ISSN: 2821-9163 (Online)

International Journal of Science Education and Teaching

IJSET Vol.3 No. 2
(May. - August. 2024)

International Journal of Science Education and Teaching
Vol. 3, No. 2 (May – August 2024)

ABOUT IJSET

International Journal of Science Education and Teaching (IJSET) is supported by Science Education Association (Thailand) or SEAT. IJSET seeks articles addressing issues including science education, physics education, chemistry education, biology education, technology education, STEM education, science teacher education, early childhood science education, science curriculum and instruction, and other related science educational fields.

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Publication Frequency
The IJSET provides an academic platform for work in the fields of interdisciplinary education. The IJSET publishes 3 issues annually. These include:

- Issue 1 (January - April)
- Issue 2 (May - August)
- Issue 3 (September - December)

Issue: IJSET Vol. 3 No. 2 (May – August 2024)
Publication Date: August 30, 2024
Publisher: Science Education Association (Thailand)

IJSET EDITORIAL TEAM

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Vol. 3, No. 2, pp. 51 - 66, May. – Aug. 2024
http://doi.org/10.14456/ijset.2024.5

Development of Virtual Exchange-Learning Management System Platform Combined with Challenge-Based Learning on the Topic of Education Leadership and Disruption in the Digital Era

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Received: 7 June 2024 Revised: 16 August 2024 Accepted: 19 August 2024

Abstract. The objectives of this research were to 1) design and create, test, use and evaluate a Virtual Exchange (VE) - Learning Management System (LMS) platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era; and 2) propose a VE-LMS platform combined with challenge-based learning management platform developed. This research is research and development. The sample group consisted of 34 graduate students in the master of education program at Rajamangala University of Technology Rattanakosin in the academic year 2024. The target group is ten experts in ICT systems and educational innovations. The research method consisted of four steps: 1) analysis of user requirement, 2) system design and development, 3) usability testing and evaluation, and 4) improving system performance. Quantitative data analysis by using statistical packages to show mean and standard deviation. The qualitative data analysis was used content analysis. The research results were as follows: 1) VE-LMS platform developed uses a DBLC development process. Experimenting with the operational system for graduate learning involves learning alongside digital technology with a simple implementation. Students have a highest level of satisfaction with the platform that is evolving, and 2) This system has a structure that consists of a website, lecturer and student database, knowledge record and exchange, knowledge assessment, discussion board, download documents, related case studies, pictures and videos demonstration of various activities. In addition, the platform will provide students with practical skills in learning Education Leadership and Disruption in the Digital Era. In addition, the platform equips graduate students with practical skills to learn about education leadership in order to improve the quality of education management to be efficient and effective.

Keywords: Virtual Exchange, Learning Management System, Challenge-Based Learning, Digital Era

INTRODUCTION

The Era of Digital Education, Information and Communication Technology or ICT system for education and its implementation to enhance the capacity of education management and the development of teaching and learning management is extremely important for educational institutions at all levels in the midst of the current education disruption (Phakamach, 2023). The Ministry of Higher Education, Science, Research and Innovation met the importance of an ICT in Education by encouraging the use of ICT to develop and apply in order to enable learners to learn and develop to a higher level of knowledge. This is in line with the government's policy according to the 20-year national strategy 2017-2036, and under the ICT Master Plan 3 (ICT Master Plan 3) Higher Education Act B.E. and more educational platforms due to the global connection of information, it is a new avenue for education. People use this main road as a path to intellectual treasures and to develop new learning styles (Lyapina et al., 2019; Phakamach, Senarith, & Wachirawongpaisarn, 2022). Therefore, the Ministry has established policies and standards to encourage educational institutions and agencies to implement the policy to promote the development of ICT for education by providing teachers. Educational personnel and learners have developed the ability to use educational platforms to benefit teaching and learning. Educational institutions at all levels need to have an ICT management system for educational innovation development as a standard system for improving the quality of education at all levels (Panjarattanakorn & Phakamach, 2020; Phakamach, Panjarattanakorn, & Onsampant, 2024).

Teaching in the era of transformational change or under an education disruption has a variety of teaching and learning management models that are used to promote and solve educational management problems in various fields, especially in the situation of the epidemic of Coronavirus (Ismaili, 2021). Teaching and learning management must align with the new learning paradigm. This enables learners to be able to seek knowledge on their own. This is specially true of the ability to fully use innovation and educational technology in pursuing knowledge. Virtual Exchange (VE) is a team "used to refer to the engagement of groups of learners in online intercultural interactions and collaboration project with the partner from other cultural contexts or geographical locations as an integrated part of their educational programmes" (O'Dowd, 2021; Gioiosa & Kinkela, 2022; Evian, Moore, & Hawkridge, 2023). While VEs allow students to interact from a distance and work actively with peers. Challenge-Based Learning (CBL) is a pedagogical approach that engages learners by challenging "challenges" defined as situations or activities that are defined through prompt perception and action. There is competition with oneself to achieve this in a realistic situation that has self-relevance (Nichols, Cator, & Torres, 2016; Inkaew & Napapongs, 2020). Key principles of challenge-based learning are built on the need to stimulate curiosity while creating opportunities for learners to discuss and encourage action. This type of learning provides context for realism by defining challenges and allowing students to take action on their own or help them learn within a group in order to achieve academic outcomes that benefit themselves and their workgroup. In addition, the process of challenge-based learning starts with Big Idea, Essential Question, The Challenge, Guiding Question, Guiding Activities, Guiding Resources, Solution, Action and Assessment (Manaarah Education Development, 2023; Nguyen, Gijlers, & Pisoni, 2023). Therefore, if the challenge-based learning management process is considered for graduate students' teaching and learning, it will also affect the quality of education appropriately.

Education Leadership and Disruption in the Digital Era is a core course in the Master of Education program at the Rajamangala University of Technology Rattanakosin; many institutes provide teaching and learning at the graduate level and are compulsory courses for modern educational administrators. This is because it aims to develop education administrators in the digital era to have high performance for the management of

educational institutions in both Thai and international educational contexts to be of high quality and towards internationalization (Phakamach, Wachirawongpaisarn, & Panjarattanakorn, 2021). Most of the learning takes place in a regular classroom, creating severe obstacles to student learning if there is no good source of support for the use of modern management techniques and operating systems to build an educational platform. It is worthwhile considering using learning materials on web applications, a teaching and learning process management system that connects learners with teachers and learners with learners. It provides digital learning materials and teaching materials with instructors acting as trainers (Adele, Ellinger, McWhorter, & Egan, 2023) and are inspirers by designing experiential proactivity activities that correspond to the course content (Huang & Lai, 2020), which is a self-paced learning model that supports knowledge management in a given course, helping to solve problems and obstacles that arise in students' learning. In particular, graduate teaching and learning focus on creating learning challenges in order to create new knowledge to appear with quality.

Based on this idea, the researcher is interested in developing a virtual exchange learning management system (VE-LMS) platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and applications for graduate learner. This system will change the learning process by using the learning management system platform to support teaching and learning activities. To be a complete learning organization, this design and development present educational innovations with specific dimensions: 1) electronic learning media; 2) a knowledge management support system, i.e., knowledge repository and exchange, knowledge record, chat board, and a knowledge assessment form; 3) a database of teachers and students as well as academic services; 4) online electronic bulletin boards to exchange learning; and 5) linkage with universities (e-MIS). The education platform will be a model of a learning management system using software and services. as well as assessing the efficiency and satisfaction of the learners. Performance improvements are based on expert feedback. The platform is ideal for serving graduate students. It can be used to respond to student needs and effectively engage in learning about leadership in educational disruption situations.

RESEARCH OBJECTIVES

The study had two research objectives were as follows:

1. To design, create, test, use and evaluate a virtual exchange-learning management system (VE-LMS) platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era.

2. To propose a virtual exchange-learning management system (VE-LMS) platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era.

RESEARCH CONCEPTUAL FRAMEWORK

Research concepts can be formulated from the literature review and related research process design. The goal is to create a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era, as shown in Figure 1.

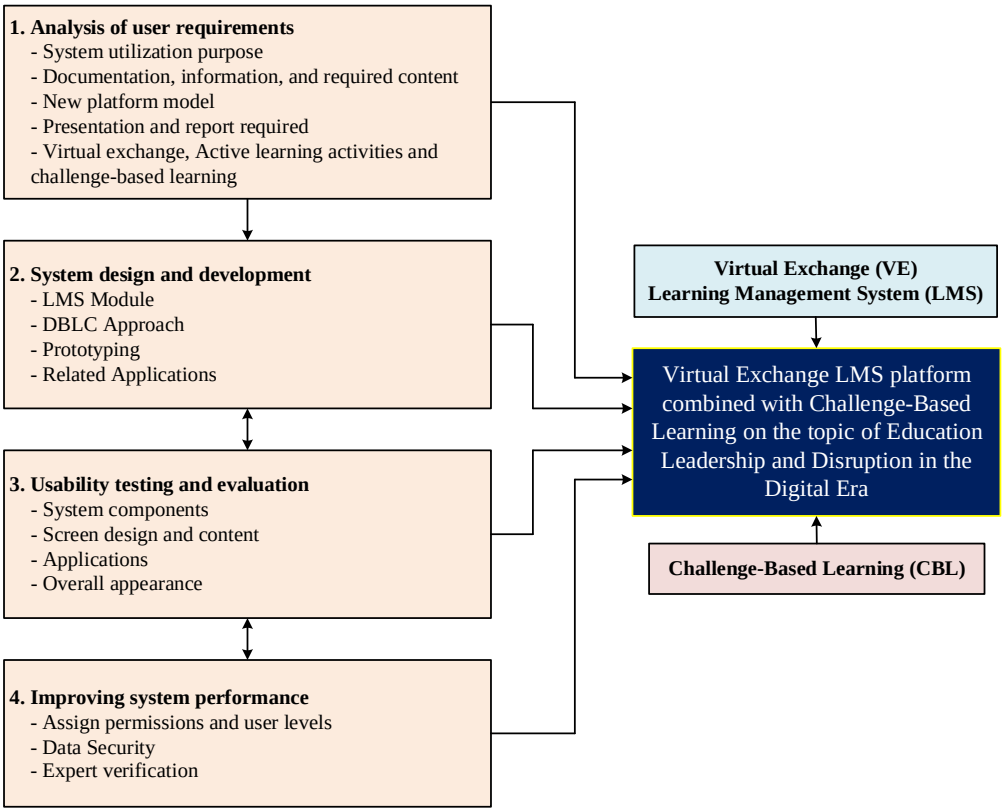

Figure 1: Research Conceptual Framework

METHODOLOGY

This research includes research and development with related details as follows:

Population and Sample

The population used in this research were graduate learners of the Master of Education program, Department of Education Administration and Strategies, Rattanakosin International College of Creative Entrepreneurship, Rajamangala University of Technology Rattanakosin, Enrolled in Education Leadership and Disruption in the Digital Era (EAS 6102) in the first semester of the academic year 2024, there are 34 students because the total study population is small and requires data based on the opinions of all learners. Therefore, the panel used a method of selecting the entire population by defining it as a sample. The target group would be 10 experts in ICT systems and educational innovation.

Research Instruments

The research tools consisted of (1) a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and (2) the tools used for data collection were:

(1) Quality assessment form (for experts) in ICT systems and educational innovations is a 5-level rating scale that assesses the efficiency of the system in terms of system components, design and development, as well as usability.

(2) The student satisfaction assessment form is a 5-level rating scale that assesses the suitability of the system in terms of system components, screen design and content, as well as usability and attitude.

(3) Structured interview form for interviewing students' use of the system on issues of (1) knowledge exchange and implementation, (2) behavior and response, (3) participation, (4) results of use, and (5) problems and suggestions.

Procedures for Conducting Research

This research is research and development. The research method consisted of four steps:

(1) Analysis of user requirements, which is the study and analysis of user needs for both faculty and students. This establishes the necessary requirements for building a learning management system promotes solving current challenges through a five-step learning process. Starting from 1) Big Idea, 2) Essential Question, 3) The Challenge, 4) Solution and Taking Act, and 5) Assessment, etc.

(2) System design and development, by using learning management system and programs related to the development of online teaching materials. This entails designing a case study related to the course, including a preliminary test.

The process of creating tools used in teaching and learning management includes: 1) Studying the curriculum/course and analyzing the content of the Education Leadership and Disruption in the Digital Era (EAS 6102) course at the graduate level; 2) Defining the learning objectives to determine the scope of content in each unit including challenging learning activities accordingly; 3) Determine the format for presenting content by collaborating academic seminars and virtual exchange in accordance with the learning management approach that promotes the solution of challenging problems in 5 steps. Start with (i) Big Idea, (ii) Essential Question, (iii) The Challenge, (iv) Solution and Taking Act, and (v) Assessment, etc.; 4) Write a flowchart of the learning management platform to define internal communication channels for convenience; 5) Design the storyboard according to a hierarchical structure based on proactive knowledge management techniques and exchanges; 6) Develop the platform layout using LMS tool box and related computer programs; 7) Conduct trial to revise the platform; and 8) Evaluate the quality and satisfaction of the platform.

(3) Usability testing and evaluation, platform quality and suitability checks by 10 experts in ICT systems and educational innovation. This is a 3-month trial phase, and satisfaction is tested by students enrolled in the EAS 6102 course.

(4) Improving system performance, by taking the test and evaluation results obtained from Step 3 for confirmation and improving the performance of the VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era.

Experiment and Data Collection

The experimental model and the data collection were set as follows:

The preparation of the experiment includes:

(1) ask for permission for the data collection and test the system by collecting data and testing the system in the first semester of the academic year 2024.

(2) prepare the developed VE-LMS platform and put it on the LMS Learning Center, send the data to the server, and test its use.

(3) prepare the location and the computer, and schedule the experiment by testing the operating system in the content of educational platform development.

Experiment:

Take a platform that has been evaluated by an expert and test it for performance evaluation according to the following format.

One to One Testing: an experiment with three students who have taken this course before selected on the basis of high, medium and low grades based on their average grades in the past semester. Using a simple random sampling method, test the system to find defects and then use it to improve and fix it with the value $E_1/E_2 = 61.24/62.36$

Small Group: Testing Experiment with nine students who have taken this course before by selecting students with high, medium and low grades based on the average of the course

scores in the past semester as criteria. Using a simple random sampling method, test the system to find bugs and use them to improve E_1/E_2 = 71.56/72.64

Field testing, including:

(1) Bring the system to students for a one-month workshop experiment by selecting a sample group of 34 students and organizing a pretesting knowledge meeting. The meeting is carried out in the following order: (1) Pretest by having students test from the achievement test of 40 items, (2) let learners study by using a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era for the graduate learner, (3) allow learners to do exercises from the system ten items per learning unit, and (4) then post-test by having learners test from the achievement test of 40 items and evaluate the overall efficiency of E_1/E_2 with a value of E_1/E_2 = 81.79/ 83.27

(2) Interview a sample group of students, who use it regularly about their use.

(3) Analyze the results of the interview summarized in an essay manner and improve the system to be suitable and complete.

Data Analysis

The data obtained in the research process were analyzed in the following order:

1) Analysis of user requirements: summarized in an essay to illustrate the details that consist of (a) the purpose of using the system, (b) the required documents, information and content, (c) the format of the new system, (d) presentation and required report (e) the activities of Challenge-Based Learning, and (f) practical activities.

2) System design and development: by ten experts in ICT systems and innovations for education administration, summarized in an essay format to illustrate the details, which consist of (a) LMS Module, (b) DBLC Approach, (c) Prototyping, and (d) related applications.

3) Usability testing and evaluation: Assessment of the efficiency of the platform by experts and based on the satisfaction by 34 students using a 5-level rating scale.

The research at this stage will apply the process in steps 1 and 2 by assessing the effectiveness and satisfaction of use. The information in step 2 can adjust the process as appropriate. There is a practical test. as well as study according to the prescribed format in order to obtain a system that is suitable for VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era for graduate learner.

The study population at this stage can be divided into two groups as follows:

Group 1: the target group is 10 experts in ICT and educational innovations.

Group 2: the sample group consisted of 34 students in Education Leadership and Disruption in the Digital Era (EAS 6102) course at Department of Education Administration and Strategies, Rattanakosin International College of Creative Entrepreneurship, Rajamangala University of Technology Rattanakosin.

The tool used to collect the data is an unstructured interview form to test its effectiveness. Problems and obstacles, as well as corrective guidelines. Data collection can be divided according to the study population as follows:

Group 1: workshops and interviews,

Group 2: was a workshop facilitation and participant observation. The questionnaire consisted of checklist questions, Text form and a 5-level rating scale, with the questionnaire having three parts with details as follows:

Part 1: Information about the respondents.

Part 2: Opinions on using a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era. Will be an analysis to determine the efficiency and satisfaction of the system's users.

The criteria for using the score measurement are as follows:

Strongly Agree; the weight was scored as 5.
Agree; the weight was scored as 4.
Neutral; the weight was scored as 3.
Disagree; the weight was scored as 2.
Strongly Disagree; the weight was scored as 1.

Part 3: Suggestions and guidelines for developing a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era.

Creation and verification of the questionnaire tools draft will be submitted to experts to verify content validity and the appropriateness of language and wording. Then the next step is to test the reliability of the questionnaire using Cronbach's Alpha Coefficient formula. The reliability of the whole questionnaire was .967.

The data were then analyzed by statistical methods using a ready-made computer program. to find the efficiency and satisfaction of using a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application for graduate learner and present a statistical model for assessing efficiency and user satisfaction as follows:

Data analysis of group 1:

Bring the data to analyze and synthesize in order to find ways to improve and develop the system. Also, recommend the correct usage according to the prescribed format so that users can use it effectively.

Data analysis of group 2:

Part 1: Information that is the status of the respondents analyzed by frequency distribution and percentage.

Part 2: Information about opinions on using a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application for graduate learner. It is approximate scale data and is analyzed by calculating the mean and standard deviation.

Part 3: Information on recommendations and guidelines for developing a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application for graduate learner, which is text-based information. Use content analysis to obtain recommendations and development guidelines.

The mean was obtained from the estimation scale questionnaire data from the data analysis in group 2 and was compared with the criteria.

The criteria for interpreting the mean, in summary, are as follows:

4.21 – 5.00 means efficiency and satisfaction are at the highest level.
3.41 – 4.20 means efficiency and satisfaction are at a high level.
2.61 – 3.40 mean efficiency and satisfaction are moderate.
1.81 – 2.60 means that efficiency and satisfaction are at a low level.
1.00 – 1.80 means that efficiency and satisfaction are at the lowest level.

where the spectral range is determined by the formula = (5-1)/5 = 0.8

4) Improving system performance:

The research at this stage will apply the results of the 3rd step to improve a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application for graduate learners. Next, conduct interviews with five experts in ICT systems and educational innovations using a non-structured interview, focused interview method verification for opinions and suggestions. Then apply the examination results to improve the system's performance and complete the learning requirements according to the teacher's council of Thailand course criteria.

RESULTS

Developing a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era. The results of the research were as follows:

Research results according to objective 1

Design and create, test, use and evaluate a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era. The findings can be listed as follows:

Results of Analysis user requirements

1) The results of analysis of user requirements in order to use data to design and build a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era. Users have commented on their needs in critical areas, including: (a) it must be a system that can be used to support teaching and learning in a given course; (b) the system must support the process of teaching and learning with complete support functions; (c) the system should provide operating parts consistent with the course content; (d) the system should have relevant practical learning and case studies to enhance knowledge and understanding; and (e) the system designed and create must be able to operate according to the schedule designated classes.

2) Guidelines for developing a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and recommendations. One should study the information related to academic Education Leadership and Disruption in the Digital Era before teaching management. Then, the system development method should be chosen according to the standard model. DBLC has the proper research and development process to achieve an operational learning system combined with case study learning on Entrepreneurship and Ventures in Education. That responds to the complete knowledge management model in the course.

Results of System design and development

System design and development will use the DBLC standard method to make the system efficient. The key steps are (1) System Analysis, (2) System Design, (3) System Implementation, (4) System Installation, (5) System Operation and Evaluation, and (6) System Maintenance and Evolution, resulting in a learning management system for the course.

Results of Usability testing and evaluation

The results of the test and trial of a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era with students enrolled in Education Leadership and Disruption in the Digital Era (EAS 6102) course in the first semester of the academic year 2024 by quality assessment by experts and the satisfaction assessment by students showed the following:

1) The results of evaluating the effectiveness of a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application to graduate learner based on the opinions of 10 experts, as shown in Table 1.

Table 1, shows system performance evaluation by experts in three areas: system components, screen design and content, and usability. It was found that the system's overall quality was at a high level in all aspects ($\bar{x}$=4.15, S.D.=0.55). When considering each aspect, it was found that as for the components of the system, 7 items, the overall picture was at a high level ($\bar{x}$=4.11), arranged in order of averages from highest to lowest in 3 sequences: 1) website, 2) discussion board, and 3) learning activities, respectively, with the highest level, is the website. In terms of screen and content design, 8 items were overall at a high ($\bar{x}$=4.10), arranged in order of averages from highest to lowest in 3 sequences: 1) content and consistency, 2) overall screen, and 3) design process accordingly

sequence, with the highest level on the overall screen as a whole. As for the usability aspect of the 7 items, the overall picture was high ($\bar{x}$=4.25). The mean was sorted from highest to lowest in 3 orders, namely 1) how to use it for the purpose, 2) the membership system, and 3) the interaction section. Respectively, with the highest level in terms of how to use it for the purpose.

Table 1: Results of efficacy assessment by experts

Topics and Assessment Items		$\bar{x}$	S.D.	Interpreting
System components	1. Website	4.25	0.65	Highest
	2. Record knowledge	4.19	0.65	High
	3. Measuring and evaluating knowledge	3.89	0.50	High
	4. Discussion board	4.23	0.55	Highest
	5. Knowledge repository and exchange	4.07	0.55	High
	6. Learning activities	4.21	0.65	Highest
	7. Pictures of various activities	3.99	0.55	High
Design and development	8. Content and Consistency	4.43	0.65	Highest
	9. Format and font size	4.11	0.45	High
	10. Font color and background	4.07	0.65	High
	11. Visual and sound effects	4.17	0.55	High
	12. Multimedia system	3.63	0.55	High
	13. Instructions and Manuals	3.72	0.50	High
	14. Overall screen	4.40	0.55	Highest
	15. Design process	4.34	0.50	Highest
Usability	16. Membership system	4.33	0.65	Highest
	17. Back-end system	4.18	0.45	High
	18. Link section	4.23	0.65	Highest
	19. Interaction section	4.39	0.45	Highest
	20. Search system	3.99	0.45	High
	21. How to use it for the purpose	4.46	0.55	Highest
	22. Practice in the course	4.18	0.55	High
Total		**4.15**	**0.55**	**High**

2) The results of the satisfaction assessment of the use of the model of a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application to graduate learner according to the opinions of 34 students are shown as follows: Table 2.

Table 2, shows student satisfaction with using the system in three areas: system components, screen design and content, and usability. It was found that the overall system satisfaction was at a highest level in all aspects ($\bar{x}$=4.22, S.D.=0.66). When considering three aspects, it was found that for 7 items of the system, the overall picture was at a high level ($\bar{x}$=4.22). The averages were sorted from least to most significant in 3 orders: 1) website, 2) learning activities, and 3) pictures of various activities, respectively, with the highest level on the website. In terms of Screen Design and Content, 8 items, the overall picture was at a high level ($\bar{x}$=4.19), arranged in 3 descending orders of average values: 1) content and consistency, 2) instructions and manuals, and 3) overall screen, respectively, with the highest level of content and consistency. As for the usage aspect, 7 items, the overall picture was also high ($\bar{x}$=4.26). The mean was sorted from highest to lowest in 3 orders, namely 1) cognition of learning activities, 2) practice in the course, and 3) implementation for Education Administrators. respectively, with the highest level in terms of cognition of learning activities.

Table 2: Results of the satisfaction assessment by students

Topics and Assessment Items		$\bar{x}$	S.D.	Interpreting
System components	1. Website	4.41	0.67	Highest
	2. Record knowledge	4.23	0.45	Highest
	3. Measuring and evaluating knowledge	4.19	0.74	High
	4. Discussion board	4.25	0.58	Highest
	5. Knowledge repository and exchange	4.08	0.50	High
	6. Learning activities	4.35	0.66	Highest
	7. Pictures of various activities	4.29	0.61	Highest
Screen design and content	8. Content and Consistency	4.40	0.57	Highest
	9. Format and font size	4.27	0.58	Highest
	10. Font color and background	4.20	0.59	High
	11. Visual and sound effects	4.12	0.72	High
	12. Multimedia system	4.18	0.68	High
	13. Instructions and Manuals	4.08	0.63	High
	14. Overall screen	4.37	0.67	Highest
	15. Screen design process	4.32	0.53	Highest
Usability and attitude	16. Membership system	4.01	0.74	High
	17. Back-end and search system	3.92	0.72	High
	18. Link and interaction section	4.26	0.60	Highest
	19. How to use it for the purpose	4.15	0.67	High
	20. Practice in the course	4.40	0.74	Highest
	21. Cognition of learning activities	4.43	0.68	Highest
	22. Implementation for Education Administrators	4.30	0.70	Highest
Total		**4.22**	**0.66**	**Highest**

3) The results of the interviews about student' opinions towards the model of a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application to graduate learner included 5 issues, as follows:

3.1 Knowledge exchange and implementation: students have a system suitable for teaching and learning styles at the graduate level for issues related to Education Leadership and Disruption in the Digital Era. As well as the ability to apply knowledge to become an educational administrator in the digital era, including future research design.

3.2 Behavior and response: students use the interaction section with the instructor and between learners together; that they practice this in the course (as group discussion and exchange, One-on-one discussion, brainstorming, doing exercises and presentation of assignments); they can use a search system and link sections related to the course, and record knowledge for exchanging and sharing knowledge. The students can also develop themselves. In addition, learners can also increase their learning capacity to become an educational leader in the digital era.

3.3 Participation: the system can motivate students to use it to create an atmosphere of exchange and transfer knowledge in social media, participatory operations, and challenge-based learning. It also helps students practice design and development skills and strategies for building a modern educational platform.

3.4 Utilization: students were satisfied with the system by applying their knowledge and skills in educational administration a of other members. It also helped build learning skills in effective educational administrator in the digital era.

3.5 Problems and suggestions: students want a system to customize the screen by themselves to be more beautiful, as well as more attractive. When accessing this course,

as with other social networks, practice sessions should be timed appropriately for both learning theory and practice in the course.

Results of Improving system performance

The research team synthesized the results of testing and trials of the system from the expert quality assessment and student satisfaction assessment to improve the system's efficiency. Then, five experts in ICT systems and education innovation were interviewed for a definitive review. An experts commented on the benefits of VE and CBL including: (1) Learning with student centred; (2) Learning takes place in smaller groups (versus traditional classroom); (3) Teachers are coaches and facilitators; (4) Challenges provide the organizational focus and stimulus for learning; and (5) Challenges ensure development of both subject and generic competences. An experts continue to provide feedback and suggestions for further improvements in system performance by developing interactive digital content. Online interactions include other techniques and methods for further improvement of academic achievement.

Research results according to objective 2

Designing and creating, testing, using and evaluating a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application to graduate learners found that the system developed according to the methods presented here can be assured of sufficient quality for effective implementation of this system in teaching and learning at the graduate level. An example of a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application to graduate learners as shown in Figures 2-4, respectively.

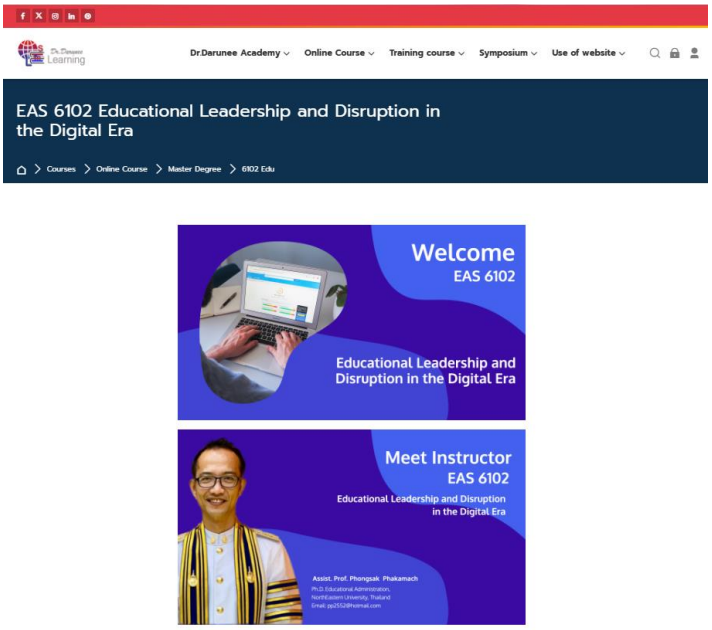

Figure 2: VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era

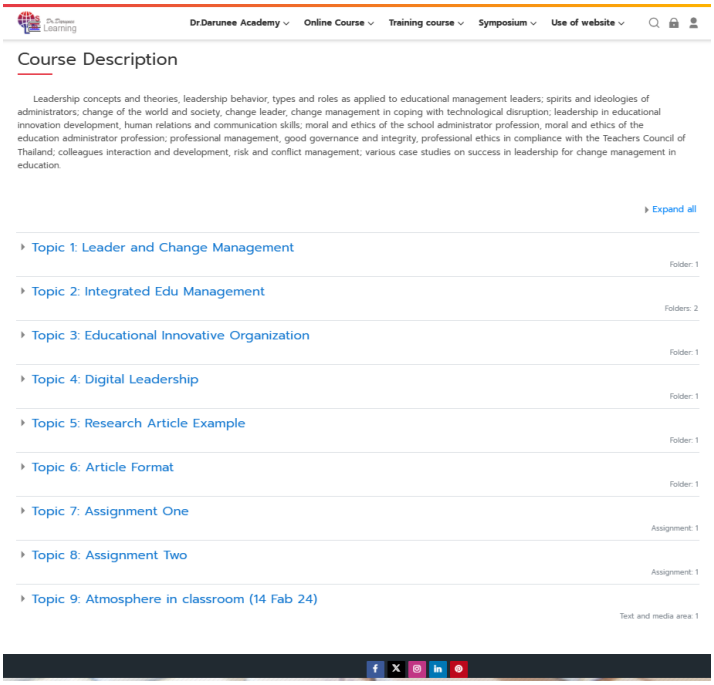

Figure 3: Course Description and Topics

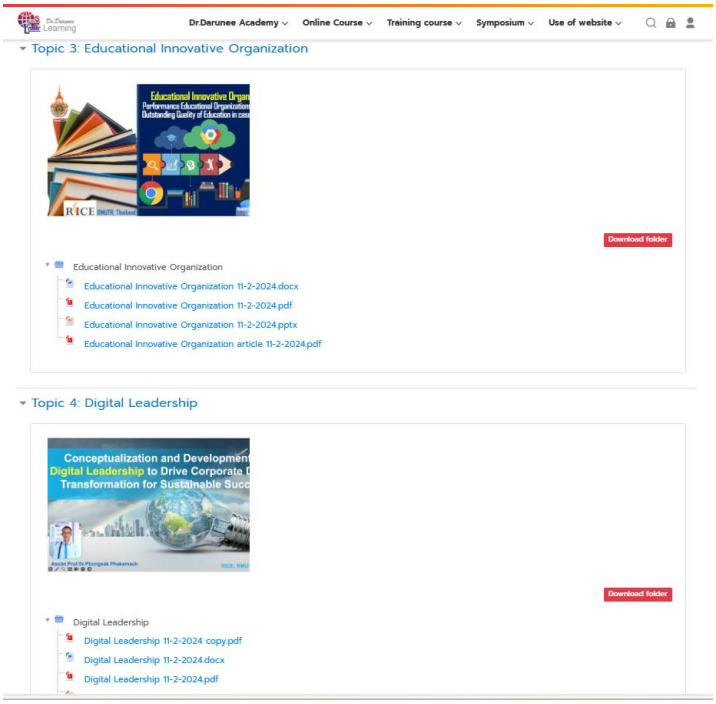

Figure 4: Example of active learning and knowledge exchange

CONCLUSION AND DISCUSSION

The research results can be summarized and discussed in crucial issues according to the objectives and research process as follows:

Conclusion

1) Research and development methods for a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application to graduate learner consisted of 4 steps: 1) Analysis of user requirements, 2) Design and development of systems, 3) Usability testing and evaluation,

and 4) Improving system performance. Design and development result in a system with important characteristics, such as a system that can actually be used for teaching and learning in the course. The system must support the teaching and learning process with complete support functions, provide operating sections consistent with the course content, and have practical learning and relevant case studies to enhance knowledge and understanding. In addition, the system must be able to operate according to the specified schedule, and should use a content management system and Virtual Environment Challenges (VEC) to make the system perfect.

2) Design and development of a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application to graduate learners. A standard ICT development process should be used to develop a learning system. It determines clear procedures and practices to obtain a system that can fully respond to learning management in a given course or content.

3) An analysis of the efficiency and satisfaction of using a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era and application to graduate learners yield this results:

3.1 The efficiency of using the system from experts' opinions was a high level ($\bar{x}$=4.15, S.D.=0.55), indicating that the developed system could be used as a tool for teaching in the course. This system can be used as effective learning and implementation tool in the EAS 6102 course. It can also support learning about Education Leadership and Disruption in the Digital Era.

3.2 Overall satisfaction from the students' opinions of using the system was a highest level ($\bar{x}$=4.22, S.D.=0.66), indicating that the students who used this system had a satisfactory level of satisfaction because this system can respond well to the management of learning about Education Leadership and Disruption in the Digital Era.

Discussion

Discussion of this research includes, related parts under these headings:

1) Developed platform, the researcher has applied the conceptual framework for research and development from the ideas of Cheng (2016); Adnan and Anwar (2020) and Kant, Prasad, and Anjali (2021) to design the following steps: (1) course content analysis; (2) system design by ordering content, classify subject according to learning principles, assign learning activities, determine the relevant research resources, and creating a virtual learning room and knowledge processing; (3) the development of the system based on the principles of 4Is: Information, Interactive, Individual and Immediate Feedback; (4) the use of the system for teaching and learning based on the communication channels provided; and (5) testing for the efficiency of the system is mainly based on the opinions of students. That is consistent with the research work of Phakamach, Panjarattanakorn, and Onsampant (2024), the research on the development of a platform for graduate education uses the same methodology to create an appropriate and quality platform.

2) The evaluation results by experts found that the developed system is suitable for a high level. It shows that the developed platform has this quality and that it can be used in practice because the researcher develops the lessons systematically from the study and analysis of the data using the (Analysis, Design, Development, Implementation, and Evaluation) or ADDIE process, which experts have reviewed. After that, the data are tested with the sample to evaluate the efficacy and to apply the results for improvement. It is a method of conducting media production according to research and development (R&D) and relying on trials and modifications to be as complete as possible. That is consistent with the research work of Phakamach, Wachirawongpaisarn, and Panjarattanakorn (2021); Demir, Maroof, Sabbah Khan, and Ali (2021) and Trivedi, Patra, and Singh (2022). However, to get a good model and make students understand the subject matter more, some aspects of multimedia and graphics system design should be improved related to the

operation. This is required to make the system more complete and provide more educational options.

3) The satisfaction assessment results by students found that the developed system showed highest satisfaction. It shows that students can learn about Education Leadership and Disruption in the Digital Era. The platform can support learning management and virtual exchange very well. That is consistent with the research by Wang et al. (2021; Singh, Sharma, and Paliwal (2021); Hamdan et al. (2022) and Nguyen, Gijlers, and Pisoni (2023) stated that developing a sound model system requires at least four elements: i, data source and content, ii, support resources; iii, discussion boards; iv, online learning activities; and case studies to help learners understand, which can be used to create a virtual learning model. (Parramore, 2019). In addition, the VE-LMS platform has all the elements that can be used as a system to support learning management in this course.

4) The results of confirmation of the platform used by experts from group interviews found that the VE-LMS platform combined with challenge-based learning can be a support system for teaching and learning at the graduate level. It can enable students to gain theoretical knowledge and practice learning experiences in the study. Therefore, it can be confirmed that the performance of the platform has been developed from the elements and stages of the development of a quality management system and learning exchange (Chapman & Bell, 2020; Kant, Prasad, & Anjali, 2021; Tam, 2022).

In closing, The VE-LMS platform design process based on the above research methods can be applied as a model for designing teaching and learning management in courses related to the development of digital technology for education at all levels. In order to be able to improve the quality of education further.

SUGGESTIONS

The researchers put forward two kinds of feedback as follows:

Suggestions for applying the research results

Implementation and development of this VE-LMS platform combined with challenge-based learning to be more effective consists of

(1) A learning support system requires a qualified development team, such as lecturers, educators, educational psychologists, programmers, and educational innovation and technology designers. Appropriate and efficient.

(2) For the learning management process to be fast and cost-effective, there should be literacy training using browser programs or applications before learning to understand the correct method. And can solve problems that arise during self-study.

(3) Appropriate details should be added to the course, such as the website, related case studies, and the interaction section. To provide in-depth practical training for learners and to promote broader learning.

(4) The development of online learning systems should use appropriate and consistent fonts, graphics, sounds and multimedia. To make situational learning and processing possible effectively and efficiently.

Suggestions for further research

(1) This VE-LMS platform combined with challenge-based learning should be developed to use more elements as standard learning materials. It will provide insights to improve learning styles to be more effective.

(2) There should be research and development of multi-tasking digital platforms based on VE-LMS platform combined with challenge-based learning models that can make online learners feel more positive and imaginative by developing multimedia that attracts online learners' attention.

(3) There should be more research and development of VE-LMS platform combined with challenge-based learning in other subjects to increase modern learning resources for the further development of higher education in Thailand.

According to the design and development methodology, it can be assured of sufficient quality for implementing this VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era for teaching and learning at the graduate level. Therefore, it can be concluded that research and development of a VE-LMS platform combined with challenge-based learning on the topic of Education Leadership and Disruption in the Digital Era produce a desirable performance for graduate learners.

ACKNOWLEDGEMENTS

The authors are grateful to acknowledge the support of Rattanakosin International College of Creative Entrepreneurship, Rajamangala University of Technology Rattanakosin and Educational Innovation Institute, Promote Alternative Education Association, Thailand.

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International Journal of Science Education and Teaching
Vol. 3, No. 2, pp. 67-78, May. – Aug. 2024
http://doi.org/10.14456/ijset.2024.6

Development and Evaluation of Grade 4 Printed and Digitized Reading Materials on Topic Light, Heat and Sound

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Received: 27 May 2024 Revised: 11 September 2024 Accepted: 10 September 2024

Abstract. The aim of this research is to create engaging and informative printed and digitized reading materials for the fourth-grade level regarding Light, Heat, and Sound based on the DepEd curriculum and learners' materials. The methodology adheres to the ADDIE model with 10 sample respondents as try-out implementation. The developed materials comprised three stories and were evaluated with a DepEd rubric for General Reference Material. The material was further subjected to a readability test that provided reading ease and grade level. The final version of the reading material was converted to a digital form with audio components. The digital version was uploaded to an unlisted YouTube channel for easy dissemination. Based on the evaluation, the average rating is 4.875 on the general reference which translates to "excellent". On the readability, the two stories achieved a reading ease of 87.8 which is appropriate for 8-9 years old. Its average grade level is 3.1 which is consistent with the target learners. Post-intervention yielded an average of 93% which corresponds to "outstanding". The study concludes that it is highly possible to create reading material that embeds specific science learning content.

Keywords: Comprehension, Science-Infused descriptive story, Light, Heat and Sound

INTRODUCTION

Reading comprehension represents one of the most intricate cognitive processes that humans use, making it challenging to teach, assess, and study (AM Elleman, 2019). Reading comprehension is a complex cognitive process that requires coordinating brain processes and understanding context. As students make progress in education, more reading is necessary to cope with complex courses. However, it is challenging to practice and lack of reading materials can hinder effective reading comprehension exercises. Accordingly, this study was carried out create a printed and digitized reading material as supplementary material to science modules as part of a school reading intervention to help students in their learning about topics of Light, Heat, and Sound, as well as to improve reading fluency and measure the reading comprehension level of Grade 4 learners in

Science and English. Reading is a valuable life skill that can be applied in school and everyday life. The materials should also aid in developing reading strategies, such as predicting, visualizing, and making connections, to enhance learners' reading abilities. The study aims to respond to the following research question in order to address the problems: (1) How was the Reading Material: Grade 3 topic on Light, Heat, and Sound developed? (2) What is the evaluation of the content expert to the printed and digitized reading materials? (3) Are the reading materials appropriate to the intended grade level? (4) What is the performance of the respondents to the post-intervention questions?

There have been researches concentrating on higher-level comprehension skills, but they recognize the underlying importance that efficient word identification plays in reading comprehension (Perfetti & Stafura, 2014). There are also studies that discuss digital reading experience of young people, growing up in a digitized context, and how digital reading shapes new generations' concepts of reading and textuality (Frederico, 2017). The use of the Most Essential Learning Competencies (MELC) distinguishes this current study. The MELC served as the basis for the content of the printed and digitized reading materials, integrating scientific and literary concepts, and serving as an evaluation tool to keep track of the student's reading comprehension. The reading materials were created in the form of descriptive stories with three different objectives focusing on the MELC.

Theoretical Framework

The Cognitive Theory of Multimedia Learning (CTML) is a framework for instructional design in the field of Instructional materials. It is defined as learning that draws on auditory and visual stimuli, or learning from the combination of text and pictures, which means that deeper learning can occur when information is presented in both text and graphics than by text alone. Learners absorb sensory information through their eyes and ears and then store this knowledge in working memory, where they construct graphical and verbal models (Clark & Mayer, 2007).

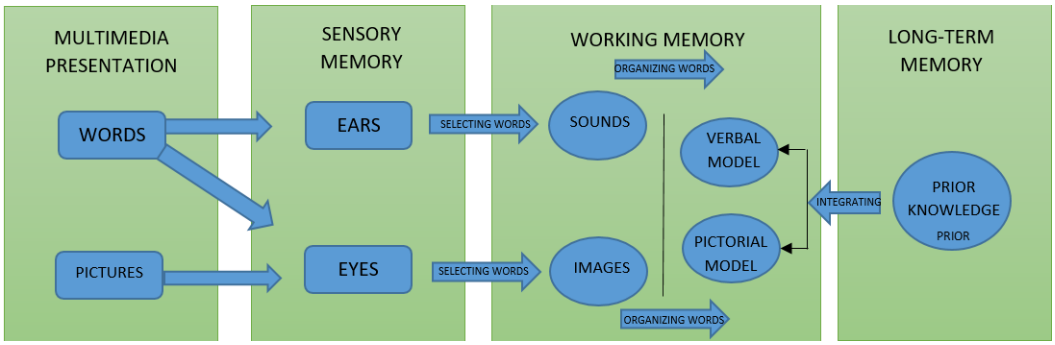

Figure 1: CTML Theory by Dr. Richard E. Meyer

Moreover, this study aims to design a science-infused reading material to be used as supplementary reading material during reading instruction or intervention to grade 4 learners on specific topics on Light, Heat and Sound. This research was based on the study of Florida State University, the ADDIE model of Edgar Dale (1964). It is used to design efficient learning experiences. Instructional designers and training developers use a learning model.

Conceptual Framework

The Input–Process–Output or IPO Method is used to understand and describe the flow of information and activities. It provides a structured approach for analyzing and designing systems by breaking them into three components: Input, Process, and Output.

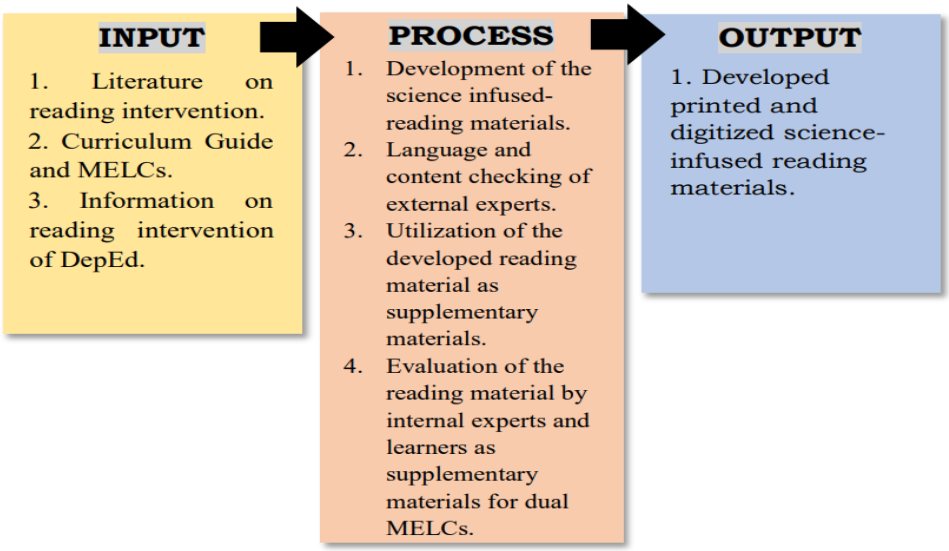

Figure 2: Input, Process, and Output of the Study

Input represents the data or information provided to the system for processing. It includes all the resources and instructions that serve as the raw material for processing. For this study, the input contains literature on reading intervention, curriculum guide and MELCS, and information on reading interventions for DepEd. On the other hand, the process represents the activities, operations, or transformations performed. It involves developing the reading materials, language and Content checking, utilizing the developed reading material as supplementary materials, and evaluation. Lastly, the output represents the results, information, or outcomes generated by the reading material after input processing. Hence, the developed print and digitized science-infused reading materials.

METHODOLOGY

The researchers used developmental research in this paradigm. Science content professionals and reading experts verified the produced printed and digitized reading material in terms of Practicality, Reliability, Validity, and Authenticity. Thus, this study utilized Convenience Sampling. The beneficiary of this study is the selected ten (10) fourth-graders from public and private schools situated in Iligan City. Both qualitative and quantitative data are collected during the development process and after the try-out phase. The post-assessment test results of students in the try-out phase are used to collect quantitative data. In contrast, qualitative data is acquired from the thoughts and suggestions of content experts on the developed reading material. The reading materials used the ADDIE model, which included five stages: analysis, design, development, implementation, and evaluation.

For this study, the researcher concentrated on the Flesch Kincaid Grade Level scores, which reflect the number of years of educational attainment needed for a person to comprehend the text effectively on the initial reading. Reading material development, which includes creating assessment tests for comprehension. Language professionals and science content experts will go over it to see if there are any modifications or recommendations that could help revise the material and the assessment. For the purpose of evaluating the materials' content, correctness, language, and graphics, content experts were given an Evaluation Rating Sheet for General Reference Materials that had been amended from the Department of Education (DepEd).

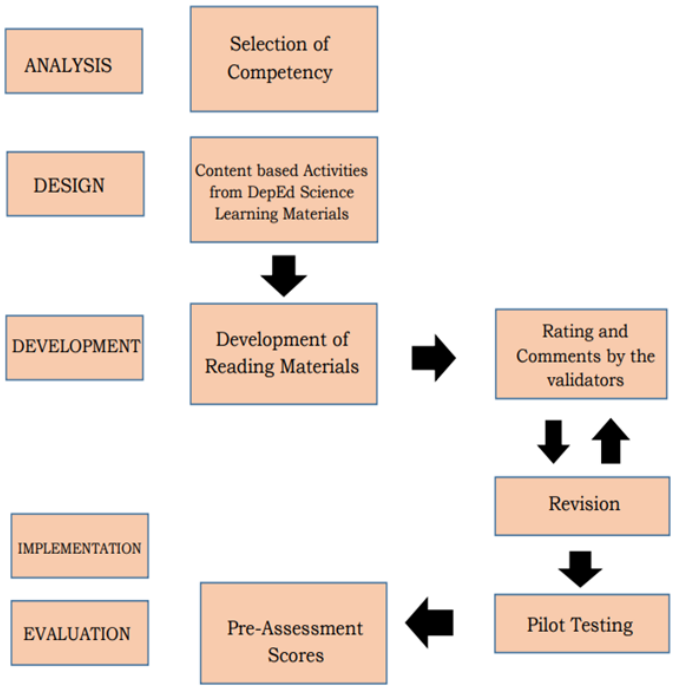

Figure 3: Steps used in gathering data.

The ADDIE model was utilized in the study to come up with a visual representation of how the researcher created the reading material. The selection of competency can be identified in the MELCS during the Analysis stage. In the Design stage, researchers look into the content and activities from the DepEd Science Learning Materials, which will be the basis of the reading materials. It is in the Development stage where reading materials are created, and then rating and feedback from evaluators are required for revision. If the reading materials aren't revised further, the researchers will conduct pilot testing and evaluate the Pre-Assessment results.

RESULTS AND DISCUSSION

This chapter features the results and discussions in accordance with the overall procedure of the study as outlined by the ADDIE Model: Analysis, Design, Develop, Implement, and Evaluate.

Analysis Stage: Selection on the Competency

This research focuses on learning issues that can be traced back to the characteristics of the subject matter itself, particularly within the context of the K-12 Basic Education Curriculum's Most Essential Learning Competencies (MELCs) for Grade 3 with a code S3FE-IIIe-f-3. This requires learners to describe how Light, Heat, and Sound travel; investigate properties and characteristics of Light, Heat, and Sound; and 3. Describe ways to protect oneself from exposure to excessive Light, Heat and sound. Table 3.1 below shows the K-12 Basic Education Curriculum MELCs Specialized subject (Grade 4). Our approach was multi-faceted. We first conducted a detailed review on the MELCs to pinpoint specific learning goals and identify any gaps or challenges. This review ensured that the curriculum objectives were clear and achievable for Grade 3 students. Next, we analyzed instructional materials, including textbooks to assess their alignment with the curriculum objectives. This analysis involved evaluating the clarity of explanations and the effectiveness of practical activities provided, ensuring that these resources adequately supported the curriculum. Then, we observed classrooms to see how students learned

about Light, Heat, and Sound. We focused on how well approach and interactive activities were used, as these methods are key for making the concepts of Light, Heat, and Sound clear and engaging for students.

We also reviewed student assessments to evaluate their grasp of the concepts and application of what they learn. This analysis revealed whether students met the desired learning outcomes. This research stage uncovered important specific findings, the gap between instructional materials and curriculum goals led to inconsistent teaching effectiveness across classrooms hence, Interactive approach and applications of the topic will significantly enhanced students' understanding in the Topic Light, Heat, and Sound. Based on these findings, we recommended improving alignment, and enhancing the instructional materials. These measures are aimed at addressing the identified issues and improving educational outcomes. The results are summarized, which compares Grade 3 MELCs with the Grade 4 specialized subject MELCs. This comparison shows how crucial it is for the curriculum to build on previous lessons and maintain a clear progression. Overall, this research stage examined how the subject matter, specifically Light, Heat, and Sound, impacts learning. It identified key challenges and effective approach, and provided recommendations to enhance teaching and learning outcomes on students.

Design Stage: Content based on activities from DepEd science learning material

In this stage of the research, we developed science reading materials for Grade 4, focusing on Light, Heat, and Sound, based on the K-12 Basic Education Curriculum (S3FE-IIIe-f-3). The design centered on three core objectives from the competency, aiming to make learning engaging and enhance student's learning performance. The Supplementary Reading Material's content was based on the K-12 DepEd Science Learner's Material for Grade 4, ensuring it complemented the curriculum and was accessible for students. This involved analyzing the guidelines, reviewing existing resources, and incorporating appealing and relevant visuals and examples. The outcome was a set of materials designed to enhance engagement and understanding through interactive visuals and clear activities, aligning with curriculum goals and supporting effective science education.

Development stage: Development of the reading material, rating, and comments by content experts

Throughout this period, the developers' reading material underwent a variety of versions. The developers made several versions of the Science-based story until they created a refined version that meets the competencies and objectives of the grade 4 MELCs. An assortment of tools was utilized to assess the readability level of the stories in the early versions of the reading material, and several sets of evaluators examined the science and literacy content of the reading materials.

The researchers created supplemental reading materials for the first version of Developing Science-Infused Reading Material, which bases its competency on the MELCs Intervention from the K–12 Curriculum (S3FE-IIIe-f-3). The researchers used familiar objects and settings to make it relatable for learners. After showing the first version of the story to the literary content evaluator, the researchers took note of the comments and suggestions that can be shown below to provide a better version of the story. The evaluator remarked that the developers should focus on constructing a descriptive story to widen the information inclined to the topics of Light, Heat, and Sound.

In version 2, researchers revised the reading materials based on the evaluator's previous recommendations and developed a science-infused descriptive story, highlighting all the competencies. As you can see there are numbers beside each line indicating which of the lines induced the first, second, and third competencies. A table was created to list the three competencies and specify the lines where they are located. This is a clear illustration of how methodically everything was made. However, it should be enhanced and rendered sufficient to make the reading material more sensible and reliable. That being said, the evaluator's advice must be taken into account. The shift from three write-ups, one for each competency under MELCs, to creating a descriptive story took place, still involving the three competencies but now compiled in a story alone.

In version 3, from "Amazing Grace", the title changed to "Science-like Life" since it suits the content of the story. As you can see, the story gave justice to the word "descriptive" because it looks more descriptive than the previous version. At this point, the output was checked with corrections and suggestions on it. This version contains significant knowledge unlike the previous one. However, it becomes more intricate, making it difficult for the intended audience (grade 4) to understand the narrative. That being stated, it defeats the purpose of reading comprehension, which is said to be the focal point of the reading material for grade 4 students to learn from. It would be challenging to make the reading comprehension effective with the reading material produced. In conclusion, the evaluator proposed disregarding this one and creating another story that is simpler and more understandable, which resulted in another version.

In Version 4, there are now three stories; Playing with Margarine, The Bright Flashlight, and The Garcia Family. This is not just about creating three stories, each presenting a certain competency accordingly; Describe how Light, Heat, and Sound travel, Investigate the Properties and Characteristics of Light, Heat, and Sound, and Describe ways to protect oneself from exposure to excessive Light, Heat, and sound. This version is stepping forward from text-only manuscripts to visualized. Now that this version applies graphics to each story, with the use of photos gathered from Google photos and Canva for reference, the researchers visualize the story's concept before illustrating the entire story using Canva. Version 4 was created to bring the text-only manuscript to life by adding text, components, and applying color theory to the designed reading material. Characters and situations are depicted to highlight key plot points before adding more elaborate features, such as backgrounds, on the latter part.

Short Story One. The first story of this version represents a competency which is to "Describe how Heat travels." Considering it only needed a little polish, the evaluator opted to make his criticisms and suggestions verbally rather than writing them down. The comments in the table were taken note by the developers as they paid attention to the evaluator's explanation. After pondering, the researchers applied them right away. This is due to the fact that images can assist students understand the meaning of words in a manner that is clearer. For example, if a student is learning the word "run," they may recall it better if they see an image of something or someone running. By all means, given that the goal of designing reading materials is to strengthen learners' reading comprehension, proper word usage and sentence form to avoid grammatically incorrect statements must be considered. The graphic design approach was meticulously detailed to ensure that the aesthetics appropriately portrayed the story being told. This improved the readers' knowledge and understanding of the context. The creators further modified the artwork to make them more interesting to learners in 4th grade. These adjustments aim to improve the learning experience for all students by making it easier for students to understand and apply the concepts taught in the reading material. The changes should result in a more engaging and successful educational endeavor.

Short Story Two. The Bright Flashlight is the second story of this version which represents the second competency, "Investigate properties and characteristics of Light". As with the first story in this version, neither corrections nor comments were made to the printed draft, but rather were explained verbally during the consultation. The story was fine, but the evaluator remarked that the illustration should be improved, therefore the researchers decided to enhance the visuals along with using a suitable color scheme and adjusting the contrast. That one is supported by Anja Zorko (2017) with her statement that the color combination is one of the best for achieving optimal text readability and legibility. Moreover, the right color harmony can result in a harmonious graphic that will encourage readers to peruse the reading material.

Short Story 3. The third story, "The Garcia Family" shares knowledge of the third competency, which is "Prevention of Excessive Exposure." The evaluator reiterated the comments from the previous stories. In addition, the dialogues of the story must be clarified so that the Grade 4 learners can understand the content of the story. The objects and information must also be accurate so as not to feed the readers with the wrong idea.

The researchers relied on literacy tools including Flesch Kincaid Grading Level and Flesch Kincaid Reading Ease as the development of the reading materials made progress. To make sure that the reading materials are legible for Grade 4 learners, readability strategies were employed. The researchers' primary goals were to obtain a 90 or higher on the Flesch Kincaid Reading Ease (FKRE) and a 4.0 or lower but not more than 5.0 on the Flesch Kincaid Grade Level (FKGL) scores to meet the standards for the Grade 4 level.

In version 5, Following a readability test, the researchers employed Quillbot to evaluate the grammar and simplify the terms for the young learners. Quillbot is a free online paraphrase tool with the inclusion of free summarizer, grammar check, and plagiarism check to help you restructure and rephrase your documents. A Google Forms survey indicated that students could utilize Quillbot to rewrite text without affecting its meaning (Nurmayanti & Suryadi, 2023). However, when the rewritten writings from the software are not adequate for grade 4, the researchers chose specific phrases and words to keep. The developers made a few changes before the stories were readability tested once more. To attain a desirable reading score on the readability test, certain sections were alternated with simpler terminology, reduced with shorter sentences, and proper spacing and punctuation were followed. The stories are well organized, with clear phrases that are easy for readers to comprehend, hence indicating that the text is written at a fourth-grade reading level.

The researchers kept the cover page's graphic style because it is void of issues. Other components of the reading material were improvised in terms of graphic designs to the story layout, such as the background scenes, visually appealing elements, along with additional character illustrations because those features must be present to make the reading material appear imaginative, resourceful, and engaging for Grade 4 learners. The designs may look basic, but those are imaginative and comprehensible enough. According to Mayer's Cognitive Theory of Multimedia Learning (2009), the words and images we use for instruction are crucial, which is why the researcher did everything they could to create this version of reading material that is free from complexity and contains sufficient information for grade 4 learners. The premise only applies to the first story, "Playing with Margarine." The fifth version is the final version of the reading material, which is available in both printed and digital formats.

The researchers conform to the evaluators' ideas and recommendations to adhere to correct grammar, observe clear transitions, provide clear illustrations, the use of right terms, and the uniformity of the angles and lines used in the reading material. For justification, Mead, S. (2013) observed that students learn best through their senses of hearing and sight, and the researchers used multimedia resources to create an E-audiobook, which was an electronic version of a book that could be read on a computer, tablet, or

mobile device (Queenslibrary.org, 2013). The researchers produced a final edition of the reading material after weeks of revisions and reviews. It is suggested that the researchers have the document's readability evaluated as the story develops. The Flesch Kincaid Readability Tool was used by the researchers to evaluate the readability of the reading content. This indicates the years of education required for readers to fully comprehend the reading material. For this reading material, the developers used WebFX, an internet website that analyzes text and calculates its readability level using various readability methods.

Table 1: Readability Test Results of the Quilbotized Material (Version 5)

Version 5	**Readability Test**	
Part 1: *Playing with Margarine*	Flesch Kincaid Reading Ease	92.9
	Flesch Kincaid Grade Level	3.7
Part 2: *The Bright Flashlight*	Flesch Kincaid Reading Ease	90
	Flesch Kincaid Grade Level	4.3
Part 3: *The Garcia Family*	Flesch Kincaid Reading Ease	90.1
	Flesch Kincaid Grade Level	2.8

Readability Test Results of the Quilbotized Material (Version 5)

Average:	Flesch Kincaid Reading Ease	90.83
	Flesch Kincaid Grade Level	3.6

Based on WebFX evaluations, the text is consistently appropriate for 4th-grade readers. All three versions of the text received Flesch Kincaid Reading Ease scores above 90, suggesting that they are appropriate for 9 to 10-year-old readers. Furthermore, the Flesch Kincaid Grade Level scores ranged from 2.8 to 4.3, indicating that the material is legible by fourth-grade readers. These findings indicate that the material is appropriate for 4th-grade learners, as it corresponds to their expected reading ability.

The average Flesch Kincaid Reading Ease is 90.83 and 3.6 for Flesch Kincaid Grade Level indicating that the upgraded Version 5 is verified to be suitable for the targeted readers and that the text is relatively easy to read. The stories are well organized, with clear phrases that are easy for readers to comprehend, hence indicating that the text is written at a fourth-grade reading level.

As shown in the table above, the validators gave 5 or excellent, mostly in the Factor A. Content of the Reading Material. 5 for factor A.1 - factor A.3 including factor 5, factor 6, factor 8 which indicate as excellent and factor 4 they rate differently so the mean for this factor is 4.5 which indicates as very satisfactory. While for the typographic layout/design, the validators gave 4 or very satisfactory since according to them, some of the cover design of the reading material does not support the concept presented. The overall percentage of the evaluation of the validators is 96% and the reading materials gained a total mean score of 38.5 indicating that it passed the criterion.

Table *2*: Evaluation rating for the Content of the three stories (Playing with Margarine, The Bright Flashlight, and The Garcia Family)

Criteria	Validator 1	Validator 2	Mean	Interpretation
Content reference, enriches, and / or leads to the mastery of certain learning competencies for the level and the subject it was intended.	*5*	*5*	*5*	*Excellent*
Facts are accurate.	*5*	*5*	*5*	*Excellent*
Information provided is up-to-date.	*5*	*5*	*5*	*Excellent*
Language is appropriate for the level of the target user.	*5*	*4*	*4.5*	*Very Satisfactory*
Visuals are relevant to the text and suitable to the age level and interests of the target user.	*5*	*5*	*5*	*Excellent*
Visuals are clear in content and detail.	*5*	*5*	*5*	*Excellent*

Implementation stage: Pilot-testing

In this research stage, we focused on the actual implementation of the developed science reading materials, specifically for Grade 4 students on the Topic Light, Heat, and Sound. Our primary objective was to assess the practical application and effectiveness of these supplementary reading materials in a real educational setting. To execute this phase, we coordinated with Dona Juana Actub Lluch Memorial Central School. First, we obtain necessary permissions from the school head and class advisers. This collaboration was crucial for conducting a thorough testing of the materials. We selected ten Grade 4 students as participants for this trial, ensuring a representative sample to evaluate the materials' impact. The evaluation process involved both printed and digitized versions of the reading materials. Teachers from the school, who were part of the evaluation team also played a significant role in this stage. They meticulously reviewed the content, layout, and overall appropriateness of the materials. Their feedback was essential for confirming that the materials met the educational standards and were suitable for the target age group. An important aspect of the evaluation was assessing the alignment of the reading materials with the Learning Resource Management and Development System (LRMDS) requirements. This alignment check was successful, with the materials corresponding to the majority of the LRMDS standards, which indicated that they were well-suited for educational use. We also conducted a post-intervention feedback from the participating students. This feedback revealed that the students were able to read and comprehend the stories effectively. The positive responses from the learners confirmed that the materials were engaging and supported their engagement and understanding of the Topic Light, Heat, and Sound. Overall, this stage of the research involved a comprehensive trial of the science reading materials at Dona Juana Actub Lluch Memorial Central School. The successful implementation, thorough evaluation by teachers, and favorable feedback from students underscored the materials' effectiveness in enhancing Grade 4 learners'

comprehension of Light, Heat, and Sound. This phase validated the practical applicability of the materials and provided valuable insights for future use and refinement.

Evaluation Stage: Post-assessment scores

This phase is crucial in assessing the newly developed reading materials designed to enhance students' literacy skills and performance. The primary aim was to evaluate the effectiveness, feasibility, and overall impact of these materials on student learning outcomes. To achieve this, we administered a post-assessment test to the participants as post-intervention, which consisted of five questions of varying difficulty levels per story. This test was strategically developed to measure different aspects of reading comprehension and understanding of the topics covered in the reading materials. The questions were crafted to evaluate how well students could grasp and understand the concepts behind Light, Heat, and Sound presented in the materials. The post-assessment was conducted after the students had engaged with the reading materials, allowing us to gauge their comprehension and retention of the content. The results provided significant insights into the effectiveness of the materials in enhancing literacy and understanding. Analysis of the post-assessment results revealed how well students were able to process and understand the information. This evaluation was crucial for determining the materials' impact on students' performance. Overall, this phase involved a thorough assessment of the reading materials' effectiveness through a structured post-assessment test. The findings from this evaluation were essential in confirming the materials' efficacy in improving literacy and understanding of the specific topic among students.

Summary of Findings

This study aimed to develop reading materials, evaluate reading materials, and trial implementation with the participation of ten (10) Grade 4 learners to record their reading fluency and reading comprehension. The reading materials were created throughout the development stage in accordance with the learning competencies of the K–12 Basic Education Curriculum. With the code S3FE-IIIe-f-3, the learning competencies are: describe how Light, Heat, and Sound travel; investigate properties and characteristics of Light, Heat, and Sound; and describe ways to protect oneself from exposure to excessive Light, Heat and sound. Five versions were developed and recognized, alleviating deficiency of the versions.

From Version 1 to Version 5, printed and digital reading materials are used through a trial-and-error procedure. Generally, remarks and recommendations on suitability for the MELCS, grammar, suitable indentation, font size, and clearly defining transitions are given. Language and physics content experts provided comments and evaluations on the materials to ensure that they integrate the precise language and design of the material. Following the final revision, a digital copy was made available for distribution.

Through the development and distribution of instructional materials, as well as data analysis, the study was able to analyze the impact of science-infused reading material. The Flesch Kincaid Readability Ease test results are shown in the Results and Discussion in Chapter 3. The first story "Playing with Margarine," achieved 92.9%, and Flesh Kincaid's grade level of 3.7 suggests that the story is easily understandable and suitable for grade 4 readers. The second story, "The Bright Flashlight," acquired 90% of Flesch Kincaid Reading Ease and a grade level of 4.3, indicating that it is well-accepted by grade 4 readers. "The Garcia Family" garnered 90.1% and a grade level of 2.8, confirming that the story is appropriate for grade 4 readers. The average Flesch Kincaid Reading Ease is 90.83 and 3.6 for Flesch Kincaid Grade Level indicating that the upgraded Version 5 is verified to be suitable for the targeted readers and that the text is relatively easy to read. The stories

are well organized, with clear phrases that are easy for readers to comprehend, hence indicating that the text is written at a fourth-grade reading level.

The reading material received a "very satisfactory" evaluation and was advised as supplemental reading for grade 4 science students. Since the outcomes of the stories in Flesch Kincaid Reading are excellent, it is evident that this has an impact on the students' performance. The overall post-intervention mean score was 12.4. The overall percentage score was computed to be 83 % and is leveled as high in an unlisted YouTube video. The content validators-evaluators rated it as satisfactory, with an overall average mean value of 3.88.

CONCLUSION

Based on the research question presented, it is quite possible to develop reading materials with science content that are intended to target both reading skills and science learning. The reading materials received a 95% rating from the validators, denoting excellent performance. According to the evaluation rating of the evaluators, the reading material is good, supporting the viability of developing high-value and highly functional reading material. The reading materials are suitable for the grade level of the target audience. As a result, it is strongly advised that students study the reading material, which can also be complemented by audio-visual measures.

RECOMMENDATION

Considering the study's findings, recommendations for further research aimed at enhancement are made. The teacher could give a reading comprehension test (PHIL-IRI) for the students using Science Reading resources on the topic of Light, Heat, and Sound, with English and Science as its two areas of study. Prospective researchers could increase font size to take in for electronics such as cellphones, tablets, etc. Since the number of respondents is limited to ten students, the future researcher should conduct the study on a wider scale. Grade 4 Science material have been shown to help improve students' reading comprehension. Therefore, it is highly encouraged that instructional materials be included before the subject is given. In developing an e-audiobook, future researchers could utilize poems and stories with accompanying music and instrumental backdrop to guarantee learners recall the information. Future researchers should not limit the material to graphics, images, or audio with the goal of putting multisensory strategy forward. Multisensory activities, claimed by educational intellectuals, may stimulate substantial emergent literacy. Engaging students with multimedia activities is an excellent approach to help them realize their potential. Future researchers should showcase icons such as Maranao and Cebuano being involved as characters in the stories, or depict prevalent local environments and cultures to emphasize the significance of diversity and inclusion. Since this study relied on non-probabilistic means, future researchers can replicate it with a different sample of learners for verification.

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International Journal of Science Education and Teaching
Vol. 3, No. 2, pp. 79 - 85, May. – Aug. 2024
http://doi.org/10.14456/ijset.2024.7

Teaching Thermodynamics Principle of Power Generation with Analogy for Electrical Power Engineering Students to Enhance Their Understanding

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Received: 7 June 2024 Revised: 24 September 2024 Accepted: 25 September 2024

Abstract. Most electrical engineering students must make an extra effort to understand non-electrical engineering concepts in their study. An analogy approach is commonly selected by lecturer to assist the students to understand the concepts. In this paper, an analogy by conducting practical work is proposed. The objective of this practical class is to enhance the students understanding of the work principle of the economizer and what advantages will be gotten by adding economizer in the boiler. This study has been started to be implemented in 2nd semester academic year 2022/2023. The research result shows that the students who conducted the proposal practical class in 2nd semester academic year 2022/2023 demonstrated 38.75% much higher in understanding compared to the students who took the same subject in previous academic year 2021/2022 (93.75% vs 55.00% in correctly identifying economizer). All these students showed exemplary level capability for given rubric assessments, except in system efficiency improvement assessment which half of students have capability at satisfactory level. Also, more than ninety percent of students could identify the economizer, one of important components in a boiler, correctly. Whereas only fifty five percent of students who could do the same in previous academic year.

Keywords: Thermal Power Plant, Economizer, Thermodynamics, Practical Analogy Class

INTRODUCTION

Electrical Power Engineering Study Program is one of undergraduate study programs in School of Electrical Engineering and Informatics, Institut Teknologi Bandung (ITB) that provides education in the field of generation, delivery, and use of electrical energy. In curriculum 2019 of the Electrical Power Engineering Study Program, the 3rd year students shall take Electric Power Plant subject. One of the specific learning outcomes of this

subject is related to student capability in understanding the concept and designing a thermal power generation plant. Before taking this subject, the students should take thermal engineering and fluid mechanics subject and general chemistry subject in their 2nd year and 1st year studies, respectively, as their basic learning in thermodynamics principles.

In the electric power plant class, the students are, firstly, introduced to general power generation overview and some basic thermodynamic laws to review what they have learned in previous year level. Then, the students shall be focused on thermal power generation plant topics such as power plant cycle, fossil fuel, combustion process, steam generator, steam turbines, condensate-feedwater system, electrical & plant control systems and some environmental aspects of power generation plants as illustrated in a thermal power plant scheme in Figure 1.

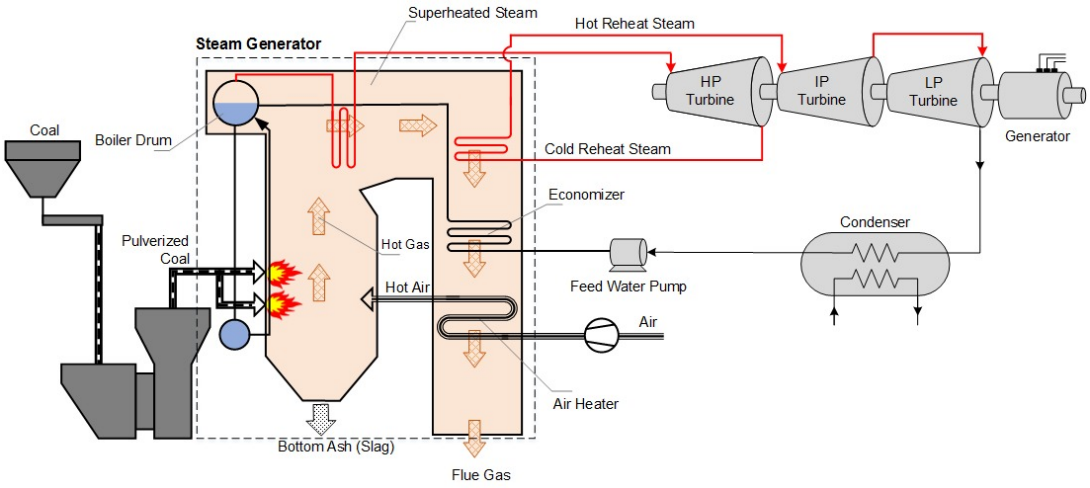

Figure 1: A Typical modern pulverized coal-fueled thermal power plant.

As shown in Figure 1, energy of the coal fuel will be converted to heat energy for heating up the working fluid (water) to produce superheated steam in the steam generator. Then, this high energy steam will be delivered to steam turbine systems for producing mechanical energy to rotate the generator for generating the electricity. From the steam turbine systems, the working fluid will go to the condenser system for changing its phase to liquid one. By changing the working fluid to liquid phase, the power plant system requires less energy for increasing the pressure level of working fluid. This increase in work pressure will be handled by the feed water pump to make a complete Rankine cycle by sending it to the steam generator for, again, generating the superheated steam.

As one of the biggest and most critical parts in a thermal power plant, steam generator is also frequently referred to as boiler (Black & Veatch, 2005). A boiler mainly consists of some important components such as furnace, drum, convection pass, air heater, burners and some apparatuses that deal with the coal fuel processing to support combustion process as described in Figure 1. The convection pass is a crucial part to transfer the thermal energy in the boiler furnace to the working fluid. This thermal energy is produced by converting pulverized coal fuel chemical energy via combustion process. Then, the hot gas will be produced and travel all over the boiler as indicated in Figure 1. This hot gas will heat up all convection pass tubes. In a steam generator, there are generally three convection pass types i.e. superheater, reheater and economizer. The first heat absorption unit in boiler is the economizer. It absorbs the energy from hot flue gas which raises the high-pressure liquid's temperature. Thus, the temperature of the working fluid becomes much higher before it passes through the narrow tubes (water wall) via downcomers. The superheater works to produce superheated steam which will stream to the high-pressure (HP) steam

turbine. From the HP turbine, to increase the working fluid temperature, it is resent to the steam generator via the reheat to get the hot reheat steam before going to the intermediate pressure (IP) turbine. Almost all these processes deal with energy conversion, heat transfer and thermodynamics knowledge which might require extra efforts to understand for electrical engineering students.

Conversely, Electrical Engineering (EE) Education in the world is nowadays focusing on enhancing education quality and quantity of graduates (Vleeshouwers, Baltus, & Raz, 2023). This concern motivates EE educators to provide a class which is more attractive and easier to understand for students. An integrated learning activities management based on the MIAP learning model might be as one of alternatives to provide a professional teaching practice for supporting electrical engineering education in a simple way (Chumchuen, N., Klinbumrung, K., & Meesomklin, S., 2020). Most students are used to adopting analogy approaches to understand many physics or electrical engineering concepts more easily (Libres, 2023). Moreover, analogy approaches are effectively proven for helping students to understand the chemistry concepts (Sriboonruang, Suwannoi & Treagust, 2022). By applying analogies which commonly adopt well known or simple models or approaches, it will help students to more easily understand any difficult and abstract concepts during the class (Harrison & Coll, 2008). Many university level textbooks also adopted analogies or equivalencies to make their contents more obvious for the book readers (Moran, M. J., Shapiro, H. N., Munson, B. R., & DeWitt, D. P., 2003; Alexander, C. K. & Sadiku, M. N. O., 2009; Chapman, S. J., 2012). Moreover, for engineering students, conducting practical work in an appropriate sequence is essential for students' concept building (Singh & Singh, 2023; Vleeshouwers, Baltus, & Raz, 2023). For providing the best practical experience for the students, a collaborative project involving industries and academic institutions become one of the solutions for enhancing EE education (Martins, M. J., Lopes, F., Fonseca, I., Ferreira, C. M., & Barbosa, F. M., 2014).

Providing a high-quality education is very challenging for educators. To check whether the education program is in high quality level or not, an assessment should be performed. In year academic 2020/2021 and 2021/2022, the students of Electrical Power Engineering Study Program ITB who taking the Electric Power Plant subject were required to do similar assessments regarding components of a typical steam generator. Unfortunately, the results showed that the student had difficulties to solve the given problem. Considering this issue, a new proposed analogy by conducting practical work will be discussed in this paper. The objective of this practical class is to enhance the students understanding of the work principle of the economizer and what advantages will be gotten by adding economizer in the boiler.

METHODOLOGY

In this study, the students of Electrical Power Engineering Study Program ITB who were taking the Electric Power Plant subject in year academic 2021/2022 and 2022/2023 were required to do similar assessments regarding components of a typical steam generator. Only the students in the year academic 2022/2023 class were requested to perform the proposed practical work before the assessment. Based on the assessment results, both classes will be compared and analyzed.

The proposed practical work adopts one of the common analogies of power plant steam generator is by adopting water kettle as illustrated in Figure 2. In Figure 2(a), thermal energy is produced from wood chemical energy (biomass energy) which is same as in typical biomass boiler. A similar analogy is much simpler by adopting electric stove where the consumed energy is much easier to be measured as depicted in Figure 2(b).

(a) (b)

Figure 2: Boiler analogy

To provide a simple illustration of the working principle of economizer in a boiler, an analogy of Figure 2(b) is adopted by adding additional another daily life stuff i.e. electric water kettle as shown in Figure 3. In the class, students are grouped into four students (maximum) for each group. All groups shall do step by step of two experiments as follows:

A. Experiment I
   a) Material and equipment:
      1. One liter of water
      2. Electric stove
      3. Water kettle
      4. Wattmeter
      5. Infrared thermometer gun
   b) Procedure
      1. Fill the water kettle with 1 liter of water!
      2. Check and note the water temperature by using the infrared thermometer gun!
      3. Heat up the water by turning on the electric stove as illustrated in Figure 3(a)!
      4. When the sound comes out from the water kettle, note the energy consumption that is indicated by the wattmeter and check the water temperature by using the infrared thermometer gun!

B. Experiment II
   a) Material and equipment:
      1. One liter of water
      2. Electric stove
      3. Water kettle
      4. Electric water kettle
      5. Wattmeter
      6. Infrared thermometer gun
   b) Procedure:
      1. Fill the electric water kettle with 1 liter of water!
      2. Check and note the water temperature by using the infrared thermometer gun!
      3. Heat up the water by turning on the electric water kettle for 3 minutes as illustrated in Figure 3(b)!
      4. After 3 minutes, note the energy consumption that is indicated by kWh meter and check and note the water temperature by using the infrared thermometer gun!
      5. Pour the water into the water kettle!

6. Reheat up the water by turning on the electric stove as illustrated in Figure 3(a)!
7. When the sound comes out from the water kettle, note the energy consumption that is indicated by the wattmeter and check the water temperature by using the infrared thermometer gun!

(a) **(b)**

Figure 3: Proposed analogy of boiler economizer

RESULTS AND DISCUSSION

The delivery method of steam generator lecture topic with the proposed analogy has been started to be implemented in 2nd semester academic year 2022/2023. In academic year 2021/2022 and 2022/2023, a same test was given to class students (20 students and 16 students, respectively). Students were asked to distinguish components of a typical steam generator. As described in Figure 4, students of academic year 2022/2023 can correctly identify the superheater, the economizer and the air heater of steam generator much better compared to the previous academic year students. In academic year 2021/2022, the students who could not correctly identify the superheater, the economizer and the air heater are 20%, 45%, and 20% of the total students, respectively. Most of these students have still confused the economizer and the air heater of boiler. These numbers are much improved in the academic year 2022/2023.

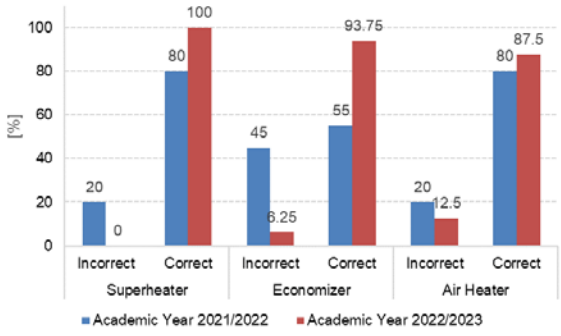

Figure 4: Students capability assessment

In academic year 2022/2023, after having performed the experiment, students were asked to discuss within their group and analyze the experiment results. The objective of this experiment is to provide more understanding for students related to the work principle of economizer and what advantages will be gotten by adding economizer in the boiler. During the group discussion, most students looked very enthusiastic to discuss the given issues. Then, the group discussion results had to be summarized in a written report.

Table 1: Rubric of student assessment

Working Principle	
Unsatisfactory (U)	Student cannot explain the working principle of the economizer
Developing (D)	Student can explain how the fluid temperature in the economizer raises, but he/she cannot explain the advantage of this temperature increase
Satisfactory (S)	Student can explain how the fluid temperature in the economizer raises and the advantage of this temperature increase
Exemplary (E)	Student can explain how the fluid temperature in the economizer raises, the advantage of this temperature increase, and its improvement to system efficiency
Energy Consumption Calculation	
Unsatisfactory (U)	Student cannot calculate the system energy consumption
Developing (D)	Student can identify all parameters for the calculation of system energy consumption, but he/she cannot finish the calculation
Satisfactory (S)	Student can identify all parameters for the calculation of system energy consumption and finish the calculation
Exemplary (E)	Student can identify all parameters for the calculation of system energy consumption, finish the calculation and apply the calculation results to show the system improvement
System Efficiency Improvement	
Unsatisfactory (U)	Student cannot calculate the system efficiency
Developing (D)	Student can identify all parameters for the system efficiency calculation, but he/she cannot finish the calculation
Satisfactory (S)	Student can identify all parameters for the calculation of system efficiency calculation and finish the calculation
Exemplary (E)	Student can identify all parameters for the calculation of system efficiency calculation, finish the calculation and apply the calculation results to show the system improvement

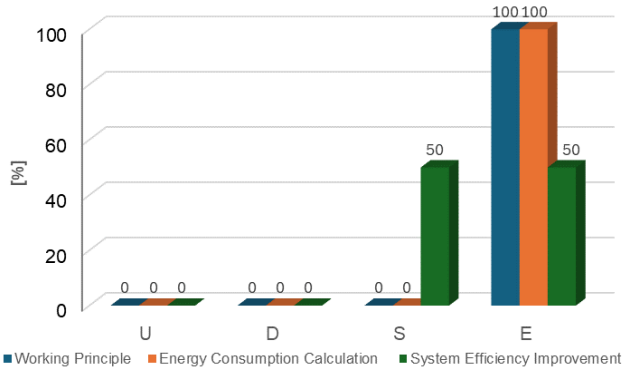

Figure 5: Students assessment results

To assess the student's capability, a special rubric was developed as described in Table 1 based on group reports. The assessment results are described in Figure 5. It shows that all students have capability at exemplary level for the given assessments, *except* for system

efficiency improvement assessment which half of students have capability at satisfactory level (instead of 100% in exemplary level).

CONCLUSION

An analogy by conducting practical work was proposed in this paper. The students who conducted the proposal practical class have demonstrated much better understanding compared to the students who took the same subject in the previous academic year. Almost all students showed exemplary level capability for given rubric assessments. The rubric assessments were designed to check the student's capability in recognizing the working principle, the energy consumption calculation, and the system efficiency improvement of boiler economizer. All assessment criteria were fulfilled very well by all students. Moreover, more than ninety percent of students could identify the economizer, one of important components in a boiler, correctly. Whereas only fifty five percent of students who do the same in previous academic year.

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Published August 30, 2024 by
Science Education Association (Thailand)
Sukhumvit 23, Bangkok, 10110, THAILAND
Tel: 66-2204-2528 Fax 66-2204-2528