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JOURNAL OF BALTIC SCIENCE EDUCATION

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

THE EFFECTS OF CROSS-DISCIPLINARY LIFE SCIENCE INNOVATION IMPLEMENTED BY STUDENTS' STIMULATED STRATEGIES FOR PBL-STEM SELF-EFFICACY

King-Dow Su

Abstract. *This research used mixed effects to construct a PBL-STEM (problem-based learning with STEM) questionnaire with high validity and reliability. The benefits of PBL-STEM focused on cross-disciplinary and longitudinal research to analyze students' self-efficacy in life science. All 175 university students who attended this course as an elective participated in this research. The purpose was to evaluate students' performance in the cake-baking practice experiential course and to use unpaired samples t-test, one-way ANOVA, and feedback analysis as quantitative and qualitative data. The following are noteworthy results: The t-test showed that five stimulated scales were significantly different and better after the cake-baking PBL-STEM activity. In one-way ANOVA, to engage with more students in STEM activities, improve conceptual learning, and close achievement gaps. The more enthusiastic students are, the more actively they study and think, and the more effectively they improve their PBL-STEM learning. Students' feedback analysis of this teaching activity is beneficial for improving technology, student-teacher engagement, process comprehension, and learning interest. The light of this research will foster a disposition of learning, enhance cake-baking skills, and encourage problem-solving based on their thinking.*

Keywords: *cross-disciplinary, life science, PBL-STEM, self-efficacy*

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Introduction

The concept of cross-disciplinary STEM education through curriculum integration originated from an initiative of the US government. Recently, increased STEM (Science, Technology, Engineering, and Mathematics) education and value have received attention on a global scale (Honey et al., 2014; Ng & Fergusson, 2019). STEM education is a cross-disciplinary integrated educational field that blends rigorous academic principles with real-world curriculum, according to Tsupros et al. (2009). It would encourage students to apply their understanding of science, technology, engineering, and mathematics to the connections between school, community, employment, and business. There was widespread agreement on the definition's shift from disciplinary to cross-disciplinary applicability (Mizell & Brown, 2016; Moore & Smith, 2014; Vasquez et al., 2013). Researchers (English & Gainsburg, 2016; Marginson et al., 2013) held that STEM education in the twenty-first century places a heavy emphasis on abilities such as topic knowledge and the process of inquiry problem-solving, systemic, logical, and critical thinking, creativity, and innovation. Therefore, in the face of life science and technology in the educational environment of the new era, STEM is an educational strategy worthy of promotion.

STEM is a research field in education that applies and incorporates science-related concepts, strategies, and procedures into students' everyday tasks and abilities. The purpose is to give students hands-on cross-disciplinary cooperative learning, systematic thinking, open communication, and ethical values through knowing and experiencing the world. STEM education is an integrated, multidisciplinary model of higher-order thinking that emphasizes problem-solving, communication, and ethical principles (Tsai et al., 2018; York et al., 2019). According to academic research (Alan et al., 2019), STEM education is an essential and significant cross-disciplinary subject for students that integrates several fields. Although disciplines can provide better products, integrating four disciplines is difficult. Therefore, promoting learning throughout the STEM practice process is meant. Students increase self-efficacy and develop a comprehensive understanding and appreciation of how content, skills, and mindsets interact to ensure continued interest in

https://doi.org/10.33225/jbse/22.21.1069

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

learning. They integrate STEM learning experiences, apply technology and scientific reasoning to challenges, and relate what they have learned to real-world experiences (Honey et al., 2014; Mohtar et al., 2019).

According to Christensen et al. (2014), teachers must use successful methodologies to link STEM education and future employment by integrating classroom learning with real-world experiences. Although STEM offers a variety of opportunities and contributions, its significance is recognized by academics and businesses both domestically and worldwide. The purpose and goals of education are unclear, there are still many challenges to be addressed in the integration, and there are many other possible issues in STEM, according to Williams et al. (2015). There is currently a lack of research on effective STEM communication and instructional design. ElSayary (2020) and Hallinger (2020) found that when using pedagogies, such as inquiry-based teaching, problem-based learning (PBL), and project-based learning, to active STEM education. Technology and a combination of content philosophies are presented in STEM education to help students modify their thinking and adapt to various interests.

PBL-STEM Education Enhances Learning

Researchers (Cedillo, 2018; Grangeat et al., 2021; Kim et al., 2018; Schmid & Bogner, 2017) found that the connected PBL-STEM teaching paradigm consisted of student-centered STEM education principles and inquiry-based creative teaching. According to some experts, choosing STEM instruction that is problem- or project-based learning can enhance their creativity (Lou et al., 2017; Siew et al., 2015). PBL emphasizes real-world problem-solving and context-designed STEM cross-disciplinary learning, allowing students to experience the authenticity of learning problems through hands-on experiences and then find the answer to the problem from new knowledge (English et al., 2017). This approach also helps students become excellent or expert problem solvers (Çalışkan et al., 2010; Gerace & Beatty, 2005).

PBL-STEM education can increase students' interest and learning effectiveness, continuing the description from above. The social implications and background knowledge of STEM practical skills will aid students in connecting with pertinent knowledge domains and navigating contemporary society. The purpose is to examine advanced technology integration challenges, consider modern citizens, and have the appropriate PBL-STEM education integration strategies when faced with technology conflicts and decision-making. In light of this, the research aims to integrate their practical abilities in creative cake-baking courses with PBL-STEM activities. Cross-disciplinary learning generates a new innovative literacy, fosters interest in hands-on learning, and improves technology through example learning and active interaction, thereby enhancing external performance. In other words, we combine STEM learning cognition with the practical experience of learning by doing and trigger learning interest through the PBL process. The learning impact of PBL-STEM self-efficacy stimulated strategies in the cake-baking course can be investigated in the future.

PBL-STEM Self-Efficacy Motivating Strategy Practice

Burwell-Woo et al. (2015) found an approach that encouraged students to think out two structures for STEM work projects. The first is to increase knowledge and enthusiasm in STEM fields, and the second is to raise students' self-efficacy. According to academic descriptions of self-efficacy (Burwell-Woo et al., 2015; Rittmayer & Beier, 2008), a person's confidence in their learning is determined by how well they perform a specific task. Rittmayer and Beier's (2008) research proposed students who have high self-confidence in their ability to perform scientific tasks independently, and who would be motivated to take on the assigned difficulties and work toward the end objective. In summary, STEM self-efficacy is better equipped to believe in their performance and reach their learning objectives earlier. As a result, the capacity to engage in tasks is related to students' STEM self-efficacy and interest (Lent et al., 2018; Rittmayer & Beier, 2008). Researchers Dökme et al. (2022) and Patrick et al. (2016) examined their findings and discovered that learners' self-efficacy influences whether or not they sustain crucial factors in the STEM area. PBL-STEM is a hands-on experiential activity, according to academics (Dökme et al., 2022; Kassaee & Rowell, 2016; Sahin et al., 2014; Sahin et al., 2017; Tsai et al., 2018; York et al., 2019). Student self-efficacy in STEM instruction is crucial to hands-on operation, which is the key to the learner's task's success.

The involvement of students in practical activities may inspire them to pursue more specialized STEM career sectors (Dökme et al., 2022; Russell et al., 2007). Theoretically, doing it is based on Kolb's experiential learning (1984) and Dewey's learning by doing (1933). Li et al. (2019) indicated that experiential learning could evidence feedback, provide thinking opportunities, solve problem skills, and construct self-efficacy. ElSayary (2021) drew attention

https://doi.org/10.33225/jbse/22.21.1069

that the PBL-STEM teaching by doing is frequently required in creative curricula, and experiential learning can apply to real-world contexts. Students combine practical knowledge with effective experience fostering learners' curiosity and self-assurance, incorporating creativity, design, and product testing, and enhancing their learning motivation (Appianing & Van Eck, 2018; Irvine, 2018; Dökme et al., 2022). Through trial-and-error experience learning, students can promote their understanding of the value of creative thinking, problem-solving techniques, and group collaborative learning (Shieh & Chang, 2014). Sahin et al. (2017) discovered that STEM majors were more excellent in science and math learning effectiveness than non-majors. Furthermore, Mohtar et al. (2019) also found that students' STEM self-efficacy influenced their interest in the subject.

To summarize, applying the PBL-STEM self-efficacy stimulated strategy as an evaluation tool in this research to incorporate into the STEM system of the students' creative cake-making course in life science throughout the practice exercise, the impact on college students' abilities to understand STEM subjects and discuss the best ways to raise students' self-efficacy.

Research Purpose and Questions

The purpose of this study was to use mixed effects to construct a PBL-STEM questionnaire with high validity and reliability for self-efficacy for motivated strategies, to use the tool through cross-disciplinary experiential learning and longitudinal studies to examine students' practice effectiveness. They have changed my role models demonstrating beneficial interactions, practical experience, technology advancement, and external efficacy. The research intends to respond to the following questions:

1. How might a life science course material be developed to support students' cross-disciplinary cake-making learning?
2. What is the reliability and validity of the instrument for evaluating students' self-efficacy for stimulation strategies?
3. How can students examine and justify variations between their pretest and posttest knowledge of PBL-STEM self-efficacy for stimulation strategies?
4. How do students' gender, age, and disposition affect their use of PBL-STEM self-efficacy for stimulated strategies?
5. What comments have you received from students who have learned the PBL-STEM self-efficacy for stimulation strategy?

Research Methodology

General Background

The research investigated how to teach PBL-STEM learning methodologies to university students at Hungkuo Delin University of Technology (HDUT) during the 2021–2022 academic year. A PBL-STEM blended plane included quantitative and qualitative methods to help students comprehend life science research concerns (Alan et al., 2019; Creswell et al., 2007). The contribution of this research encouraged STEM role model learning, hands-on practice, advanced technology, and stimulating their external effectiveness in class. Most students showed that the learning effects of PBL-STEM techniques mirrored learning goals in life science. The practice activity of cake-baking enhanced their self-efficacy by using PBL-STEM education in three classes.

Participants and Ethical Requirements

Participants in the cake-baking teaching site's three classes in HDUT, which educated college students from Grades 13 to 19, served as the basis for quantitative and qualitative research. As a representative sample of Taiwanese university students, all 175 university students who attended this PBL-STEM cake-making course as an elective participated after passing two qualification exams in this research. In the first year, 70 students conducted the pilot test to engage in research for the PBL-STEM education developments at the initial stage. The participants ranged in age from 18 to 22 and included 51 males and 19 females. The second stage of this hands-on research used PBL-STEM self-efficacy stimulated methodologies, and 105 more individuals (38 males and 67 females) with strong cognitive practice skills were the research sample. Students participated in practical cooperative learning and

https://doi.org/10.33225/jbse/22.21.1069

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

discussion with a group size of 4-5 in the Department of Hospitality Management's professional baking classroom.

Students informed consent for the acceptance of the experimental procedures in this research complied with all ethical requirements (Su, 2022). Five experts, including one professor of science education, two professors of technical communication, and two professors of STEM education, took part in this research. In order to create the experts' surface and content validity, they logically edited and reviewed the understandability of the PBL-STEM self-efficacy for stimulated strategies questionnaire draft and their applicability to the participant level.

Designing of PBL-STEM Activity

This study created PBL-STEM learning tools using the ADDIE teaching paradigm (Su, 2011). Analyzing, designing, developing, implementing, and evaluating were all phases of the approach. For integrating the PBL-STEM textbook into life science, the analysis process involved the relevant field literature, prior experience, expert interviews, student interviews, and media reports. In the designing step, assess, examine, and create the S, T, E, and M corresponding to the STEM activity unit based on the knowledge content compiled for the PBL-STEM cake-baking module. Corresponding to research question 1, Table 1 indicates the STEM knowledge analysis assessment for the cake-baking implementation curriculum.

This research is primarily quantitative in the development stage, with some qualitative components. This research creates PBL-STEM cake-baking module textbooks to educate students and increase their learning effectiveness in PBL-STEM self-efficacy for stimulated strategies. They engage in innovative courses to include machine operating and material handling techniques in lessons through practical teaching activities. To construct the PBL-STEM

Table 1
STEM Knowledge Analysis Assessment for the Cake-Baking Implementation Curriculum

Subject	S	T	E	M
Cake-baking Hands-on	Batter Fermentation, Cocoa powder Formula stirring (Flour, Water, oil, Sugar, Salt, baking soda), Energy	Time Control, Temperature control, Water volume control, Oven-baked, Finished product, use and familiarize with other functions	Design of egg whites (foaming, wet foaming and dry foaming state)	Raw material weight, Cardinality, and other calculation

Teaching activities, to help students develop their capacity, and to combine theory and practice:

(1) To conduct the experimental research paradigm with the idea that it shouldn't interfere with regular instruction. All 24 experimental discussion groups (4-5 persons each) formed to discuss issues. Create a research model for the cross-disciplinary PBL-STEM integration of instructional activities involving cake-baking, as illustrated in Table 2. Conduct tests and labels by VT and questionnaire tests before and after the teaching activity, submitting to the experimental treatment of PBL-STEM cross-disciplinary integrated cake-baking teaching activities by ET.

Table 2
The Research Model of PBL-STEM Cross-Disciplinary Integration Cake-Baking Teaching Activity

Group	Pre-test	Experimental treatment	Post-test	Questionnaire	Feedback
E_1-E_{24}	VT_1	ET	VT_2	VT_3	VT_4

(2) The construction of the STEM self-efficacy stimulated strategy questionnaire and the tool for measuring learning efficacy. The initial part of the questionnaire includes general information about the respondent, such as gender, age, and disposition toward taking baking lessons. The assessment test items make up the second section and help students discover how to increase the effectiveness of their learning.

(3) In the experimental procedures, this research conducted a cross-disciplinary PBL-STEM teaching experi-

https://doi.org/10.33225/jbse/22.21.1069

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

ment to use cake-making during the second semester of the 2021 academic year. There were 300-minute classes overall, held twice a week for three weeks. The pre-test and teaching activities for PBL-STEM during the research period took place in the second semester of the 2021 academic year (from March to May 2022). After the hands-on, the administration of a post-test was conducted using the assessment tool. Students' free online feedback was received because the Covid-19 pandemic interfered with the last stages of the activity. The PBL-STEM textbook design, use, learning, and opinions regarding instruction were all part of the feedback content. All feedback acted as the basis of the evaluation for qualitative analysis of educational activities.

Instrument Development

The first draft of the questionnaire referenced the thinking from Çalışkan et al. (2010), Chan (2022), and Patrick (2016) for the construction of research tools, according to the 5-point Likert scale compiled into a STEM self-efficacy stimulation strategy questionnaire with 30 test items. Five specialists looked over and changed the initial manuscript. The expert's triangular correction recommendations led to the deletion of one exam question, which was illogical. The expert verification's content and face validity had a mean score of 95.0% and a standard variation of 8.5%, yielding a CVI (Content Verification Index) value of .950. It surpasses the highly regarded expert CVI value of .78 (Polit et al., 2017), which is a score that experts highly recommend. All 70 students will test the questionnaire on November 30, 2021. After gathering the data from the pilot study, it was subjected to internal consistency checks and exploratory factor analysis, and one question was deleted with a subpar Cronbach's α value.

All experts conducted appropriate reviews and corrections of the content for the questionnaire, such as the subscale content and teaching method. Following statistical analysis, the information was combined into a formal exam question and developed into an acceptable questionnaire, totaling 28 items with five different aspects. The website was https://forms.gle/nnWCmAVV9KwgdetF7. The five subscales of the questionnaire were listed as follows: A1, use of positive role models; A2, positive interaction implementation; A3, practical application; A4, technical adequacy; and A5, external performance. Table 3 displays the descriptive statistical findings for the five aspects. The total questionnaire had an average Cronbach's alpha of .939 and a degree of internal consistency reliability above the ideal level accepted by specialists (Salta & Tzougraki, 2004; Su, 2018).

Due to the COVID-19 epidemic's effects, this research provided online feedback to participants freely. Feedback on the design, application, learning environment, difficulties encountered during practice, and general opinions on teachers' teaching appeared in the feedback content for the PBL-STEM textbook. These comments acted as the evaluation basis for the qualitative analysis of teaching experiments to promote further understanding. After the instructional activities, organized the learning input students as qualitative research materials. This research invited five experts to undertake a substantive analysis of the material in this feedback test to construct expert content validity. There were a total of three feedback questions.

Table 3
Descriptive Statistical Analysis of Student Self-Efficacy Strategies in STEM Questionnaire

Score	Dependent		Variable			Total
	A1	A2	A3	A4	A5	
M	4.114	4.123	3.486	3.733	2.603	3.625
SD	.626	.624	.614	.566	.846	.747
Cronbach's α	.960	.952	.608	.902	.863	.939

Research Procedures

The research designed PBL-STEM cake-making teaching activities to describe the implementation stage in the ADDIE system. This research study used the same teacher to teach the same material for as many hours as possible in the control variables to minimize the interference of experiments. Additionally, because all assessment

https://doi.org/10.33225/jbse/22.21.1069

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

methods were uniform, it was possible to regulate factors like instructional qualities, working hours, and teacher assessment methods. Teachers used group practice activities to guide the PBL-STEM cross-disciplinary cake-baking motivating strategy. After the instructional activities, this research used a post-test administration as an assessment tool. Students' background characteristics, such as gender, age, and disposition for cake-baking classes, acted as independent variables. Teachers examined students' pre-test questions from the assessment tool before the PBL-STEM cross-disciplinary integration cake-baking teaching activity. The results of the pre-test questions were the total variable in the covariant.

Data Analysis

In the evaluation stage, all data gathered anonymously by the students in each group before and after the PBL-STEM cross-disciplinary integration cake-baking teaching activity were sorted by computer and coded in English to comply with ethical standards (Taber, 2014). The Cronbach's α test questionnaire with internal consistency reliability, *t*-test, and one-way ANOVA acted as statistical techniques. SPSS for MS Windows 25.0 software was employed. In Cronbach's α, the internal consistency reliability of each scale was tested using Cronbach's α, the basis on which the STEM self-efficacy for motivated strategies evaluation tool was produced in this research.

In *t*-tests, conduct *t*-tests before and after PBL-STEM teaching sessions using the STEM self-efficacy for stimulation strategies, any significant differences are identified and talked about.

In one-way ANOVA, this research uses the gender, age, and disposition for cake-baking courses of students with various backgrounds as independent variables to explore effect factors in PBL-STEM strategies. Students should use five subscales as their dependent variables for a one-way ANOVA, analyze the results and provide feedback on the independent and dependent variables.

Research Results

PBL-STEM Cake-Baking Practical Experience Teaching Material

Knowledge and action framework of baking education was used (Miller, 1990) to build the learning objectives of the PBL-STEM cake-baking experience in this research, in order to create curriculum teaching resources that aided in the cross-disciplinary practice learning of cake baking. This PBL-STEM instructional material was based on Ausubel's theory (1968, 2000) to construct a real cake-baking practical experience. The outline from the practical experience textbook of PBL-STEM cake baking was as follows:

Science discipline: From scientific content knowledge such as fermentation, Caramelization, Maillard reaction, etc., to help students explore the functional changes of materials and product structures in the baking process.

Technology discipline: During this exploration process, use related technological equipment to help students construct literate on temperature control, stirring time, process control, oven baking temperature, etc.

Engineering discipline: Develop engineering designs that guide students to explore the effects of protein foaming stages and whipping levels on products.

Mathematics discipline: Apply mathematics information guides for students to explore content such as material measurement, milk, and juice concentration configuration, etc.

Thus, teachers serve as facilitators and mentors in the PBL-STEM cake-baking curriculum as the foundation for the design of the instructional materials. The PBL teaching process model (Su, 2022) was used to direct students in group interaction learning so that they encountered the cake-baking problem. The cake-baking practice included a problem-solving plan, self-learning, and data collecting. Therefore, they tried to establish problem-solving consensus and proposed solutions from group discussions to finish the experience task of cake-making by fundamental concept in life science.

In class displays, the photographs taken by the actual students while they participated in the PBL-STEM cake-baking activity are shown in Appendix 1.

https://doi.org/10.33225/jbse/22.21.1069

T-test of PBL-STEM Learning Effectiveness

In response to research question 3, in the context of PBL-STEM cake-baking experience learning, based on students' self-efficacy, stimulated strategies were developed. What is the difference in learning results? This project conducted 90 valid samples (recovered rate, 85.7%) pre-test and post-test and performed a *t*-test before and after PBL-STEM teaching activities by the PBL-STEM self-efficacy stimulated strategy questionnaire. When the Levene test *F* value of the variance equation does not reach significance (aspects A1, A2, and A4), an independent samples *t*-test indicated equal variance. However, when the *F* value is significant (A3 and A5), an independent sample test revealed equal variance. Table 4 displays the employment of mean scores (*M*) and standard deviations (*SD*) offer a meaningful instrument to assess students' self-efficacy for stimulated strategies in PBL-STEM. The post-test outperformed the pre-test and in every measure was substantially different ($p < .05$) according to the findings of an independent sample *t*-test conducted by pre-test and post-test of the questionnaire.

Table 4
Students' t-test in PBL-STEM Self-Efficacy for Stimulated Strategies Questionnaire

Subscale	Pre-test		Post-test		*t*	*p*
	M	*SD*	*M*	*SD*		
Role model learning	4.17	.66	4.37	.68	-2.036	.043*
Positive interactions	4.11	.68	4.37	.70	-2.514	.013*
Hands-on practices	3.66	.62	4.05	.82	-3.624	<.001***
Technical refinement	3.81	.59	4.14	.68	-3.430	.001**
External performance	3.11	.83	3.68	1.09	-3.978	.000***

Note: *, $p<.05$; **, $p<.01$; ***, $p<.001$

One-way ANOVA

In response to research question 4, the PBL-STEM self-efficacy stimulated strategy produced significantly different learning outcomes for students in the context of PBL-STEM learning background on the post-test. Therefore, this research used one-way ANOVA to examine impacting elements for three independent variables, including gender, age, and disposition of cake-baking experience courses.

Table 5 displays the findings of the one-way ANOVA of the PBL-STEM self-efficacy for stimulated strategy. The variance analysis of the independent variable gender and the five dependent variables in Table 5 shows no significance between males and females. Cohen's (1988) effect size (*f*) is small or less. Furthermore, the analysis between the independent variable age and the five dependent variables revealed no significant difference among the ages of 16-18, 19-21, and 22-24. Thus, Cohen's effect sizes (*f*) are small to medium. Lastly, the variance analysis between the five dependent variables and independent variable disposition of the cake-baking experience course presents four dependent variable (A1, A2, A3, and A4) significances. Three sub-variables, including very positive, positive, and neutral, are included in the independent variable. Cohen's effect sizes (*f*) were also above big (>.4). The four dependent variables all demonstrated that very positive is preferable to positive and preferable to neutral in a further Scheffé post-hoc analysis. Furthermore, the three dependent variables A1, A2, and A4 demonstrate that the positive is preferable to the neutral. Depending on the experimental effect, dependent variable A5, there is no significant change, and small to medium effect sizes (*f*).

https://doi.org/10.33225/jbse/22.21.1069

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

Table 5
One-way ANOVA of PBL-STEM Self-Efficacy for Stimulated Strategies (N=90)

Locking Variable	Analysis of Variance	Efficacy				Measure
		A1	A2	A3	A4	A5
Gender	*F*-ratio	.003	.199	1.436	.077	1.297
1. Males, 33	*p*-value	.956	.657	.234	.783	.258
2. Females, 57	f	.l05	.095	.071	.100	.055
Age						
1. 16-18, 38	*F*-ratio	.274	.341	.357	.656	2.040
2. 19-21, 48 3. 22-24, 4	*p*-value	.761	.712	.701	.521	.136
	f	.l32	.123	.123	.090	.153
Disposition	*F*-ratio	89.309	66.145	37.353	23.662	1.636
1. Very positive, 41	*p*-value	.000	.000	.000	.000	.201
2. Positive, 37	f	1.409	1.210	.526	.908	.119
3. Neutral, 12	Scheffé	1>2; 1>3	1>2; 1>3	1>2; 1>3	1>2; 1>3	
		2>3	2>3		2>3	

Students' Feedback Analysis

This research represented students' learning feedback (the code names are S1, S2, …) in the PBL-STEM self-efficacy stimulated strategy in response to study question 5. The overall analysis of the three items was as follows. The analysis of the three items was as follows.

Question 1, Using PBL-STEM cake-baking technology course teaching, does the teaching material design help you understand baking technology? Please give an example.

S1: The course design allowed me to recognize and learn different techniques, such as cake-making.
S2: The integrated PBL-STEM education enhanced a profound understanding of my learning in the practice process. Such as the kneading force of the dough.
S3: The PBL-STEM baking technology course could promote interaction between teachers and students. They made me want to ask questions and understand the solution to problems. Such as temperature control during the roasting process in technical tasks. The process would promote detailed knowledge of baking production.

Question 2, Does the PBL-STEM problem-solving approach help you apply it in your cake -baking technology course? Please give an example.

S4: I think the PBL-STEM problem-solving approach is helpful for me to solve the problems in the baking technology course, such as the fermentation time in the dough, because it will indirectly affect the softness and elasticity of the product.
S5: This PBL-STEM problem-solving approach applying mathematical operation skills in the process, helped me improve the success rate of cake baking and increase my confidence in STEM education.
S6: This PBL-STEM problem-solving approach allows me to experience the production of baked products at home and share the products with my family.

https://doi.org/10.33225/jbse/22.21.1069

Question 3, What is your overall evaluation and feeling about the PBL-STEM cake-baking technology course? Please give an example.

S7: I think it is good to participate in the PBL-STEM cake-baking technology course. It allows me to learn cross-disciplinary knowledge. The method is different from the traditional teaching method. Under the PBL-STEM education, I find the cake-baking learning to rich content diverse, broaden my vision, and promote my learning value in life science.

S8: I love learning by participating in the PBL-STEM cake-baking technology course, which has produced three -movement learning for me. It includes the mobile learning process of the course experience, the interaction learning between teachers and students, and the impresses learning for students in problem-solving.

S9: Using the PBL-STEM cake-baking technology course to enhance my skills, such as making dough and mixing cake batter.

Discussion

This research gave teachers a sense of how student demand for instructional resources was moving in terms of construction theory. To construct the learning objectives of the self-efficacy for stimulated strategy into the PBL-STEM cake-baking teaching materials in line with the demands of the students. As mentioned by academics (Kim et al., 2018; Schmid & Bogner, 2017), the PBL-STEM teaching approach was related to inquiry-oriented teaching. It involved practical experience learning. It focused on the experiential learning process to change teaching strategies into behavioral theory and moved away from cognitive and constructivist models of instruction toward STEM education (Cedillo, 2018). Knowledge is just the start of a top-notch learning process. You must put our knowledge to use if you wish to learn. Curriculum and teaching came together to form learning. PBL-STEM textbooks that are engaging and practical can arouse students' curiosity about what they are learning (Chan, 2022). Use the PBL framework to execute STEM experiences and construct this textbook. Teaching can help students learn meaningfully and solve problems (Mundilarto, 2018; Su, 2022).

T-test for the PBL-STEM Self-Efficacy for Stimulated Strategy

The *t*-test results of the pre-test and post-test for the experience practical teaching activity of cake-baking were presented using the PBL-STEM self-efficacy for stimulated strategy. The A1 (role model learning), A2 (implementing positive interactions), A3 (hands-on practices), A4 (technical refining), and A5 (external performance) aspects of the PBL-STEM self-efficacy stimulated strategy all showed significant differences. They demonstrated that students' five stimulated scales were significantly different and better after the cake-baking PBL-STEM activity.

In role model learning, there is a noticeable improvement in the learning effect from before the activity. Gladstone and Cimpian (2021) noted that STEM role models can inspire students to take a significant step toward a diverse STEM field and that student exposure to role models is a successful strategy for achieving diversity. Thus, according to Dökme et al. (2022), role models in STEM fields inspire students' curiosity about the subject matter. In light of Margot and Kettler (2019), teachers' perspectives on effectiveness and their emphasis on STEM education may influence students' motivation to enroll in and apply for STEM courses. In the STEM self-efficacy for stimulated strategies of this research, the arguments of scholars reaffirm the significance of providing STEM role model learning, with STEM teachers successfully influencing their positive role models.

Positive STEM educator viewpoints will influence classroom teaching strategies and contribute to learner perceptions by modeling interactions. Researchers (Aslam et al., 2018; Watermayer & Montgomery, 2018) discovered that teachers serve as the primary gatekeepers for the implementation of STEM in many countries worldwide (Carpenter & Lubinski, 1990; Relich et al., 1994; Shahali et al., 2015). As a result, the STEM self-efficacy for stimulated strategies, demonstrating positive interaction between teachers and students, highlighting the scholars' arguments, and reaching a substantial difference called out the learning effect was better than before the activity.

In hands-on practice, Kassaee and Rowell (2016) noted that STEM is a hands-on experience in the process of practice operation. It is about practice experience in life science. PBL-STEM self-efficacy stimulated strategies are crucial to learners' practice activities during the learning process. In addition, Aeschlimann et al. (2016) described this method as offering students a good education and individualized support knowledge about STEM education. Students' motivation to learn may also influence their decision to pursue careers in STEM fields. As a result, the

https://doi.org/10.33225/jbse/22.21.1069

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

learning effect after the practical experience activity is better than before. The difference is substantial in STEM self-efficacy for stimulated strategies.

In technical refining, Chang et al. (2017) called for the advanced development of STEM technology, which is indeed related to the psychological level of learners with technical refinement. This evidence supports the findings of this research that the PBL-STEM cake-baking experience practical teaching activities have a substantial impact on significant variations between the pre-test and post-test of their STEM self-efficacy for stimulated strategies.

In terms of external performance, the post-test results of the PBL-STEM cake-baking experiential activities in terms of external efficacy are better than those of the pre-test, and there is a discernible improvement. Shahali et al. (2015) pointed out that STEM educator attitudes influence learners, making students feel pressure to finish and do well on learning activities and making them want to give up when they haven't. They also find practical STEM cake-baking technology courses, which are simpler to understand and similar to Kassaee & Rowell's (2016) research, echoing the claim that STEM education belongs to real-world experience.

In keeping with the description above, this research discovered that five STEM self-efficacy strategies for stimulating the environment were significant when students undertook the PBL-STEM cake-baking experience. All five strategies indicated excellent and notable improvement before the activity. Thus, the findings of this research also confirmed the researchers' claims.

Analysis of one-way ANOVA

The results of a one-way ANOVA revealed that there was no significant difference between gender and age in the PBL-STEM self-efficacy stimulated strategies, but there was a difference in disposition. Chan's research (2022) confirmed that enriched STEM curriculum design could close the gender gap in STEM education. Zhao and Perez Felkner's research (2022) found that they have strong aspirations for STEM careers and may be better able to close the gender gap in post-secondary STEM education. Scholars (Kogan & Laursen, 2014; Laursen et al., 2014; Theobald et al., 2020) have noted that engaging in STEM activities with more students can improve conceptual learning and decrease achievement gaps. The cross-disciplinary PBL-STEM cake-baking practical activities make no significant difference between gender and age in this research, as indicated by scholars. According to the author's research (Su, 2022), actively participating in information understanding is out of a disposition for the subject, which can enhance academic performance.

Affected by the initiative, Shahali et al. (2015) also thought that it improved students' disposition toward STEM fields and enhanced higher-order thinking abilities. In keeping with the previous reasoning, it could present a considerable contrast between the PBL-STEM cake experience course and the student's disposition toward it.

Students Feedback

When teaching life science courses in cake-baking technology, PBL-STEM self-efficacy for stimulated strategies is beneficial, according to an examination of student feedback. Most students think that all tactics promote process comprehension, teacher-student engagement, and technical advancement. The cake-baking technology integrates PBL-STEM self-efficacy for stimulated strategies to solve problems. Most students are satisfied with the product success rate, assisting their families in simplifying complex issues and enhancing technical abilities, improving their confidence in practice, and developing a passion for their future profession.

In their overall assessment and perception of the PBL-STEM cake-baking practice education, they believe that the cross-disciplinary learning of PBL-STEM, broadening horizons and enhancing values, is distinct from traditional teaching. Some students believe that the PBL-STEM cake-baking technology course makes learning more enjoyable because of the three-motion learning of mobile, interaction, and mobility. Most students think that this motivational strategy, as stated by academics (Aeschlimann et al., 2016; Kassaee & Rowell, 2016; Shahali et al., 2015), has advantageous effects on learning.

Conclusions and Implications

This research created educational materials that meet students' learning for PBL-STEM cake-baking practical activities. The purpose was to report on participating *t*-test and one-way ANOVA results, evaluating how the PBL-STEM self-efficacy for stimulated strategies affected their learning. The study discovered that the outcomes of the

https://doi.org/10.33225/jbse/22.21.1069

immersive, hands-on PBL-STEM teaching activities led to the following seven conclusions:

First, the results of this research help plan potential PBL-STEM education follow-up studies in the future. Second, the experience of PBL-STEM textbooks encourages problem-solving through essential engaging, hands-on activities that arouse the curiosity of most students about what they are studying. Third, this research increased students' enthusiasm for learning about careers and their capacity for comprehension, problem-solving, self-efficacy, and group cooperation. STEM teachers use students' thinking to improve learning outcomes and help them develop their teaching expertise. Fourthly, this

research implements PBL-STEM self-efficacy for stimulated strategies, such as role model learning, encouraging engagement, hands-on practice, technical advancement, and external effectiveness. Role models are instruments for helping learners practice diversification, and STEM teachers have a beneficial role in students' choosing future work in the STEM area by modeling their technological proficiency and initiative. Therefore, STEM self-efficacy for stimulated strategies is critical.

Fifth, this research prospectively enhances their learning effectiveness in PBL-STEM. Students' attitudes, peer-to-peer message interpretation, collaborative discussion, self-reflection, learning motivation, conceptual learning, understanding of the effectiveness of PBL-STEM learning, development of higher-order thinking skills, and academic performance are all influenced by teachers' positive attitudes in life science. Sixth, the diverse PBL-STEM cake-baking experience-based curriculum planning and students' aspirations for STEM can close the gender gap, in order to engage with more students in STEM activities, improve conceptual learning, and close achievement gaps. The more enthusiastic students are, the more actively they study and think, and the more effectively they improve their PBL-STEM learning. Seventh, using the PBL-STEM cake-baking experience-based curriculum, students' feedback analysis of this teaching activity is beneficial for improving technology, student-teacher engagement, process comprehension, and learning interest.

Use of technology to aid problem-solving and foster students' appreciation, enthusiasm, and confidence for this subject, additionally motivates students to explore STEM education in terms of their future job, as most students are mobile, interaction, and mobility by three-movement learners throughout total evaluation and feeling. Thus, this research will foster a love of learning, enhance cake-baking abilities, and encourage problem-solving based on their thinking.

The challenges or impediments encountered in carrying out the research process and how to overcome them are described in the dilemma as follows:

Firstly, during the experimental teaching process, students' preconceived notions about the scientific subject and the amount of time invested in the STEM practice are experienced in cake-baking. It is necessary to resolve this problem through careful time management and STEM curriculum design. Secondly, because of the short amount of class time, it cannot develop in-depth PBL-STEM cake-baking skills. Exercise requires additional time to acquire this literacy. To help students make career decisions, short-, medium- and long-term career planning is essential. Thirdly, some students think PBL-STEM has weak problem-solving abilities and will combine animations with emerging technologies to improve their motivation to learn in the future.

In other words, overcoming the challenges or impediments faced throughout the implementation phase is crucial to ensuring the sustainable viability of future courses. In implication, since PBL-STEM is a new curricular integration in the department, future teaching trials will address a change in the demographic restrictions, such as gender, age, and disposition for the course. Additionally, we proposed that if the PBL-STEM education can be expanded to samples in the future, such as cross-school and cross-departmental research, the choice will enhance the accuracy.

Acknowledgement

The author would like to thank the Ministry of Science Education for funding their study in Taiwan (under Grant No. MOST 110-2511-H-237-001). And thanks to Prof. Hsih-Yueh Chen for her help on teaching and questionnaire.

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Appendix 1

Photos Excerpt from the PBL-STEM Cake-Baking Experience Learning in Class

(1) Group collaboration

(2) Discussion and problem-solving

(3) Baking in the oven

Received: *August 18, 2022* Revised: *October 17, 2022* Accepted: *November 26, 2022*

Cite as: Su, K.-D. (2022). The effects of cross-disciplinary life science innovation implemented by students' stimulated strategies for PBL-STEM self-efficacy. *Journal of Baltic Science Education*, *21*(6), 1069-1082. https://doi.org/10.33225/jbse/22.21.1069

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