclusions

This research attempts to provide students an extra-curricular interdisciplinary learning experience that is innovative, immersive, meaningful and with clear goals, which can attract students to autonomously participate in knowledge acquisition and skill practices, as well as collaborate in strategic competition. This project proposed interdisciplinary game-based learning with the integration of STEAM and maker hoping to provide students’ a comprehensive learning experience.

This paper provides an educational practice that has a well-structured teaching and learning model with theoretical foundations, an extensible interdisciplinary content that allows students to reach for wider knowledge body and opportunities to get in touch with other subjects and disciplines. In the extended teaching, more concepts and contents can be added. There could be more trading goods such as silk, china, tea, or rice; and functional ports such as shipyard, shops, hospitals, or bars that allow more information to circular in the game. In the sailing process, game system can randomly appear historical events that might influence the countries' sailing powers and so forth; and the system can randomly appear monsoons, currents, or storms; or spice value change in accordance to the seasons. In the artistic aspect, the students can study and observe the construction of the actual historical boats, boat figures, boat weapons, etc. Therefore, this instructional design is flexible, customizable, and sustainable for the uses in different subject areas, scenarios, and lesson needs.

From the research results, it is evident that the "Maker Game for Great Voyage" has succeeded in the instructional design with STEAM and maker, with the rich context of international history. In the story, students were motived, applied the knowledge they learned in traditional classes, and can cooperate with peers in various personalities and succeed in many different ways.

As interdisciplinary learning activities and teaching examples have been prevailed around the world, lesson plans, activity designs, learning processes and problem-solving results can be found on the web. Researchers such as Sochacka, Guyotte, and Walther [55] explored the STEAM possibilities through their autoethnographic dialogues which provide perspectives and questions that needed to be further explored. In the same sense, this research with the integration of STEAM and maker game also has brought us more teaching and learning issues that require further discussion. This study found that students' personality traits and some other factors would greatly influence the students' group dynamics and further influence their learning conditions. From the research results, how would the teachers and game designers incorporate the concerns with individual differences, and how they manage the groups to have good gaming experience, are issues needed to tackle with in the near future.

To interdisciplinary learning, what STEAM activities needs is the context which allows students to be immersed. Without sufficient learning content, activities would be simply production-based or competition-oriented. A well-designed curriculum design with interdisciplinary learning content would be similar to the science fair. Single subject research or project competition would be a one-time learning without extensive learning arena. A good integrated course design has become the major innovative design and contribution of this research

Acknowledgments. This study is supported in part by the Ministry of Science and Technology of the Republic of China, under MOST 104-2628-S-024 -002 -MY4.

References

1. Chang, C., Shih, J. L., & Chang, C. K. A mobile instructional pervasive game method for language learning. Universal Access in the Information Society, Vol. 16, No. 3, pp. 653--665 (2017).
2. Shih, J. L., & Hsu, Y. J. Advancing Adventure Education Using Digital Motion-Sensing Games. Journal of Educational Technology & Society, Vol. 19, No. 4, pp. 178--189 (2016).

3. Lin, C. H., & Shih, J. L. Evaluations to the gamification effectiveness of digital game-based adventure education course--GILT. Journal of e-Learning and Knowledge Society, Vol. 11, No. 3, pp. 41--58 (2015).
4. Huang, Y. M., Liao, Y. W., Huang, S. H., & Chen, H. C. A Jigsaw-based Cooperative Learning Approach to Improve Learning Outcomes for Mobile Situated Learning. Journal of Educational Technology & Society, Vol. 17, No.1, pp. 128--140 (2014).
5. Bybee, R. W.: Advancing STEM education: A 2020 vision. Technology and Engineering Teacher, Vol. 70, No. 1, pp. 30--35 (2010)
6. Becker, K. H., & Park, K.: Integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A meta-analysis. Journal of STEM Education, Vol. 12, No. 5, pp. 23--37 (2011)
7. Chang, Y. S., & Yang, Y. J.: An Exemplar of STEM Teaching Design - Hydraulic Arm. Technology and Human Education Quarterly - Student-Related, Vol. 1, No, 1, pp. 2--17 (2014)
8. Organisation for Economic Co-operation and Development (OECD). Assessing scientific, reading and mathematical literacy: A framework for PISA 2006. Paris: OECD, (2006)
9. Burke, DTE & Barry N.: 6E Learning byDesignTM Model. The Technology and Engineering Teacher, Vol. 70, No. 1, pp. 14--19 (2014)
10. Petrina, S.: Advanced teaching methods for the technology classroom. IGI Global, (2006)
11. Tsai, I. F., & Wu, H. Y.: Integrated STEM Learning Activity - Airdrop of Relief Supplies. Technology and Human Education Quarterly - Student-Related, Vol. 1, No. 1, pp. 40--54 (2014)
12. Lin, K. I.: To Develop Technological Talents with the Competency of Integrating Theory and Practice through Interdisciplinary STEM Education. Technology and Human Education Quarterly - Student-Related, Vol. 1, No. 1, pp. 1 (2014)
13. Oner, A. T., Nite, S. B., Capraro, R. M., & Capraro, M. M.: From STEM to STEAM: Students’ Beliefs About the Use of Their Creativity. The STEAM Journal, Vol. 2, No. 2, DOI: 10.5642/steam.20160202.06 (2016)
14. Land, M. H.: Full STEAM ahead: The benefits of integrating the arts into STEM. Procedia Computer Science, Vol. 20, pp. 547--552 (2013)
15. Ghanbari, S.: Learning across disciplines: A collective case study of two university programs that integrate the arts with STEM. International Journal of Education & the Arts, Vol. 16, No.7, pp. 1--21 (2015)
16. Miller, J., & Knezek, G.: STEAM for student engagement. In Society for Information Technology & Teacher Education International Conference. Association for the Advancement of Computing in Education (AACE), pp. 3288-3298 (2013, March)
17. Robelen, E.W.: STEAM: experts make case for adding arts to STEM. Education week, Vol. 31, No.13, pp. 8 (2011)
18. Connor, A. M., Karmokar, S., & Whittington, C.: From STEM to STEAM: Strategies for enhancing engineering & technology education (2015)
19. Winterman, B., & Malacinski, G. M.: Teaching evidence-based innovation (EBI) as a transdisciplinary professional skill in an undergraduate biology writing workshop. International Journal of Arts & Sciences, Vol. 8, No. 2, pp. 423 (2015)
20. Kim, D., & Bolger, M.: Analysis of Korean elementary pre-service teachers’ changing attitudes about integrated STEAM pedagogy through developing lesson plans. International Journal of Science and Mathematics Education, Vol. 15, No. 4, pp. 587-605 (2017)
21. Oh, J., Lee, J., & Kim, J.: Development and application of STEAM based education program using scratch: Focus on 6th graders’ science in elementary school. In Multimedia and ubiquitous engineering, Springer, Dordrecht pp. 493-501 (2013)
22. Kang, M., Jang, K., & Kim, S.: Development of 3D actuator-based learning simulators for robotics STEAM education. International Journal of Robots, Education and Art, Vol. 3, No. 1, pp. 22--32 (2013)

23. Herro, D., Herro, D., Quigley, C., & Quigley, C.: Innovating with STEAM in middle school classrooms: remixing education. On the Horizon, Vol. 24, No. 3, pp. 190-204 (2016)
24. Quigley, C. F., & Herro, D.: "Finding the Joy in the Unknown": Implementation of STEAM Teaching Practices in Middle School Science and Math Classrooms. Journal of Science Education and Technology, Vol. 25, No. 3, pp. 410-426 (2016)
25. Herro, D., & Quigley, C.: Exploring teachers' perceptions of STEAM teaching through professional development: implications for teacher educators. Professional Development in Education, Vol. 43, No. 3, 416-438 (2017)
26. Vygotsky, L. S.: Mind in society: The Development of higher psychological processes. Cambridge, Massachusetts: Harvard University Press, (1978)
27. Martin, L.: The Promise of the Maker Movement for Education. Journal of Pre-College Engineering Education Research, Vol. 5, No. 1, pp. 30--39 (2015)
28. Sheridan, K. M., Halverson, E. R., Litts, B. K., Brahms, L., Jacobs-Priebe, L., & Owens, T.: Learning in the making: A comparative case study of three makerspaces. Harvard Educational Review, Vol. 84, No. 4, pp. 505--531 (2014)
29. Vossoughi, S., & Bevan, B.: Making and tinkering: a review of the literature. National Research Council Committee on Out of School Time STEM, Vol. 67, pp.1--55 (2014).
30. Papavlasopoulou, S., Giannakos, M. N., & Jaccheri, L.: Empirical studies on the Maker Movement, a promising approach to learning: A literature review. Entertainment Computing, Vol. 18, pp. 57--78 (2017)
31. Khalili, N., Sheridan, K., Williams, A., Clark, K., & Stegman, M.: Students designing video games about immunology: insights for science learning. Interdisciplinary Journal of Practice, Theory, and Applied Research, Vol. 28, No. 3, 2 pp. 28--240 (2011)
32. Prensky, M.: Digital game-based learning. Computers in Entertainment, Vol. 1, No. 1, pp. 21 (2003)
33. Johnson, D. W., Johnson, R. T., & Smith, K. A.: Active learning: Cooperation in the college classroom. Interaction Book Company, (1998)
34. Hsiao, H. S., Chang, C. S., Lin, C. Y., & Hu, P. M.: Development of children's creativity and manual skills within digital game-based learning environment. Journal of Computer Assisted Learning, Vol. 30, No. 4, pp. 377--395 (2014)
35. Lin, C. H., Shih, J. L.: Analysing Group Dynamics of a Digital Game-based Adventure Education Course. Educational Technology & Society.(In press) (2017)
36. Shih, J. L., Jheng, S. C., Tseng, J. J.: A Simulated Learning Environment of History Games for Enhancing Players' Cultural Awareness. Interactive Learning Environments, Vol. 23, No. 2, pp. 191--211 (2015)
37. Kiili, K.: Digital game-based learning: Towards an experiential gaming model. The Internet and higher education, Vol. 8, No. 1, pp. 13--24 (2005)
38. Papastergiou, M.: Digital game-based learning in high school comp uter science education: Impact on educational effectiveness and student motivation. Computers & Education, Vol. 52, No. 1, pp. 1--12 (2009)
39. Shih, J. L., Shih, B. J., Shih, C. C., Su, H. Y., & Chuang, C. W.: The Influence of Collaboration Styles to Children's Cognitive Performance in Digital Problem-Solving Game "William Adventure": A Comparative Case Study. Computers & Education, Vol. 55, No. 3, pp. 982--993 (2010)
40. Mayer, R.E.: Thinking, problem solving, cognition (2nd ed), Freeman, (1991)
41. Klabbers, J. H.: Three easy pieces: A taxonomy on gaming. The International Simulation and Gaming Research Yearbook, Vol. 7, pp. 16--33 (1999)
42. Lin, C. H., & Shih, J. L.: Evaluations to the gamification effectiveness of digital game-based adventure education course – GILT. Journal of e-Learning and Knowledge Society, Vol. 11, No. 3, pp. 41--58 (2015)

43. Madden, M. E., Baxter, M., Beauchamp, H., Bouchard, K., Habermas, D., Huff, M., Ladd, B., Pearon, J., & Plague, G.: Rethinking STEM education: An interdisciplinary STEAM curriculum. Procedia Computer Science, Vol. 20, pp. 541--546 (2013)
44. Johnson, D. W., & Johnson, R. T.: Social skills for successful group work. Educational leadership, Vol. 47, No. 4, pp. 29--33 (1990)
45. Johnson, D. W., & Johnson, R. T.: Cooperative learning and classroom and school climate. Educational environments: Evaluation, antecedents and consequences, pp. 55--74 (1991)
46. Johnson, D. W., & Johnson, R. T.: Learning together and alone. Cooperative, competitive, and individualistic learning. Allyn and Bacon, (1994)
47. Lin, C. H., Huang, S. H., Shih, J. L., Covaci, A., & Ghinea, G.: Game-Based Learning Effectiveness and Motivation Study between Competitive and Cooperative Modes. In: Proceedings of the 17th IEEE International Conference on Advanced Learning Technologies. pp. 123--127. IEEE Computer Society (2017)
48. Cambridge, D., Davey, M. J., & Massingham, R. Prazosin, a selective antagonist of post-synaptic alpha-adrenoceptors [proceedings]. British journal of pharmacology, Vol. 59, No. 3, pp. 514 (1977)
49. Shi, Y. R., & Shih, J. L.: Game factors and game-based learning design model. International Journal of Computer Games Technology, Vol. 2015, No. 11. pp. 1--11 (2015)
50. McCrae, R.R., Costa, P.T.: Validation of the five-factor model of personality across instruments and observers. Journal of Personality and Social Psychology, Vol. 52, No. 1, pp. 81--90 (1987)
51. Creusen, M.E.H., Schoormans, J.P.: The different roles of product appearance in consumer choice. Journal of Product Innovation Management, Vol. 22, No. 1, pp. 63--81 (2005)
52. Eastburg, M. C., Williamson, M., Gorsuch, R., & Ridley, C.: Social support, personality, and burnout in nurses. Journal of Applied Social Psychology, Vol. 24, No. 14, pp. 1233--1250 (1994)
53. Mugge, R., Govers, P., Schoormans, J.P.: The development and testing of a product personality scale. Design Studies, Vol. 30, No. 3, pp. 287--302 (2009)
54. Allport, G.W.: Personality: A Psychological Interpretation. Holt, Rinehart & Winson, New York (1937)
55. Sochacka, N. W., Guyotte, K., & Walther, J.: Learning together: A collaborative autoethnographic exploration of STEAM (STEM+ the arts) education. Journal of Engineering Education, Vol. 105, No. 1, pp. 15--42 (2016)