JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

THE FEASIBILITY AND EFFECTIVENESS OF LIFE SCIENCE IN STEM PRACTICAL LEARNING ENVIRONMENT

King-Dow Su

Abstract. *Building 21st-century life science skills requires educating participants according to STEM abilities. Therefore, this research aimed to examine the effectiveness and feasibility of the STEM ability assessment framework in the practical learning environment. The study uses STEM coffee preparation experiential activity with a Royal Belgian siphon pot to construct a learning environment in the classroom. The study also develops two assessment instruments, a knowledge concept questionnaire, and an entrepreneurial scientific thinking scale, to examine their effectiveness and feasibility in the STEM learning environment. The results of the content validity index reveal the value of good-grade literature for two questionnaires. Kendall's coefficient of concordance (ω) of the four reviewers' responses shows that the inter-rater reliability of the two questionnaires reaches a better level. The Chi-square test found that this STEM learning environment is feasible and effective and will help the participants assess their STEM abilities. The entrepreneurial scientific thinking for preparing beverages of life science is rich in viability and efficacy for instrument creation and assessment. Future research lengthened the extraction process while also improving consistency. Last but not least, more teaching practices and research designs are available. However, the goal is for learners' STEM aptitude to increase practice depth.*

Keywords: *effectiveness and feasibility, entrepreneurial scientific thinking, life science, Royal Belgian siphon pot, STEM education*

King-Dow Su
Hungkuo Delin University of Technology & Chung Yuan Christian University, Taiwan

Introduction

STEM is the abbreviation of **s**cience, **t**echnology, **e**ngineering, and **m**athematics. Tsupros et al. (2009) defined STEM education and believed that STEM education is an interdisciplinary educational approach that combines rigorous academic concepts with real-world courses, prompting students to integrate science**.** Researchers (Mizell & Brown, 2016) accepted this definition by knowledge in STEM applied to link schools, communities, jobs, and businesses. Technology-integrated STEM education can arouse students' willingness to learn more than other single subjects or technology-integrated subjects (Becker & Park, 2011). The United States led many countries to maintain a competitive advantage in global economic development. Therefore, educators and policy-making departments should actively promote science, technology, engineering, and mathematics domain knowledge to take action in STEM regard (Kelly & Knowles, 2016). In science, both scientific thinking and scientific concepts construct the fundamental background of mathematics; in engineering and technology, which rely upon the application between mathematics and science; in mathematics, it helps learners integrate their understanding of scientific concepts. This interdisciplinary approach to STEM teaching is inseparable from the nature of science, technology, engineering, and mathematics. They have a unified structure throughout history, overlapping and merging (Broggy et al., 2017).

The successful promotion of STEM fields contributes to the competitive advantage of the labour market and the stable development of the national economy (Bicer et al., 2017). Accordingly, STEM education is welcomed by more and more teachers, researchers, administrators, and policymakers, making it a popular interdisciplinary focus of attention (Brown et al., 2011). STEM education aims to develop learners' critical thinking skills and enable them to become effective problem solvers on STEM-related issues (White, 2014). Therefore, assessing STEM abilities will help learners choose a decision-making reference for future careers related to STEM (Enderson & Ritz, 2016). Saxton et al. (2014) pointed out that the assessment framework will facilitate the development of more effective tools for assessing learners' STEM competencies. The study also pointed to a comprehensive STEM assessment framework that reflects the diverse structure of STEM education, including

https://doi.org/10.33225/jbse/24.23.131

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

a focus on experiential context and higher-order thinking skills in STEM-related content. However, the thinking skill cognition that forms the basis of the STEM assessment framework is reasoning ability (Mullis & Martin, 2017, p. 22) and non-routine problems. Milgram (2007) pointed out that non-routine problems require students to activate innovations to integrate their reasoning abilities and find solutions. So far, the literature for the life science and technology disciplines has rarely examined the evaluation application of STEM interdisciplinary.

Entrepreneurial Scientific Thinking in STEM Education

In 2017, the U.S. Department of Education emphasized that integrated interdisciplinary STEM education can cultivate learners' ability to understand information, make precise decisions, solve problems, and overcome future challenges. In the 21st century society, this importance is even more significant (Salmi et al., 2021; Struyf et al., 2019). STEM education emphasizes knowledge application and practical experience to provide participants with multi-dimensional learning, such as knowledge, communication, skills, coordination, thinking, creation, design, and cooperation (Bybee, 2010; Moore et al., 2015; Tsai et al., 2021). Try to link schools, communities, work, and enterprises (Tsupros et al., 2009; Mizell & Brown, 2016) to integrate academic concepts and real-world courses. To show the core value of STEM Education through hands-on learning, brain thinking, and communicating with verbs (Baran et al., 2016; Tsai et al., 2018).

STEM education emphasizes technology and scientific thinking to solve problems and connects the knowledge learned with life experience in practice (Mohtar et al., 2019; York et al., 2019). It is an interdisciplinary integration model of high-level thinking. This interdisciplinary model, Buang et al. (2009) theoretical model of entrepreneurial scientific thinking, and Kolb's (1984) four-stage experiential learning all emphasize their actual participation, critical thinking, innovation, and problem-solving. Gunawan and Shieh's research (2020) found that integrating entrepreneurial scientific thinking into STEM courses will impact students' learning. Eltanahy et al. (2020) pointed out that applying entrepreneurial scientific thinking in STEM learning can improve learners' design awareness and increase their ability to judge product value. Ahmad and Siew (2021) also believe that entrepreneurial scientific thinking in STEM education will help cultivate talents who can solve problems, make decisions, and be innovative and creative to benefit the future society. As a result, STEM education supports the development of entrepreneurial scientific thinking skills in this study.

The Importance of STEM Competency Assessments

Shulman (2009) pointed out that assessment is a powerful tool to improve the quality of teaching. Accordingly, the assessment of STEM abilities can help improve the quality of STEM education. Saxton et al. (2014) also believe that assessing STEM competencies in domain knowledge can promote the quality of learning and teaching. The evaluation methods include a formative and summative evaluation. In contrast to summative assessment, STEM evaluation is a formation, according to Capraro and Corlu (2013). Some scholars believe that formative assessment can involve timely feedback in each process and be effective (Han et al., 2015; Haudek et al., 2011). Compared with the research on summative assessment of STEM ability, although it is more specific and clear, it is rarely mentioned in the literature. A significant problem is the absence of a STEM pedagogical assessment framework (Capraro & Capraro, 2013; Ing, 2014).

Researchers (Jang, 2016; Loukomies et al., 2013; Salmi et al., 2021; Struyf et al., 2019) pointed out that raising STEM learning environmental design was necessary. It could improve learning interest, motivation, and twenty-first-century skills across the interdisciplinary. Harwell et al. (2015) thought that the STEM assessment framework would help to assess the instrument development and verification abilities of STEM. Bicer et al. (2017) believed that STEM assessment models are necessary to examine students' STEM skills and gain a profound understanding of STEM fields in an interdisciplinary manner. Science, technology, engineering, and mathematics (STEM) practised learning environments will be effective and successful engagement. However, no comprehensive pedagogical assessment frameworks enable the creation of a STEM learning environment (Mäkelä et al., 2022; Struyf et al., 2019).

Accordingly, this study develops a summative STEM ability assessment method and proposes the development of the STEM knowledge concept questionnaire and the entrepreneurial scientific thinking scale.

https://doi.org/10.33225/jbse/24.23.151

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Purpose and Research Questions

It is crucial to educate participants based on STEM abilities to build 21st-century life science skills. Therefore, this research aimed to apply the STEM pedagogical assessment framework to attempt to construct a learning environment of technology application in STEM coffee-making experiential activities. To develop assessment instruments for knowledge concept questionnaires and entrepreneurial scientific thinking, trying to examine the learning environment in the process of STEM education. Test the effectiveness of students' entrepreneurial scientific thinking ability and evaluate its feasibility to pass the test evidence of empirical research on the framework structure. The research questions explored in this study were as follows:

1. What is the domain of the STEM pedagogical assessment framework?
2. What are the content and face validity of the STEM ability assessment instruments?
3. What is the inter-rater reliability of the STEM ability assessment instruments?
4. What is the feasibility and effectiveness of using this assessment instrument to examine learners in the STEM practical learning environment?

Research Methodology

General Background

This research builds a competence evaluation system in life science using the design thinking STEM learning paradigm and the Royal Belgian siphon pot. This assessment framework is meaningful for the creation, verification, and experience of STEM ability. The study developed two standardized research instruments, the STEM knowledge concept questionnaire, and the entrepreneurial scientific thinking scale, to collect data and learn from the STEM learning environment. Six experts were rated based on eight evaluation questions, with the average value serving as the content validity index (CVI). The study uses descriptive statistics, the harmony coefficient, and the Chi-square fitness test to investigate the reliability, validity, and fitness of two assessment questionnaires. The content dimensions of the STEM ability assessment framework contain and define each subject and associated sub-dimension of science, technology, engineering, and mathematics. This framework exemplifies the various integration of STEM education with life science. The practicality and efficacy of the STEM practical learning environment, along with brain thinking, hands-on activities, and verbal argument, may assist students in constructing mental models in STEM education and promote students to have a deeper idea of life science and profound comprehension during the 2022 academic year.

Participants and Ethical Approval

The participants of this research, from the K-12 and K-14 of the Department of Hospitality and Tourism of the University of Science and Technology in Taiwan, two recruiting classes and 70 students (41% males and 59% females) who took the coffee beverage preparation in life science course participated in the experiential activities. They are similar in age (18-20) and have just started to learn drink-making. Furthermore, six people are involved in the role of experts. They reviewed as long as the logic of the questionnaire structure, the rationality, and fluency of the content. Distribution of their expertise included two professors of education and curriculum communication, two technology education, and two science education. They consisted of three females and three males, aged 55 to 62, with more than 20 years of teaching experience in six different science and technology universities.

Students' involvement in this experiential teaching method is voluntary, and after completing the informed permission form, they gain practical experience in the STEM learning environment. After finishing the STEM curriculum, they fill out the questionnaire anonymously and code using Arabic numbers and English on ethical issues. Taiwan Ethics Committee, certificate number NCCU-REC-202205-E022, issued consent.

Instrument Design

The STEM ability assessment instruments included the STEM knowledge concept questionnaire and the entrepreneurial scientific thinking scale. As for the STEM knowledge concept questionnaire, divide the question-

https://doi.org/10.33225/jbse/24.23.151

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

naire with open-ended questions into three parts. The first part, the opening words, let voluntary participants understand that this questionnaire had nothing to do with the grades of the courses they have taken and only express their learning perceptions; the second part, there were demographic questions; in the final part, refer to Bloom's revised (Anderson & Krathwohl, 2001) cognitive taxonomy for open-ended test questions and design, allowing students to complete the test after the STEM experiential learning activities and present their revised Bloom learning outcomes and cognitive domain distributions in a cognitive taxonomy. The first draft has six aspects from remember, understand, apply, analyse, evaluate to create, and has three test items in each one. The first draft of the test questions will be adapted and revised about the learning outcome scale framework of Dedeturk et al. (2021), Honey et al. (2014), and Su (2019). To design a total of 18 questions about STEM knowledge concepts. The first draft invited the above six experts to conduct a substantive review and revise the content and logic of this questionnaire. Furthermore, eliminate illogical topics or contents according to the opinions and suggestions of the experts after the triangular correction to ensure the content and face validity of the questionnaire.

Additionally, the degree of success is scored from 1 to 5 points by the six experts asked to participate in this study, using the 8 test questions from the literature (Burton & Mazerolle, 2011; BSNP, 2016; Wahono & Chang, 2019) as the scoring criteria. Item 1, the tool system preparation; Item 2, the clarity and readability of each item in the phrase; Item 3, the coherence between item and item; and Item 4, depending on the goal of tool creation Item integrity; Item 5, STEM knowledge, attitude, application, and accuracy of each item; Item 6, ease of use; Item 7, the survey results will tell the truth; Item 8, does not include race, ethnicity, religious issues, infringement of intellectual property rights, pornography, and prejudice (such as gender, region, etc.). Six experts scored according to these eight items and their average value as content validity index (CVI). This study also invites four of them to answer the content of the test items in the assessment instrument. The scoring standard refers to Gunter and Alpat (2017) to build reliability among raters and make it a formal STEM knowledge concept test questionnaire.

There are 18 questions in the questionnaire, some of which are summarized as follows: Item 1 What is the relationship between vapour pressure and boiling point when brewing coffee in a Belgian pot? (A) Directly proportional (B) Inversely proportional (C) Exponential relationship (D) Uncorrelated. Please write the reason: ___ ́ Item 2, What is the scientific principle of the seesaw when brewing coffee in a Belgian pot? (A) Siphon phenomenon (B) Correlation (C) Thermal radiation (D) Ideal gas. Please write the reason: ___; Item 3, What is the scientific phenomenon of the Belgian pot brewing coffee? (A) Internal and external gravity (B) Internal and external mass (C) Internal and external volume (D) Internal and external pressure balance. Please write the reason: ___.

The initial draft of the test questions for the entrepreneurial scientific thinking scale corresponds to the design observation, new thinking, and innovation test questions of Schelfhout et al. (2016), Ahmad and Siew (2021), and Bung et al. (2009). This scale comprises five creative and value aspects and 15 open-ended test items. The first draft requested the six experts stated above to evaluate and revise the questionnaire content and logic and to exclude illogical items based on the updated opinions and suggestions following the expert triangular revision to confirm the content validity. Process the CVI value of this scale in the same way as the above questionnaire. Simultaneously, four experts filled out the scale test questions to build the inter-rater reliability, resulting in a formal test questionnaire for the entrepreneurial scientific thinking scale. The grading criteria for open-ended test questions depend on Ahmad and Siew (2021) and Ho et al. (2013) to understand students' entrepreneurial scientific thinking abilities.

There are 15 open-ended test items in the questionnaire on entrepreneurial scientific thinking, some of which are summarized as follows: Item 1, Explain that you have observed the advantages of using the Belgian siphon pot to brew coffee and the materials used: _______; Item 2, Explain that you can watch the design used for brewing coffee using a Belgian siphon pot: _______; Item 3, Explain that you can examine the rebreathing of coffee brewed in a Belgian siphon pot: _______.

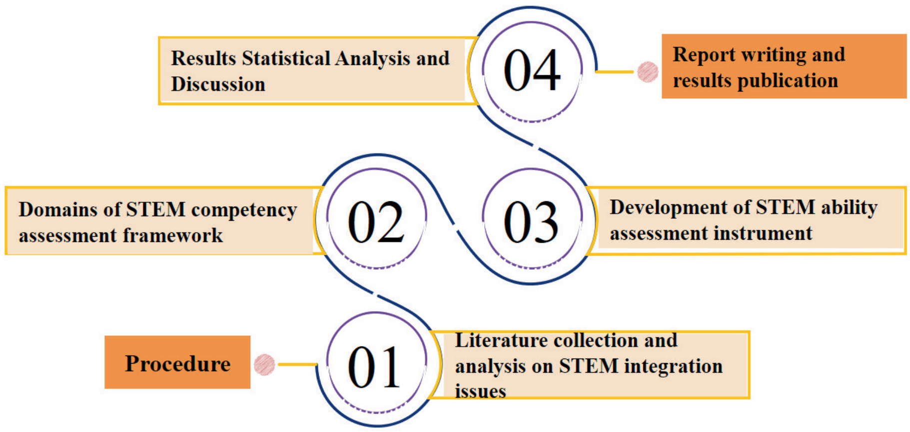
Research Procedures

The study approach consists of four steps: topic confirmation, assessment of STEM competence framework domains, development of STEM ability assessment instruments, and empirical research on the feasibility and effectiveness. Figure 1 depicts the four stages of the

https://doi.org/10.33225/jbse/24.23.151

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Figure 1
Flowchart of the Research Process



research process. In Figure 1, the initial step is to analyse STEM literature to identify research issues. The second stage is the domains of the STEM ability evaluation framework. Following that, create a STEM ability evaluation instrument. Furthermore, when the participants have understood the experiential learning environment, have them fill out the questionnaire. This research finished statistical analysis, identified supporting literature from the analysis findings, and then composed the results into a report and published it.

Data Analysis

A questionnaire is an instrument designed in this study to collect quantitative data. The STEM knowledge concept questionnaire and the entrepreneurial scientific thinking scale are two parts of the STEM ability assessment. The purpose is to use statistical methods such as descriptive statistics, harmony coefficient, and Chi-square fitness test to analyse the reliability, validity, and fitness of the STEM ability assessment questionnaire. Implement all statistical approaches to use SPSS for MS Windows version 25 statistics.

Research Results

STEM Ability Assessment Framework

The Royal Belgian siphon pot, created by the British shipbuilder James Napier (Bramah & Bramah, 1989), is utilized as the foundation for the context of science and technology education in this research. The image in Figure 2 shows a hand-painted schematic and its elements. Use

https://doi.org/10.33225/jbse/24.23.151

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Figure 2
The Royal Belgian Siphon Pot Hand Drawing and its Elements

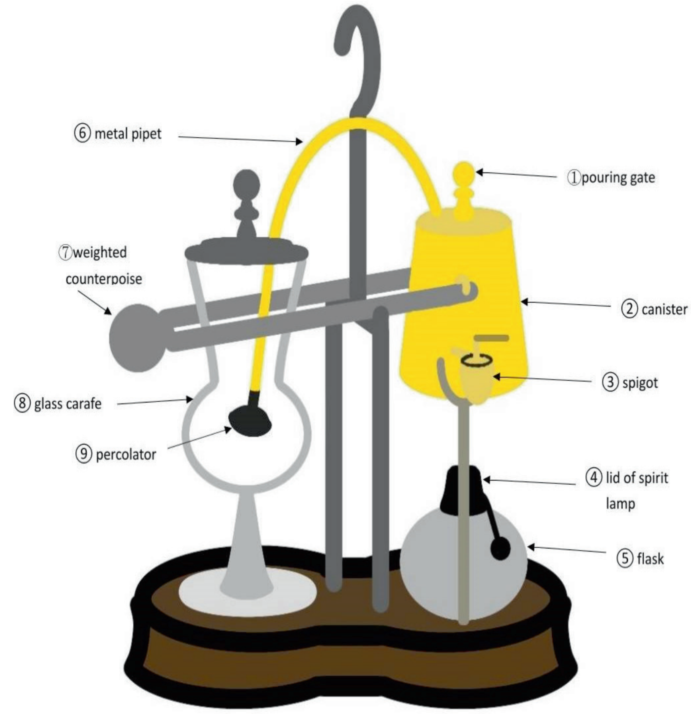
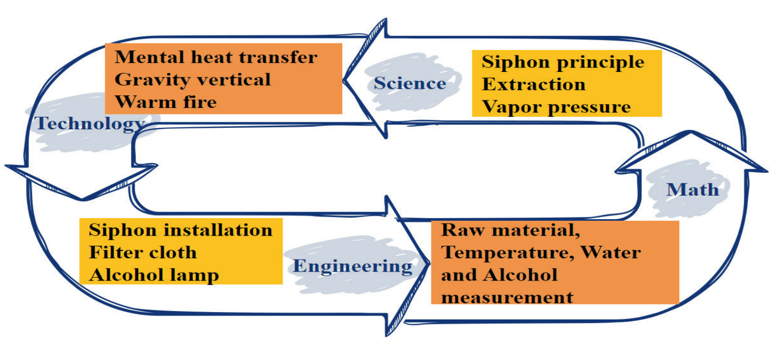


Figure 2 as an educational technology to construct a STEM course learning model with design thinking. Figure 3 depicts this STEM course learning approach and combines the functions of the siphon pot to design a learning mode for STEM courses with rich educational functions. It reveals the field of STEM ability assessment framework to construct learning domains in coffee preparation. It also includes the balance of the siphon principle, extraction, and vapour pressure used in the science implementation process. The technology ability assessment includes metal heat transfer, control of gravity balance, and warm fire. Next is engineering capability assessment, including siphon installation, filter cloth installation, and alcohol lamp installation design. Lastly is the mathematical ability assessment, including raw material weight, temperature, water volume, alcohol volume addition, etc. In other words, building the STEM ability assessment framework with the Royal Belgian siphon pot is around mathematics in coffee preparation. The content dimensions of the STEM ability assessment framework include and clarify each theme and related sub-dimensions of science, technology, engineering, and mathematics. This content framework is indicative of the diverse integration of STEM education.

Figure 3
Domain of STEM Ability Assessment Framework



https://doi.org/10.33225/jbse/24.23.151

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

The accuracy of an evaluation instrument represented its validity. The measured data is more accurate when reducing the error. Six experts conducted a substantial review and logical modification of the content and logic of the two questionnaires in this study. According to the opinions and suggestions of experts after triangular correction, modify or remove illogical items so that the two questionnaires meet the face validity of experts. Furthermore, experts accorded eight test items as score standards. Six experts scored the two questionnaires based on the eight items, and the descriptive statistics and average values after scoring are shown in Table 1.

Content validity and face validity of research instruments

Table 1 presents two expert content validity indices (CVI). They include the STEM knowledge concept questionnaire and the entrepreneurial scientific thinking scale. In the STEM knowledge concept questionnaire, the distribution of each item ranges from .8333 to 1.0000, and the CVI of the mean score (.9458) and standard deviation (.0485). In the entrepreneurial scientific thinking scale, the distribution of each item ranges from .8667 to 1.0000, and the CVI of the mean score (.9542) and standard deviation (.0557). Table 1 shows the mean CVI for both research instruments, with indices above .94.

Table 1
Expert Content Validity and Face Validity of Research Instruments

Code	Content	*M*	*SD*
QA	STEM knowledge concept questionnaire	.9458	0.0485
QB	Entrepreneurial scientific thinking scale	.9542	0.0557

Feasibility and Effectiveness of the STEM Practical Learning Environment

The feasibility of a practical learning environment for STEM teaching, this study invited four interdisciplinary professors to answer the test questions of the research instruments, STEM knowledge concept questionnaire, and entrepreneurial scientific thinking scale. To assess the inter-rater reliability of the study instrument, we utilized Kendall's consistency coefficient (ω) based on the results of the four experts, as shown in Table 2.

In Table 2, Kendall's coefficient of concordance, ω value of the STEM knowledge concept questionnaire is .718, reaching a significant level ($p < .001$). The other coefficient ω value of the entrepreneurial scientific thinking scale is .664, a significant level ($p < .001$). Therefore, the feasibility of the STEM teaching practice learning environment is also verified.

In addition, in terms of the effectiveness of the STEM teaching practice learning environment, the Chi-square test of the fitness of the STEM knowledge concept questionnaire ($\chi^2 = 34.469$, $p < .001$) showed a significant level; the Chi-square test of the fitness of the other entrepreneurial scientific thinking scale ($\chi^2 = 29.888$, $p < .001$) also showed same level, Table 2 showed the data. This Chi-square test of goodness-of-fit reveals that the research instrument is effective for students' knowledge concepts and entrepreneurial scientific thinking in the STEM practical learning environment.

To sum up the research results, the feasibility and effectiveness of the STEM practical learning environment, combined with brain thinking, hands-on and verbal debate, can help students develop mental models in STEM education and promote students to have a deeper concept and profound understanding of life science.

Table 2
Feasibility and Effectiveness of Two Research Instruments

Code	Content	ω	χ^2	p
QA	STEM knowledge concept questionnaire	.718	34.469	< .001
QB	Entrepreneurial scientific thinking scale	.664	29.888	< .001

https://doi.org/10.33225/jbse/24.23.151

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Discussion

Previous research (Könings et al., 2014) had shown that integrating student and teacher perspectives in experiential learning and designing for STEM environments could improve design quality. The dynamic domain of the STEM ability assessment framework included science, technology, engineering, and mathematics and integrated into coffee-making experiential activities in the Royal Belgian siphon pot. In the practical learning environments, the subdomains represented each main domain with the educational technology application. The learning environments consisted of the siphon principle, extraction, and the balance of vapour pressure to implement in life science. The siphon pot included metal heat transfer, control of gravity balance, and a warm fire to carry out in technology. Engineering comprised siphon installation, filter cloth installation, and alcohol lamp installation design to fulfill. Mathematics incorporated raw material weight, temperature, water volume, and alcohol volume in addition to putting it into effect. Bicer et al. (2017) also believed a STEM assessment model is necessary for students' STEM abilities.

This study uses the Belgian Royal Coffee Pot in coffee beverage preparation in a life science course to solve STEM education real-world problems, such as dietary issues, art to relieve stress, etc. With the incorporation of vapour, gravity, pressure, and fire, brewing coffee is not only a romantic situation but also a piece of art. Integrating these scientific principles into one, drinking coffee becomes a rational and emotional game. The learning in the course is full of the romantic sentiment of royalty, allowing students to feel the flip of the curriculum, which is different from traditional science course learning. In addition, apply the scientific principles of this equipment to STEM education in life science courses on hot beverages such as fruit tea, flower tea, hot matcha, hot milk tea, green tea, oolong tea, and black tea.

According to Saxton et al. (2014), the STEM ability assessment framework incorporates the multifaceted framework of STEM education by emphasizing higher-order thinking abilities in the cognitive component and STEM-related coffee-making experiential activities in educational technology. STEM stands for science, technology, engineering, and math integration. In other words, the STEM learning environment blends mathematical operations, engineering design, technology manipulation, and scientific cognition before using those concepts to solve STEM challenges. Through this study reported in the article, this research constructed the STEM ability assessment framework domain, as found in the study of Harwell et al. (2015), which will help the instrument development and verification of STEM ability assessment.

Content Validity and Face Validity of Research Instruments

Oluwatayo (2012) pointed out that face validity is the researcher's subjective comment on the presentation and relevance of the measurement instrument. That is, whether the items in the instrument appear relevant, reasonable, unambiguous, and distinct. Gelfand et al. (1975) stressed that face validity was the weakest validity form. Many people thought it was not the form of validity in the strictest sense. Therefore, Straub et al. (2004) proposed content validity as the degree to which items in an instrument reflect the content domain to which it will generalize (Taherdoost, 2016). Some researchers (Lewis et al., 1995; Boudreau et al., 2001) strongly recommend the application of content validity when developing new instruments. Content validity involves evaluating a new survey instrument to ensure it includes all necessary items and eliminates unrequired items in other structural fields. Accordingly, this study examined the content and face validity of research instruments and assured their quality and researchers' ability to obtain accurate data before using them in actual research.

This study used the expert CVI value and invited six experts to evaluate the above eight items of the second questionnaire as the expert's CVI value to establish content validity. In the STEM knowledge concept questionnaire, the CVI values of each item are above .8333, and the overall average is .9458; in the entrepreneurial scientific thinking scale, the distribution range of the CVI values of each item is above .8667, and the overall average is .9542. The CVI values of the two questionnaires are better than .78 in the literature (Polit et al., 2007) and better than the CVI value of the new instrument suggested by Davis (1992), which should be greater than .80.

To sum up, the CVI value of each item in the two questionnaires was better than the literature value. Therefore, the two questionnaires developed in this study had high content validity and face validity, which would help collection and improve the accuracy of the data in this study. Mäkelä et al. (2022) found that the involvement of experts increases the creation of STEM learning environments and skills assessment.

https://doi.org/10.33225/jbse/24.23.151

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Feasibility and Effectiveness of STEM Practical Learning Environment

This research uses Kendall's coefficient of concordance and the Chi-square test of goodness-of-fit as statistical approaches to examine the feasibility and effectiveness of evaluation in the STEM practical learning environment. However, two research instruments, the STEM knowledge concept questionnaire and the entrepreneurial scientific thinking scale in STEM competency assessment play a role in the decision of learning environment. The concordance coefficients of the two research instruments are all between .6 - .8, indicating that the reviewers have a better degree of consistency between the two STEM competency assessment instruments (Marozzi, 2014; Su, 2019). Ozkan and Topsakal's research (2021) pointed out that in learner-centred STEM education learning, the feasibility and effectiveness of the environment will help learners understand concepts and have a positive impact.

This research can further understand the degree of inter-rater consistency among the four raters from the value of the concordance coefficient, which belongs to the better level, and constructs the inter-rater reliability. In addition, based on the Chi-square test of goodness-of-fit, two research instruments of the STEM knowledge concept and the entrepreneurial scientific thinking scale are significant. This research instrument presented effective characteristics in the entrepreneurial scientific thinking of students in STEM education. To sum up, the feasibility and effectiveness of evaluation in the STEM practical learning environment mean that the two instruments are feasible and effective to use in the STEM ability assessment.

Value and Application of the Two Tools

In summary, this study applies the scientific principles of the Royal Belgian siphon pot to develop a summative STEM ability assessment tool, namely the STEM knowledge concept questionnaire and the entrepreneurship scientific thinking scale, to assess the learning effectiveness of students' STEM cognitive levels and entrepreneurial scientific thinking skills, respectively. The value and application of the two instruments are as follows:

According to Shulman (2009), assessment is a potent instrument for raising teaching effectiveness. Thus, STEM competencies may contribute to raising the standard of STEM instruction. In the light of Saxton et al. (2014), STEM skills that evaluate domain knowledge may also improve the calibre of learning. Based on this scientific education principle, this research developed two instruments for summative STEM ability assessment: the questionnaire of knowledge concept used Bloom's revised cognitive taxonomy (Anderson & Krathwohl, 2001) to conduct open-ended test question propositions and design. It assesses students' learning efficacy on six levels: memory, understanding, application, analysis, evaluation, and creation. In terms of the entrepreneurship scientific thinking scale, use an open-ended questionnaire to design five aspects of entrepreneurial scientific thinking ability. Such as observation, fresh ideas, innovation, creativity, and value are examples of such skills.

Scientific Education Principles and Insights

The Royal Belgian siphon pot integrates the scientific principles of vapour, gravity, pressure, and fire to construct a STEM learning environment as a teaching practice site. According to Harwell et al. (2015), a learning environment will enhance STEM experiential learning independence in the design and evaluation. Bicer et al. (2017) also believe that a STEM experiential learning environment and STEM abilities for students are necessary. Based on this research, develop summative STEM ability assessment instruments, a STEM knowledge concept questionnaire, and an entrepreneurial scientific thinking scale. The conducted research study by Enderson and Ritz (2016) highlights that the creation process of these two tools yielded valuable insights that will aid learners in their decision-making to future engagement with STEM-related careers. Applying entrepreneurial scientific thinking to STEM education might enhance students' comprehension of design and assess the worth of products (Eltanahy et al., 2020). Additionally, Ahmad and Siew (2021) thought that incorporating entrepreneurial scientific thinking into STEM education will assist in developing an aptitude for problem-solving, decision-making, innovation, and creativity to contribute to society in the future.

The STEM experiential learning at the Royal Belgian Siphon Pot enriches their visions and innovative value in the domain knowledge of life sciences. It improves their effective and meaningful scientific cognition in a STEM practical context. It is a unique highlight of this study for the above STEM studies.

https://doi.org/10.33225/jbse/24.23.151

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Conclusions and Implications

This research described the development process of the application of life science and educational technology in the STEM practical learning environments. Create their learning settings during this procedure with five Royal Belgian siphon pots as instructional equipment. The design thinking supported STEM experience learning environments and integrated the STEM ability assessment framework in the life science domain. Integrating student and teacher perspectives in experiential learning and designing for STEM environments could enhance design quality. The results evidenced that the framework would help the instrument development and verification of STEM ability assessment in this research.

Based on the analysis of the CVI values of content and face validity, a high degree of validation is helpful for data collection in this research. The two research instruments of this article revealed that the two designed questionnaire research variables are correct and accurate and have high index values in terms of academicism, systematisms, objectivity, logic, and rigour. A high content and face validity would improve the quality of a new instrument. The involvement of experts increases the creation of STEM learning environments and skills assessments. The results examined the content and face validity of research instruments and assured their quality and researchers' ability to obtain accurate data before using them in actual research.

This research used Kendall's coefficients of concordance (ω) of the results of the four reviewers to conduct inter-rater reliability. Based on the STEM assessment framework, they indicated that the four reviewers had reached a better level of consistency between the two STEM ability assessment instruments. In addition, based on the Chi-square test of goodness-of-fit, two research instruments of the STEM knowledge concept and the entrepreneurial scientific thinking scale are significant. The findings found that this STEM experience learning environment is feasible and effective and will help examine participants' STEM abilities. However, the feasibility and effectiveness of evaluation results in the STEM practical learning environment mean that the two instruments are feasible and effective in the STEM ability assessment. The present study uses the scientific principles of the Royal Belgian siphon pots to create two summative STEM ability evaluation instruments. Their importance and use may increase the standard for STEM instruction and teaching effectiveness.

On the top finding of that statement, the STEM knowledge concept and technological application of entrepreneurial scientific thinking in beverage preparation experience activities are rich in feasibility and effectiveness in the STEM ability assessment instruments development and evaluation framework. In other words, the Royal Belgian siphon pot integrates the scientific principles of vapour, gravity, pressure, and fire to construct a STEM learning environment in life science. Interdisciplinary learning will enrich learners' vision and innovative value. It will help enhance learners' feasibility and effectiveness and be meaningful for implementing the STEM practical learning environment.

Limitations and Future Research

This research highlights the role of educational technology in STEM practical learning environments. STEM practical learning enriches learners' vision and innovative value and helps enhance their feasibility and effectiveness. That is meaningful in the STEM learning environment of life science. Above research results, we found that the learning environment is feasible and effective and will help examine participants' STEM abilities. Therefore, according to the findings, the evaluation framework and STEM ability development tools are apparent when using the Royal Belgian siphon pot for making coffee. However, there are still some inference restrictions and suggestions on two aspects of teaching practice and follow-up research design to make the inference more cautious:

1. Suggestions on teaching practice
   The teaching practice suggests that STEM education should integrate into the field of life science and technology. Let this pot not only be used in coffee brewing courses but can also expand to other beverage brewing STEM courses, such as traditional tea brewing, scented tea brewing, and other life science curricula. Furthermore, the ease of use should increase in the operation and design of STEM practice learning environment. For example, to control and increase the extraction time until fully extracted to promote the taste, hoping to improve the learning efficiency of the experiencers.
2. Suggestions for follow-up research design
   In future research design suggestions, the number of samples and the number of siphon pots discussed in this study are limited. Therefore, if we want to make broader inferences, we must proceed with caution. We look forward to successfully increasing the number of effective samples and the number of

https://doi.org/10.33225/jbse/24.23.151

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

siphon pots in the future, enriching the STEM experience learning environment, and strengthening the depth and breadth of teaching practice to enhance learners' STEM abilities.

Acknowledgments

The author was grateful for the financial subsidy from the National Science and Technology Council in Taiwan (project No, MOST 111-2410-H-237 -001 -MY2), without this support, the research would not be possible. The author thanks the teachers and students of the department for their assistance and advice. Thank you for this.

Declaration of Interest

The author declare no competing interest.

References

Ahmad, J., & Siew, N. M. (2021). Development of a children's entrepreneurial science thinking test for STEM education. *Journal of Baltic Science Education, 20*(4), 528–545. https://doi.org/10.33225/jbse/21.20.528

Anderson, L. W., & Krathwohl, D. R. A. (2001). *Taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman.

Baran, E., Billici, S. C., Mesutoglu, C., & Ocak, C. (2016). Moving STEM beyond schools: students' perceptions about an out-of-school STEM education program. *International Journal of Education in Mathematics Science and Technology, 4*(1), 9–19. https://doi.org/10.18404/ijemst.71338

Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education, 12*(5/6), 23–36. https://go.exlibris.link/cMs2fmrk

Bicer, A., Capraro, R. M., & Capraro, M. M. (2017). Integrated STEM assessment model. *Eurasia Journal of Mathematics Science and Technology Education, 13*(7), 3959-3968. https://doi.org/10.12973/eurasia.2017.00766a

Boudreau, J. W., Boswell, W. R., & Judge, T. A. (2001). Effects of personality on executive career success in the United States and Europe. *Journal of Vocational Behavior, 58*(1), 53–81. https://doi.org/10.1006/jvbe.2000.1755

Bramah, E., & Bramah, J. (1989). *Coffee Makers: 300 Years of Art & Design*. Quiller.

Brown, R., Brown, J., Reardon, K., & Merrill, C. (2011). Understanding STEM: Current perceptions. *Technology and Engineering Teacher, 70*(6), 5–9.

Broggy, J., O'Reilly, J., & Erduran, S. (2017). *Interdisciplinary and science education.* In Akpan, B., & Taber, K. (Eds.), *Science Education. New directions in mathematics and science education* (pp. 81–90). Sense Publishers. https://doi.org/10.1007/978-94-6300-749-8_6

BSNP. (2016). *Instrumen penilaian buku teks pelajaran tahun 2016* [The instrument of a textbook assessment on 2016 teaching period]. Kemdikbud RI.

Buang, N. A., Halim, L., & Mohd Meerah, T. S. (2009). Understanding the thinking of scientists entrepreneurs: Implications for science education in Malaysia. *Journal of Turkish Science Education, 6*(2), 3–11.

Burton, L. J., & Mazerolle, S. M. (2011). Survey instrument validity Part I: Principles of survey instrument development and validity in Athletic training education research. Athletic *Training Education Journal, 6*(1), 27–35. https://doi.org/10.4085/1947-380X-6.1.27

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering* Teacher, *70*(1), 30–35.

Capraro, R. M., & Corlu, M. S. (2013). *Changing views on assessment for STEM project-based learning*. In Capraro, R. M., Capraro, M. M., & Morgan, J. (Eds.), STEM project-based learning: An integrated Science, Technology, Engineering, and Mathematics (STEM) approach (2nd ed., pp. 109–118). Sense Publishers. https://doi.org/10.1007/978-94-6209-143-6_12

Davis, L. L. (1992). Instrument review: Getting the most from a panel of experts. *Applied Nursing Research, 5*(4), 194–197. https://doi.org/10.1016/S0897-1897(05)80008-4

Dedeturk, A., Saylan Kirmizigul, A., & Kaya, H. (2021). The effects of STEM activities on 6th-grade students' conceptual development of sound. *Journal of Baltic Science Education, 20*(1), 21–37. https://doi.org/10.33225/jbse/21.20.021

Eltanahy, M., Forawi, S., & Mansour, N. (2020). Incorporating entrepreneurial practices into STEM education: Development of interdisciplinary E-STEM Model in high school in the United Arab Emirates. *Thinking Skills and Creativity, 37* (September), Article 100697. https://doi.org/10.1016/j.tsc.2020.100697

Enderson, M. C., & Ritz, J. (2016). STEM in general education: Does mathematics competence influence course selection. *The Journal of Technology Studies, 42*(1), 30-40. https://doi.org/10.21061/jots.v42i1.a.3

Gelfand, D. M., Hartmann, D. P., Cromer, C. C., Smith, C. L. & Page, B. C. (1975). The effects of instructional prompts and praise on children's donation rates. *Child Development, 46*(4), 980–983. https://doi.org/10.2307/1128408

Gunawan., S., & Shieh, C. J. (2020). Effects of the application of stem curriculum integration model to living technology teaching on business school students' learning effectiveness. *Contemporary Educational Technology, 12*(2), 1–7. https://doi.org/10.30935/cedtech/8583

Günter, T., & Alpat, S. K. (2017). The effects of problem-based learning (PBL) on the academic achievement of students studying "Electrochemistry". *Chemistry Education Research and Practice 18*, 78-98. https://doi.org/10.1039/C6RP00176A

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Han, S., Capraro, R., & Capraro, M. M. (2015). How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement. *International Journal of Science and Mathematics Education, 13*(5), 1089–1113. https://doi.org/10.1007/s10763-014-9526-0

Harwell, M., Moreno, M., Phillips, A., Guzey, S. S., Moore, T. J., & Roehrig, G. H. (2015). A study of STEM assessments in engineering, science, and mathematics for elementary and middle school students. *School Science and Mathematics, 115*(2), 66–74. https://doi.org/10.1111/ssm.12105

Ho, H.-C., Wang, C.-C., & Cheng, Y.-Y. (2013). Analysis of the scientific imagination process. *Thinking Skills and Creativity, 10* (December), 68-78. https://doi.org/10.1016/j.tsc.2013.04.003

Honey, M., Pearson, G., & Schweingruber, H. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research*. The National Academies Press.

Ing, M. (2014). Can parents influence children's mathematics achievement and persistence in STEM careers? *Journal of Career Development, 41*(2), 87–103. https://doi.org/10.1177/0894845313481672

Jang, H. (2016). Identifying 21st century STEM competencies using workplace data. *Journal of Science Education and Technology, 25*(2), 284–301. https://doi.org/10.1007/s10956-015-9593-1

Kelley, T. R., & Knowles, J. G. (2016). A Conceptual Framework for Integrated STEM Education. *International Journal of STEM Education, 3*(July), 11. https://doi.org/10.1186/s40594-016-0046-z

Kolb, D. A. (1984). *Experience as the source of learning and development.* Prentice Hall.

Könings, K. D., Seidel, T., Jeroen, J., & van Merriënboer, G. (2014). Participatory design of learning environments: Integrating perspectives of students, teachers, and designers. *Instructional Science, 42* (1), 1–9. http://www.jstor.org/stable/43575211

Lewis, B. R., Snyder, C. A., & Rainer, K. R. (1995). An empirical assessment of the information resources Management construct. *Journal of Management Information Systems, 12*(1), 199–223.

Loukomies, A., Pnevmatikos, D., Lavonen, J., Spyrtou, A., Byman, R., Kariotoglou, P., & Juuti, K. (2013). Promoting students' interest and motivation towards science learning: The role of personal needs and motivation orientations. *Research in Science Education, 43*(6), 2517–2539. https:// doi. org/10.1007/s11165- 013- 9370-1

Mäkelä, T, Fenyvesi, K., Kankaanranta, M., Pnevmatikos, D., & Christodoulou, P. (2022). Co-designing a pedagogical framework and principles for a hybrid STEM learning environment design. *Education Technology and Research Development, 70*, 1329–1357. https://doi.org/10.1007/s11423-022-10114-y

Marozzi, M. (2014). Testing for concordance between several criteria. *Journal of Statistical Computation and Simulation, 84*(9), 1843–1850. https://doi.org/10.1080/00949655.2013.766189

Mohtar, L. E., Halim, L., Rahman, N. A., Maat, S. M., Iksan, Z. H., & Osman, K. (2019). A model of interest in STEM careers among secondary school students. *Journal of* Baltic Science Education, *18*(3), 404-416. https:// doi. org/10.33225/jbse/19.18.404

Mizell, S., & Brown, S. (2016). The current status of STEM education research 2013-2015. *Journal of STEM Education, 17*(4), 52–56.

Milgram, R. J. (2007). *What is mathematical proficiency?* In Schoenfeld, A. H. (Ed.), Assessing mathematical proficiency (pp. 31–58). Cambridge University Press. https://doi.org/10.1017/ CBO9780511755378.007

Mullis, I. V., & Martin, M. O. (2017). *TIMSS 2019 Assessment Frameworks.* http://timssandpirls.bc.edu/timss2019/frameworks/

Moore, T. J., Tank, K. M., Glancy, A. W., & Kersten, J. A. (2015). NGSS and the landscape of engineering in K-12 state science standards. *Journal of Research in Science Teaching, 52*(3), 296–318. https://doi.org/10.1002/tea.21199

Oluwatayo, J. A. (2012). Assessment of computer literacy of secondary school teachers in Ekiti State, Nigeria. *Journal of International Education Research, 8*(2), 97–104. https://www.learntechlib.org/p/89448/

Ozkan, G., & Topsakal. U. U. (2021). Investigating the effectiveness of STEAM education on students' conceptual understanding of force and energy topics. *Research in Science & Technological Education, 39*(4), 441– 460. https://doi.org/10.1080/02635143.2020.1769586

Polit, D. F., Beck, C. T., and Owen, S. V. (2017). Is the CVI an acceptable indicator of content validity? Appraisal and recommendations. *Research in Nursing & Health, 30*(4), 459-467. https://doi.org/10.1002/nur.20199

Salmi, H., Thuneberg, H., Bogner, F. X., & Fenyvesi. K. (2021). Individual creativity and career choices of pre-teens in the context of a math-art learning event. *Open Education Studies, 3*(1), 147–156. https://doi.org/10.1515/edu-2020-0147

Saxton, E., Burns, R., Holveck, S., Kelley, S., Prince, D., Rigelman, N., & Skinner, E. A. (2014). A common measurement system for K-12 STEM education: Adopting an educational evaluation methodology that elevates theoretical foundations and systems thinking. *Studies in Educational Evaluation, 40*(March), 18–35. https://doi.org/10.1016/j.stueduc.2013.11.005

Schelfhout, W., Bruggeman, K., & De Mayer, S. (2016). Evaluation of entrepreneurial competence through scaled behavioral indicators: Validation of an instrument. *Studies in Educational Evaluation, 51*(December), 29–41. https://doi.org/10.1016/j.stueduc.2016.09.001

Shulman, L. (2009). *Assessment of teaching or assessment for teaching?* In Gitomer, D. H. (Ed.), Measurement issues and assessment for teaching quality. Sage Publications.

Straub, D., Boudreau, M., & Gefen, D. (2004). Validation guidelines for IS positivist research. *Communications of the Association for Information Systems, 13*. https://doi.org/10.17705/1CAIS.01324

Struyf, A., De Loof, H., Boeve-de Pauw, J., & Van Petegem, P. (2019). Students' engagement in different STEM learning environments: Integrated STEM education as promising practice? *International Journal of Science Education, 41*(10), 1387–1407. https://doi.org/10.1080/09500693.2019.1607983

Su, K. D. (2019). A feasible guidance for ordered multiple-choice items in students' hierarchical understanding levels. *Journal of Baltic Science Education*, *18*(1), 77–89. https://doi.org/10.33225/jbse/19.18.77

Taherdoost, H. (2016). Validity and reliability of the research instrument; How to test the validation of a questionnaire/survey in a research. *International Journal of Academic Research in Management, 5*(3), 28–36. http://dx.doi.org/10.2139/ssrn.3205040

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Tsai, H., Chung, C., & Lou, S. (2018). Construction and development of iSTEM learning model. *Eurasia Journal of Mathematics, Science and Technology Education, 14*(1), 15–32. https://doi.org/10.12973/ejmste/78019

Tsai, L. T., Chang, C. C., & Cheng, H. T. (2021). Effect of a stem-oriented course on students' marine science motivation, interest, and achievements. *Journal of Baltic Science Education, 20*(1), 134–145. https://doi.org/10.33225/jbse/21.20.134

Tsupros, N., Kohler, R., & Hallinen, J. (2009). *STEM education: a project to identify the missing components.* Intermediate Unit 1: Center for STEM Education and Leonard Gelfand Center for Service Learning and Outreach, Carnegie Mellon University, Pennsylvania.

Wahono, B., & Chang, C.-Y. (2019). Assessing teacher's attitude, knowledge, and application (AKA) on STEM: An effort to foster the sustainable development of STEM education. *Sustainability, 11*(4), 950. https://doi.org/10.3390/su11040950

White, D. W. (2014). What is STEM education and why is it important? *Florida Association of Teacher Educators Journal, 1*(14), 1–9. http://www.fate1.org/journals/2014/white.pdf

York, S., Lavi, R., Dori, Y. J., & Orgill, M. K. (2019). Applications of systems thinking in STEM education. *Journal of Chemical Education, 96*(12), 2742–2751. https://doi.org/10.1021/acs.jchemed.9b00261

Received: *November 19, 2023* Revised: *December 25, 2023* Accepted: *January 30, 2024*

Cite as: Su, K.-D. (2024). The feasibility and effectiveness of life science in STEM practical learning environment. *Journal of Baltic Science Education*, *23*(1), 151–163. https://doi.org/10.33225/jbse/24.23.151

King-Dow Su PhD, Professor, Department of Hospitality Management and Center for General Education, Hungkuo Delin University of Technology; NO.1, Lane 380, Ching-Yun Road, Tu-Cheng District., New Taipei City, Taiwan 23646, & Center for General Education, Chung Yuan Christian University, 200 Chung Pei Road, Chung Li District, Taoyuan City, Taiwan 32023.
E-mail: su-87168@mail.hdut.edu.tw
ORCID: https://orcid.org/0000-0001-5248-5589

https://doi.org/10.33225/jbse/24.23.151