様　式　Ｃ－１９、Ｆ－１９－１、Ｚ－１９　（共通）

科学研究費助成事業　　研究成果報告書

令和　３ 年　 ６ 月　 ９ 日現在

機関番号：１７１０２
研究種目：若手研究
研究期間：2018～2020
課題番号：１８Ｋ１３１６８

研究課題名（和文）Effective framework to develop critical and creative thinking in children to drive future innovation in Japan

研究課題名（英文）Effective framework to develop critical and creative thinking in children to drive future innovation in Japan

研究代表者
ＬＯＨ　ＷＥＩ・ＬＥＯＮＧ（LOH, WEI LEONG）

九州大学・芸術工学研究院・助教

研究者番号：５０７９０４３２

交付決定額（研究期間全体）：（直接経費）　　2,700,000円

研究成果の概要（和文）：本研究では、学校の生徒の批判的思考や創造的思考を育成するためのデザイン活動を教師が開発・実施する際の指針となるフレームワークを開発することを目的としています。フェーズ1では、アジア・オセアニアの中学・高校を対象に、デザイン活動を通じて批判的・創造的思考をどのように育むことができるかを研究しました。フェーズ2では、PaulとElderによる批判的思考モデルを採用し、デザインプロセスにおける正当な理由を評価するために、関連する知的基準を文脈に沿って明確にしました。本研究のフェーズ3では、調査結果の一部を統合し、批判的で創造的な思考を育むために、日本の高校教育にパイロットデザイン活動を導入しました。

研究成果の学術的意義や社会的意義
This study explored and provided a effective method to evaluate critical thinking in design process. The findings in this study may provide important insights that may provide teachers in Japanese schools to develop children in critical thinking and creativity at a young age.

研究成果の概要（英文）：The study aims to develop a framework to guide teachers in developing and implementing design activities to develop critical and creative thinking in school students. In Phase 1, a study was conducted in Asian and Oceania secondary schools to study how critical and creative thinking can be developed through design activities. The iterative cycles between the identification of problems and manufacturing of the proposed prototype during the process of designing is crucial to the development of critical and creative thinking. In Phase 2, adopting the critical thinking model by Paul and Elder, the study contextualized and articulated relevant intellectual standards to evaluate good reasonings during the design process. This method of evaluating critical thinking can be used as guidelines to develop critical thinking. Phase 3 of the study integrated some of the findings to implement pilot design activities into a Japanese high school education to develop critical and creative thinking.

研究分野：Design Education

キーワード：design education　critical thinking　creativity　design and technology　technology

１．研究開始当初の背景

In 21st century, students need to be systematically educated with skills to be creative and innovative to confront future problems that are unpredictable and complex. Design education like Design and Technology (D&T), also call Technology Education, develops critical thinking and creativity, which are important skills required for innovation. D&T is commonly offered in secondary schools in Europe, America, Hong Kong, Singapore, Taiwan and China. For Japan, although similar subject like Technology is available in junior high school, but creative problem solving through design is not much focused in the subject. Up till now, thinking skills development in D&T has been explored under various themes like design and problem solving, complex thinking, analogical reasoning and etc. But frameworks for the development of critical thinking and creativity through design activities is not clarified.

２．研究の目的

The current study aims to develop an educational framework to guide teachers to improve developing, planning and teaching of design/D&T related lessons that develop critical and creative thinking.

As a broad impact, the framework will be robust, yet flexible enough to be implemented across different context in different countries. At local impact, important insights may provide insights for teachers in Japanese elementary, junior high and high school to develop children in critical thinking and creativity at a young age, and as a form of human resource development to build the foundations for future innovations in Japan.

３．研究の方法

The main research questions set for this study are as follow:

- What are the different appropriate pedagogies that facilitate student development in critical thinking and creativity through design activities?
- How can learning experience in design activities be designed to promote critical thinking and creativity?
- How can the learning environment be set to stimulate learning and development of critical thinking and creativity?
- What are appropriate assessment methods to evaluate and provide feedback to improve the development of critical thinking and creativity?
- What are relevant and meaningful content that provides authentic learning for students?

As D&T and Technology subject is widely offered in overseas and local schools at secondary and junior high level, this study will use D&T education in Asian countries such as Singapore, Hong Kong and Taiwan as a study target. A qualitative approach will be used to develop case studies using established D&T education in Asian secondary schools such as in Singapore, Hong Kong and Taiwan so as identify effective models of critical and creative thinking can be elucidated.

The study will be conducted in 2 main phases.

In Phase 1, an overseas study to clarify the current status of developing critical thinking and creative thinking through D&T and Technology subject will be clarified.

In Phase 2, the study will develop case studies to clarify effective models for critical and creative thinking development.

In Phase 3, the study hopes to implement and test some of the findings into the Japanese school context.

４．研究成果

Phase 1

In Phase 1, a network was able to be established for research in Asia and Oceania. The iterative cycles between the identification of design problems and the manufacturing of the proposed prototype during the process of designing is crucial to the development of critical thinking skills. During the process of designing, skills such as interpretation, analysis, evaluation, inference, ability to clarify, decision-making and problem solving are deeply involved. Such skills are key to the development of a critical thinker.

In Australia, the current Australian curriculum was implemented in 2014. Since the implementation, is was understood that until just recent years, teachers, in secondary schools at large, were still focusing on making and skills development rather than incorporating design to provide a structure for creative problem solving. But, a trend could be seen where more design emphasized projects have been developed and implemented into the school curriculum. In Taiwan, TE, also known as Living Technology, has undergone a transition from Industrial Arts, to Technology focus and in the last one year, moving into a more design-based curriculum in anticipation for the new TE curriculum implementation in 2019. Though learning through design has been incorporated, the Taiwanese TE can be characterized by a more engineering-based creative problem-solving approach. While D&T in Australia can be characterized by a product design approach towards creative problem solving. A common trend can also be observed where the Makers' approach towards the design and rapid prototyping through using more advance manufacturing systems like 3D printers, laser cutters and CAD are gaining more traction in students project and learning experience. In Singapore, D&T was first implemented in 1986, has all along been envisioned to be a subject that engages students through product designing and prototyping of ideas with the mind and hands. Though technology knowledge such as mechanism, structures and electronics had been taught as part of the curriculum, these knowledges play a more supportive role in the realization of the working prototype. Unlike, Taiwan and Australia, the manufacturing of prototypes are mostly based on manual manufacturing.

Based on study in Phase 1, some key points may be concluded: 1) While design has been a major focus in D&T learning in Singapore, a trend can be observed in Australia and Taiwan where the shift from the emphasis on making and concepts of technology, to a more design-based learning in recent years. 2) The type of design activities can be distinctively different where TE in Taiwan has a slant towards engineering design; whereas D&T in Singapore and Australia has a slant towards product design. 3) Despite the different focus on design activities in the three countries, it is evident that students are heavily involved in designing activities where critical thinking skills can be heavily involved. 4) D&T and TE are in prime position to systematically develop students with important 21st CC skills such as creativity, innovative and communication skills, that are considered necessary for students to navigate the uncertain future.

At the moment, the common issue for all three countries includes that inconsistent quality of D&T and TE across secondary/ junior high schools at national level. The speculated current challenge for all three countries will be to strengthen research and development for the subject, creating a local and international network for research and development of common educational contents and Teaching and Learning tools and strengthening teachers' in-service development to achieve a common high standard in delivering D&T and TE nationwide.

Phase 2

The main concept of critical thinking process revolved around the process of reasoning. With this assumption, the critical thinking model by Paul and Elder provided a clear structure to unpack reasoning into parts. Without the need for a standardized critical thinking assessment test, Paul and Elder had also created a model to allow the quality of reasoning to be assessed using the intellectual standards, through questioning techniques. Furthermore, this model is flexible in application across different subject areas and provides a great potential for the application in this study. With above considerations, the current study adopts the definitions of critical thinking conceptualized by Paul and Elder, and at the same time, attempts to apply the concept of elements of reasoning and intellectual standards to contextualize and articulate relevant intellectual standards that be used to evaluate good

reasonings during the design process.

Using the problem identification process in the design activities as an example, the intellectual standards for good reasoning skills in the problem identification processes such as, problem exploration, understanding the design problem and design specifications, and problem selection can be articulated respectively. To be able to develop critical thinking to achieve the standards for good reasoning during the problem identification process the following suggestions may be presented.

When exploring problems in the design process, to achieve depth, accuracy and unbiased understanding of the problem, students need to research information and data from different sources to triangulate the problem. Secondly, it is necessary for students acquire necessary background knowledge in order to conceptualize problems accurately and clearly. Thirdly, the development of intellectual standards for reasoning relevant to the design process in D&T may be a potentially useful strategy for teachers to explicitly develop critical thinking skills in D&T.

When understanding the design problem towards determining appropriate design specifications, background knowledge generated by research in a minimal of three areas such as environment, users and products, with respect to the design problem, is necessary. Secondly, to enhance research authenticity and accuracy for the benefit of learning, it is important for students to engage in a problem where field visits and interview with target users and/or stakeholders can be conducted.

When choosing the design problem, the use of decision-making tools does not necessary enable students to achieve quality reasoning. While students may be able to articulate clearly and logically their choice of the problem, but in most cases, their decisions are mainly based on assumptions which may not be well justified. Thus, a more systematic process of information or evidence gathering is necessary. Secondly, the selection criteria for choosing a problem should be formed early in the problem identification process, before students engage into problem exploration. By doing this, students may be able to know the selection criteria in advance, this will sharpen students search for information to understand the problem better and in turn form important background knowledge that are necessary to perform quality reasoning during the problem selection process. Thirdly, the process of choosing problems may be a good opportunity to touch on students' ethical and emotional considerations towards the problems. Thus, when forming the selection criteria to choose a problem, it is suggested that students should focus on factors such as ethical, significance, reasonability, relevance, emotions and achievability. Finally, the current study may provide curriculum developers with some fruits for thoughts on the possibilities to develop relevant assessment standards that may be useful in evaluating and developing quality critical thinking in design-based learning.

In addition, skills such as observation skills are helpful for students to develop critical thinking skills during the problem identification process. Observation skills can be developed during the early years of secondary education. To develop observation skills at lower secondary level, observation skills needs to be scaffolded as students are generally lacking in design experience. To enhance observations, questioning techniques has the potential to sharpen clarity and purpose of observations. In addition, actual site observations are important learning experience that cannot be replaced by looking at images and videos from social media. More importantly, observation skills support critical thinking and social emotional learning. Lastly, a set of characteristics for skilled observer for problem identifications can be suggested and presented in Table 1.

Table 1. Student outcomes for observation skills in problem identification

Characteristics of a skilled observer in problem identification:
• purposeful in observation • clearly and accurately report what is observed • logical in interpreting the observations • unbiased so as to observe different aspects of the problem • unbiased in reporting observations • make observations using different senses • meticulous in observation • clear about the questions to be answered through observation

Phase 3

This phase of the study integrated some of the findings in Phase 1 and 2 to implement into high school education in Japan. Using Fukusho High School in Fukuoka city, Japan, as a case study to pilot a design programme for Year 1 students in the *Global Management Programme* the research outcomes may be presented as follow. From this pilot design program, design education can be positioned as a form of problem-based learning (PBL) to integrate into the Japanese high school education that is not structured for design learning. Design education also provides another way of learning for students to engage in solving real-world problems that are different from other subjects. The design activities also allowed high school students to develop 21CC and SEL such as critical thinking, creativity, collaborative and communication skills, and hearing other points of view. As a form of education for sustainable development (ESD), the current study has the potential to enhance awareness of sustainable development goals (SDGs) and sustainable issues in the local community.

References

Loh, W. L. (2019). The Type of Design in Design and Technology Education for the Development of Critical Thinking Skills: A Perspective Based on the Asian and Oceania D&T and TE Education. 120-121. *Abstract from 13th International Conference on Technology Education in the Asia Pacific Region*, Cheongju, Korea.

Loh, W. L. (2020). Critical Thinking in Problem Exploration in Design and Technology Design Project. *Design and Technology Education: An International Journal*, 25(1), 35-58. https://ojs.lboro.ac.uk/DATE/article/view/2738

Loh, W. L. (2020). Sharpening Critical Thinking in Problem Identification in Design and Technology Education. *In Proceedings of DRS 2020: Synergy,* Vol. 2, pp. 899. https://doi.org/doi: 10.21606/drs.2020.358

Loh, W. L., Moe SHIMOMURA, & Zhang, Y. (2020). Unlocking Creative Minds to Engage SDGs Through Design Education in Japanese High School. *In Proceedings of the 22nd International Conference on Engineering and Product Design Education (E&PDE 2020)* https://doi.org/10.35199/EPDE.2020.16

Loh, W. L. (2021). Sharpening Critical Thinking in Design Problem Selection in Design Project: A Perspective Based on Singapore Design and Technology. *Abstract from International Conference on Technology Education in the Asia-Pacific Region 2021*, Taipei, Taiwan.

Paul, R., & Elder, L. (2002). *Critical Thinking: Tools for taking change of your professional and personal*. New Jersey: Pearson Education.

Paul, R., & Elder, L. (2008). *Intellectual Standards: The words that name them and the criteria that define them*. CA: Foundation for Critical Thinking.

Paul, R. & Elder, L. (2019). *The miniature guide to critical thinking concepts and tools (8th ed.)*. Lanham, Boulder, New York and London: Rownman & Littlefield.

５．主な発表論文等

〔雑誌論文〕　計4件（うち査読付論文　3件／うち国際共著　3件／うちオープンアクセス　3件）

１．著者名 LOH, Wei Leong	４．巻 25(1)
２．論文標題 Critical Thinking in Problem Exploration in Design and Technology Design Project	５．発行年 2020年
３．雑誌名 Design and Technology Education: an International Journal	６．最初と最後の頁 35-58
掲載論文のDOI（デジタルオブジェクト識別子） なし	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 該当する

１．著者名 LOH, W. L.	４．巻 Vol. 2
２．論文標題 Sharpening Critical Thinking in Problem Identification in Design and Technology Education	５．発行年 2020年
３．雑誌名 Proceedings of DRS 2020: Synergy, Design Research Society	６．最初と最後の頁 899-925
掲載論文のDOI（デジタルオブジェクト識別子） 10.21606/drs.2020.358	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 該当する

１．著者名 LOH, W. L., Moe SHIMOMURA, & ZHANG, Y.F.	４．巻 -
２．論文標題 Unlocking Creative Minds to Engage SDGs Through Design Education in Japanese High School	５．発行年 2020年
３．雑誌名 Proceedings of the 22nd International Conference on Engineering and Product Design Education (E&PDE 2020)	６．最初と最後の頁 -
掲載論文のDOI（デジタルオブジェクト識別子） 10.35199/EPDE.2020	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 該当する

１．著者名 Leon LOH，猪狩克也，向田識弘	４．巻 -
２．論文標題 オンラインによる技術・情報教育教員の国際交流	５．発行年 2021年
３．雑誌名 オンラインで拓く技術・情報教育の可能性：小学校、中学校，高等学校，大学，教員研修，学会活動の取り組み	６．最初と最後の頁 208-215
掲載論文のDOI（デジタルオブジェクト識別子） なし	査読の有無 無
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 －

〔学会発表〕　計5件（うち招待講演　1件／うち国際学会　2件）

1．発表者名
LOH Wei Leong

2．発表標題
The Type of Design in Design and Technology Education for the Development of Critical Thinking Skills: A Perspective Based on the Asian and Oceania D&T and TE Education

3．学会等名
International Conference on Technology Education in the Asia Pacific Region（国際学会）

4．発表年
2019年

1．発表者名
大倉幹生 , LOH Wei Leong

2．発表標題
小学校におけるデザイン教育に対応する施設についての研究: 福岡市の公立小学校における図画工作を事例にして

3．学会等名
日本デザイン学会第５支部

4．発表年
2018年

1．発表者名
Loh, W. L.

2．発表標題
Developing observation skills in problem identification for lower secondary design and technology

3．学会等名
63rd Annual Meeting of the Japan Society of Technology Education

4．発表年
2020年

1．発表者名
Loh, W.L.

2．発表標題
The Design and Technology Teacher Education in Singapore: a journey based on a personal narrative

3．学会等名
Annual Conference of Industrial Technology Education Association of Taiwan（招待講演）

4．発表年
2020年

１．発表者名
Loh, W. L.

２．発表標題
Sharpening Critical Thinking in Design Problem Selection in Design Project: A Perspective Based on Singapore Design and Technology

３．学会等名
International Conference on Technology Education in the Asia-Pacific Region 2021（国際学会）

４．発表年
2021年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

A teacher seminar for junior high school teachers, teaching Technology education, was conducted in 2019 to share findings related to critical and creative thinking development based on design activities in Asian and Oceania secondary schools. The information of seminar is as follow.
Seminar Title: Introduction to Design & Technology and Technology Education in Oceania and Asia, 広島県技術教育学会 (Hiroshima Society for Technology Education), 広島市西区民文化センター大会議室A (Hiroshima City).

６．研究組織

	氏名 （ローマ字氏名） （研究者番号）	所属研究機関・部局・職 （機関番号）	備考

７．科研費を使用して開催した国際研究集会

〔国際研究集会〕　計1件

国際研究集会	開催年
International Design-Technology Education Exchange Forum (Online)	2020年～2020年

８．本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関