

Exploring the Impact of E-Portfolio Reflections on Learning Efficiency and Cognitive Loads among Thai Undergraduate Students

Chain Chuanchom¹, Peerada Wichamuk¹, & Pariwat Imsa-ard²

¹ Faculty of Education, Ramkhamhaeng University, Thailand

² Faculty of Liberal Arts, Thammasat University, Thailand

Correspondence: Pariwat Imsa-ard, Thammasat University, Thailand. Email: pariwat.i@arts.tu.ac.th

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Abstract

The disparity between theoretical knowledge and practical application in undergraduate education poses a formidable challenge, potentially burdening students' cognitive load. In response, e-portfolios have emerged as a promising solution, capable of fostering self-directed learning and promoting students' ownership of the quality of their educational outcomes. This study investigates the impact of employing e-portfolios for reflective practices on learning efficiency and cognitive load among Thai undergraduate students. The sample comprised twenty English major undergraduates selected through purposive sampling from a university in Thailand. Employing a mixed-methods experimental design, the intervention involved incorporating reflection activities (i.e., writing a learning log) through e-portfolios. Pre- and post-tests, coupled with a cognitive load survey, were administered, while qualitative data were collected to delve into participants' attitudes and perspectives. The results revealed a significant improvement in post-test scores when compared to pre-test scores (Cohen's $d = 0.891$), underscoring the substantial impact of the intervention. Additionally, the average cognitive load exhibited a decrease in intrinsic and extraneous load, while the automatic load remained unchanged. In addition, student interviewees believed that reflections through e-portfolios could help them learn better, but also expressed some issues with its utilization. However, a small sample could influence the generalizability. These findings hold practical implications for leveraging reflection through e-portfolios to enhance learning efficacy, promote a comprehensive understanding of lessons, and foster self-monitoring of academic progress.

Keywords: reflection, cognitive loads, learning efficiency, undergraduate level, higher education

1. Introduction

In the realm of higher education, the primary objectives revolve around nurturing students' knowledge and skills, ultimately producing graduates equipped with critical thinking abilities. In Thailand, the Ministry of Education (2019) has delineated the desired attributes for graduates (referring to those who completed the program) in the field of teacher education, emphasizing analytical thinking, knowledge synthesis, evaluation, and the effective application of knowledge in professional teaching practice. In today's digital era, additionally, it is essential for graduates to not only possess traditional knowledge but also be well-versed in digital literacy, media literacy, and cutting-edge technologies. This shift towards a digital landscape has made the practical application of knowledge a central focus in contemporary teaching and learning practices, as emphasized by Bell and Morse (2013). This emphasis on practicality is particularly significant for student teachers who are entrusted with the responsibility of translating their acquired skills and knowledge into effective teaching methods. Within educational contexts, the concept of "learning efficacy" assumes a critical role, referring to individuals' capacity to both acquire and apply knowledge and skills (Libii, 2007; Ma et al., 2023; Schunk & Ertmer, 2000). A higher level of learning efficiency signifies effective learning and application, indicating that individuals can achieve desired learning outcomes with greater effectiveness. Conversely, lower learning efficiency suggests that more time or effort may be required to attain the desired learning outcomes. This paradigm underscores the importance of not only acquiring knowledge but also applying it effectively in the ever-evolving digital landscape. However, previous research (e.g., Jakobsen et al., 2021; McNiff, 2006; Peiser et al., 2023; Ribaeus et al., 2022) has revealed that student teachers often encounter difficulties when attempting to apply theoretical knowledge to practical situations. Notably, student teachers struggle with the inconsistency and mismatch between theory and practice, particularly concerning the integration of technology in classrooms, despite its prevalent use in the learning process.

Furthermore, to support students learning, educators must devise appropriate learning processes and assessment methods to support learners in the new normal situation precipitated by the COVID-19 pandemic, promoting the acquisition of knowledge and skills resilient in real-world scenarios. Consequently, traditional instruction and assessment may prove suboptimal for facilitating learning in the new normal. Innovative approaches, such as assessments and evaluations emphasizing complex thinking skills and self-cooperative assessment, are crucial for fostering long-term learning. Authentic assessment and formative assessment, for instance, have gained widespread adoption, with portfolios serving as a comprehensive method of compiling evidence of learners' knowledge and skills in the assessed domain (Gok & Ayaz, 2021; Lam, 2020; McDonald, 2012). Portfolios, systematically employed in education over the past few decades,

provide a collection of students' academic work intended to inform their progress and achievements (Contreras-Soto et al., 2019; Sanjaya et al., 2022). By identifying students' weaknesses, promoting teaching for understanding, actively involving students, and enhancing their motivation, formative assessment has the potential to enhance learning gains (Xiao et al., 2022). Furthermore, the integration of reflective practice within portfolios encourages learners to reflect on their comprehension of the learning materials, fostering self-directed learning and instilling responsibility for the quality of their learning outcomes, as learners actively participate in assessing and making decisions about their own progress (Arnold & Savleski, 2020; Dumlao & Pinatacan, 2019; Krishnan & Yunus, 2017).

Given the rapid evolution of educational technology, the integration of novel applications into the instructional framework has become not only essential but imperative (Suskie, 2018). This shift has catalyzed the development of e-portfolios, digital renditions of conventional learning portfolios (Al-Naibi et al., 2018; Newbery, 2002). With their ability to present reflections in versatile formats, e-portfolios have the potential to revolutionize the landscape of teaching and learning. The overarching goal of incorporating reflections through e-portfolios is to empower students in synthesizing new knowledge and forging meaningful connections between their educational experiences. However, it is crucial to acknowledge that the assimilation of new information can exert substantial cognitive demands. In this context, leveraging e-portfolios for reflective journals has been demonstrated to mitigate cognitive load, thereby fostering a positive impact on the learning process and enhancing long-term knowledge retention among learners.

Considering these critical aspects, this research endeavors to delve into the nuanced ways in which e-portfolio reflections influence the learning efficacy and cognitive loads of undergraduate students in Thailand. In light of this objective, this study proposes the utilization of e-portfolio reflections as a strategic tool to facilitate students' learning, with a specific focus on alleviating cognitive burdens (Shepherd & Bolliger, 2011). By probing into the multifaceted impact of e-portfolios on cognitive processes, this research seeks to provide empirical insights that can potentially inform and shape pedagogical practices in the contemporary educational contexts.

2. Literature Review

2.1 Reflection and ePortfolio

There have been several scholars providing definitions of 'reflection', with Dewey being one of the first to conceptualize it. Dewey defines reflective thinking as a comprehensive consideration and contemplation of beliefs or knowledge based on supporting evidence, including appropriate problem-solving. Furthermore, Horton-Deutsch and Sherwood (2008) assert that reflective thinking is a learning management method that enhances learners' abilities to comprehend, dissect, and articulate the situations that occur, enabling learners to adjust their perspectives. This necessitates learners' active participation in events or experiences, which facilitates a critically analytical approach to activities. In addition, Armstrong et al. (2017) have expanded the concept of reflective thinking to encompass an evaluative and integrative analysis between learners' experiences that relate to the occurring events, resulting in a thoughtful and reasoned ideation for the learners. Clearly, reflective thinking is a process wherein learners engage in critical contemplation and introspection regarding their thoughts, beliefs, attitudes, and actions in various situations, incorporating multiple perspectives. It involves reasoning to support claims, fostering an understanding of the phenomenon, and being conscious of one's actions and the significance within the context of the learning experience. This heightened awareness aids in the development of a plan for one's future self-improvement. From the aforementioned study, it can be concluded that reflective thinking refers to the reflection of actions that practitioners can perceive about themselves within the context of their own experiences. This is achieved through the process of confronting, understanding, and resolving both anticipated and actual problems arising from one's own practice.

Presently, the use of portfolios has gained popularity as it enables the assessment of students' learning through authentic assessment. This method involves the consideration of collected works and reflective thinking that demonstrate the real-life learning process. The advancement and easy accessibility of technology have significantly contributed to the facilitation of the learning management process, including the development of electronic portfolios (e-portfolio, hereafter). Barrett (2002) defines electronic portfolios as the utilization of technology and electronics to develop portfolios that reflect students' learning achievements and progress. Additionally, a proposed five-step process for the development of electronic portfolios includes establishing goals and content, portfolio creation, self-reflection, designing portfolio connections, and presenting the portfolio. Furthermore, Woodward and Nanlohy (2004) have highlighted the benefits of electronic portfolios, emphasizing that they allow viewers to gain a more comprehensive understanding of the achievements and development of the portfolio creators. This is attributed to the fact that the creators compile diverse data and accumulated information. According to Zhang and Tur (2022), an e-portfolio serves as a comprehensive digital collection of diverse artifacts that serve as evidence of learning. These artifacts can be effectively employed in various educational contexts such as teaching, learning, assessment, and presentation. E-portfolios focus on the journey of skill development, emphasizing the process of learning, tracking progress, and celebrating achievements. Additionally, they require individuals to engage in self-regulation, self-reflection, and self-evaluation. E-portfolios prompt students to reflect on their knowledge, academic training, and professional prospects. Teachers utilizing e-portfolios gain deeper insights into their students' learning and assessment processes, becoming more actively engaged in their students' educational journeys (Acker, 2005; Barrett & Carney, 2005). The primary purposes of e-portfolio systems revolve around storing and reflecting on students' learning progress from the beginning to the end of a course (Chang et al., 2014). In addition, Chen et al. (2012) suggest that e-portfolios can assist students in learning and career development. To facilitate effective reflection and learning, e-portfolio assessment environments should incorporate explicit guidelines and explanations for portfolio creation, goal-setting guidelines, work submissions, appropriate assessment rubrics, and teacher assessments (Chang & Wu, 2012). Moreover, reflection within e-portfolios can be presented in flexible ways, revolutionizing teaching and learning practices. One of the significant objectives of reflections via e-portfolios is to aid

students in constructing new knowledge and establishing connections between their learning experiences. However, the intake of new knowledge can impose cognitive demands, which will be discussed in the next section. Therefore, based on literature, it can be concluded that an electronic portfolio refers to a system that aids in the creation and dissemination of one's own portfolio in the form of an online system through online platforms. The e-portfolio serves as a means to collect and compile works, objectives, and self-reflective feedback through electronic media. In the context of this research, the e-portfolio is defined as a Google Sites system that accumulates and aggregates individual student reflections.

2.2 Cognitive Loads

Sweller (1994) introduced the “Cognitive Load Theory” (Fig. 1), asserting that the cognitive processing of subject matter is influenced by both the difficulty of the learning task and the instructional design. Learning task complexity results in an “intrinsic cognitive load,” while instructional design generates an “extraneous cognitive load.” The remaining capacity of working memory is allocated to generating meaning, also known as “germane cognitive load.” Effective instructional designs aim to minimize extraneous cognitive load, thereby creating space in working memory for meaning-making, i.e., germane cognitive load, which improves learning outcomes (Jo & Kim, 2020; Sweller, 2016). Employing various methods and techniques can mitigate the impacts of overlapping cognitive load and enhance learners’ effectiveness (Aldalalah, 2021; Ercan, 2014). Advancements in cognitive neuroscience and psychology have contributed to a deeper understanding of the unique features of human cognition, which are now considered when designing effective learning and teaching processes (Dönmez et al., 2022). In addition, Kelly et al. (2022) suggested that pedagogies should support and facilitate cognitive and behavioural engagement and learning. Based on the use of reflective journals through e-portfolios, it can be observed that engaging in reflective journals facilitated learners in self-reflection, enabling them to identify their strengths and weaknesses through the act of recording and reflecting. Consequently, this process also empowers learners to leverage the insights gained from reflection to enhance their own learning experiences, ultimately leading to improved academic performance. Moreover, the utilization of e-portfolios for reflective journals also alleviated cognitive load, positively impacting the learning process and fostering long-term retention in learners. Therefore, this study was built upon several key concepts and theories related to reflection and cognitive loads. Sweller’s (1994, 2016) Cognitive Load Theory (CLT) serves as the foundation, as it posits that the cognitive processing of educational material is intricately shaped by the complexity of the learning task and the manner in which instructional materials are designed. In the context of e-portfolios, CLT suggests that the design of reflection activities and the presentation of information within e-portfolios should be optimized to minimize extraneous cognitive load while enhancing germane cognitive load, thereby promoting more efficient learning.

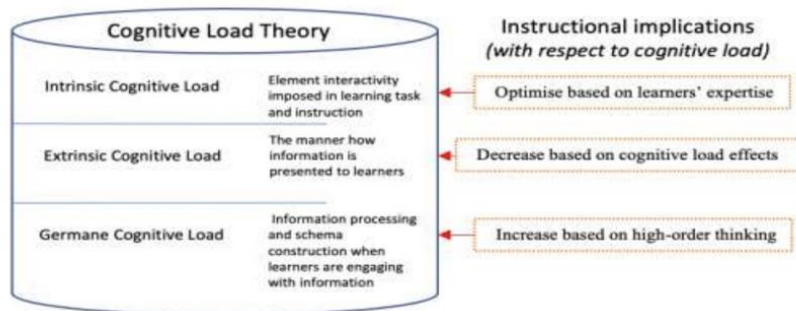


Figure 1. Cognitive Load Theory

Presently, research concerning e-portfolios and cognitive load is relatively limited. However, Shepherd and Bolliger (2011) have examined the impact of e-portfolios on cognitive load and found that e-portfolios have a minimal effect on cognitive load while being able to promote cognitive load and facilitate learning. Additionally, Bradford (2011) studied the relationship between online learning and cognitive load among 1401 students, revealing that online learning can enhance cognitive load, thereby promoting learning. Furthermore, Händel et al. (2020) investigated weekly reflective thinking through electronic portfolios and its effects on exam performance among 1469 students. The study found that consistent reflective thinking through the use of electronic portfolios positively influenced exam performance, with one of the reasons being the promotion of cognitive load. Due to the relatively limited research on cognitive load, especially concerning reflective thinking through e-portfolios, there is a particular interest in exploring this topic. This exploration aims to enhance the learning process for students and contribute to the relevant literature in the field. Drawing from Cheng and Chan’s (2019), Finlay (2008), Forrest (2008), and Reis et al.’s (2010) reflective practice, this framework emphasizes the importance of reflection in learning. Reflective practice involves the critical examination of one’s experiences and the generation of new knowledge from these reflections. With this, fostering reflective practices among students can enhance their ability to connect prior experiences with new information, leading to deeper understanding and more efficient learning processes. By integrating these theoretical frameworks, this research aims to explore how e-portfolio reflections influence the learning efficiency and cognitive loads of Thai undergraduate students. With this concern, in this study, e-portfolio reflections are proposed as a means to facilitate students’ learning, particularly in terms of their cognitive loads (Shepherd & Bolliger, 2011).

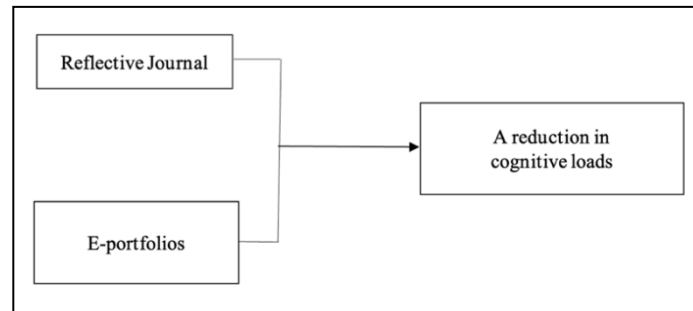


Figure 2. Research framework

With the COVID-19 pandemic necessitating online teaching and learning and the ongoing reliance on technology in post-pandemic education, e-portfolios prove appropriate and effective for fulfilling the needs of online learning management. However, there is still a scarcity of research on the effects of e-portfolio reflection on learning efficiency and cognitive load, particularly within the context of teacher education in Thailand, with existing studies primarily focusing on nursing students (e.g., Chang et al., 2019; Hj. Ebil et al., 2020) and medical students (e.g., Greviana et al., 2020; Santiworawut et al., 2020). Furthermore, while there is existing evidence supporting the positive impact of written reflections on learning efficacy, the specific influence of reflective writing within e-portfolios on cognitive loads in English as a Foreign Language (EFL) contexts remains unexplored. Given this knowledge gap, the researchers aimed to examine the effects of e-portfolio reflection on both learning efficiency and cognitive loads among Thai undergraduate students. The findings of this study are expected to provide valuable insights and guidance for enhancing learning and implementing effective assessments in similar educational contexts. Therefore, this study seeks to address the following research questions:

1. To what extent does reflection through e-portfolio affect students' learning efficiency?
2. To what extent does reflection through e-portfolio affect the students' cognitive loads?
3. What are students' perspectives towards reflection through e-portfolio?

3. Research Methodology

3.1 Research approach

This study employed a one-group quasi experimental research design with two phases: intervention in quantitative research, and qualitative research. This study involved the collection of quantitative data, followed by qualitative inquiry (Creswell & Creswell, 2018). Consequently, a quasi-experimental approach was used to answer the first research question (RQ), whilst a subjective cognitive load measure and focus group interviews were used to answer the second and third RQs, respectively. In the first phase, a quantitative part comprises an intervention involving reflection through an e-portfolio, with data collected from a pre-test, a post-test, a pre-cognitive loads scale, and a post-test cognitive loads scale. After implementing reflection through e-portfolios with the participants, qualitative research was carried out to collect qualitative data, including attitudes and views. With a priority given to the quantitative approach, quantitative data were analyzed to examine the effects of reflection through e-portfolio on students' learning efficacy and cognitive loads. Then, qualitative data were analyzed to provide a more comprehensive explanation for the quantitative results.

3.2 Research design

This study conducted through a one-group quasi experimental research design, combining quantitative measures such as pre- and post-tests and a cognitive load survey, with a qualitative data collection method like interviews. This comprehensive approach facilitated a deeper exploration of participants' attitudes, perspectives, and learning experiences related to the use of e-portfolios. By employing a rigorous research design and utilizing both quantitative and qualitative methods, this study aims to provide valuable insights into the effects of e-portfolio reflection on learning efficiency and cognitive load among Thai undergraduate students. The findings will contribute to the existing body of knowledge and have practical implications for enhancing learning outcomes, comprehension, and self-monitoring of progress in similar educational contexts.

3.3 Participants

This study targeted Thai undergraduate students specializing in English at a semi-open university in Thailand. The participant pool consisted of 20 undergraduates enrolled in the Language and Culture for English Language Teaching course during the first semester of 2022. The selection of participants was carried out using purposive sampling methodology. This approach was chosen because it allowed the researchers to handpick individuals who possessed the specific characteristics required to fulfill the study's objectives. As highlighted by Ary et al. (2006), purposive sampling enables the identification of participants who can offer comprehensive insights into the research topics under scrutiny. This deliberate selection aimed to capture a diverse range of perspectives and experiences relevant to the research objectives. By including individuals with varying backgrounds, knowledge levels, and perspectives, the study sought to obtain a comprehensive understanding of the impact of e-portfolios on learning efficiency and cognitive load among Thai undergraduate students.

3.4 Context

This study was conducted at a Thai university that features a distinctive semi-open system. The university offers a four-year bachelor's degree program in teacher education. The program specifically admits candidates who have successfully completed their high school. As per the requirements set by the Teachers' Council of Thailand, students are expected to complete a range of language and education courses. In the final year of their studies, students engage in a teaching practicum as part of their coursework. This two-semester practicum is a mandatory component for pre-service student teachers, providing them with an opportunity to apply and critically examine the knowledge and theories acquired during their coursework. The objective of the teaching practicum is to bridge the gap between theoretical concepts and practical implementation, offering students authentic teaching experiences. By actively participating in teaching practice, students can assess the relevance and effectiveness of their coursework in real-world settings. This practical experience nurtures their professional development and prepares them for their future teaching careers.

Table 1. Demographic data of participants

Genders	No.	Percentage
Male	3	15.00
Female	17	85.00

As shown in Table 1, the majority of participants ($N=17$) were female, whereas there were only three male students ($N=3$). All twenty participants registered in the course in their final year of coursework prior to commencing a teaching practicum; as a result, they have all passed the prerequisite courses, making them relatively proficient in the major-related courses.

3.5 Research Instruments

In this study, there were four research instruments: 1) e-portfolio, 2) pre- and post-tests, 3) a subjective cognitive load measure, and 4) focus-group interviews.

3.5.1 E-portfolio

The e-portfolios utilized in this research employed Google Sites as a platform for weekly lesson reflections. Google Sites was chosen due to its accessibility and availability as a free tool, as the research institution utilized Google Sites as its learning management system. The researchers assessed the participants' reflections based on the alignment with the study objectives and established criteria to monitor and evaluate students' learning progress. To ensure clarity and consensus, participants received training on how to effectively engage in reflection using e-portfolios. Furthermore, a comprehensive manual for creating e-portfolios on Google Sites was developed by the researchers, and its content validity, language, appropriateness, and accuracy were verified through expert evaluation by computer education specialists with over five years of experience.

For the reflective evaluation criteria, the researchers adapted and modified existing frameworks from Cheng and Chan (2019) and Reis et al. (2010). To ensure the content validity of the criteria, three experts with extensive backgrounds in applied linguistics and language education were invited to review and validate them. Based on the expert recommendations, the reflection evaluation criteria were refined. Subsequently, a pilot study was conducted with non-participant students possessing similar qualifications to the research group to assess the suitability and reliability of the revised criteria. The final version of the criteria was then employed in the actual research study. The criteria included:

- **Writing style:** Learners must be able to demonstrate a thorough understanding of their own reflection and the ability to apply their learning experience in writing.
- **Reflection ability:** Learners must be able to demonstrate both critical thinking skills and reflective understanding of the subject matter being studied.
- **Meaning-making ability:** Learners must be able to thoroughly analyze a variety of topics and make sense and meaning of what they have learned.

3.5.2 Pre- and post-tests

The researchers used pre-test and post-tests from the course to determine students' learning efficacy. The test is consistent with the course description and course objectives. The topics in the test included:

- English language and its culture
- Language and culture for English language teaching
- Awareness of cultural diversity

Participants were administered the pre-test in the first week of the course. The researchers utilized the end-of-semester 2022 achievement test for the post-test. Three experts with at least five years of experience teaching English and teaching language and culture were invited by the researchers to validate the content validity and language of the tests using the Index of Item Objective Congruence (IOC).

- If the IOC is more than 0.50, then the items correspond to the actual objectives.
- If the IOC is less than 0.50, then the items do not align with the actual objectives.

The expert evaluation found that the $IOC = 0.835$, which is greater than 0.50, indicates that this test is appropriate and can be used in the

study. The experts also gave suggestions for improvements in various areas, such as editing the language used in the test. After revising the tests based on the suggestions of experts, the researchers carried out a pilot study with 10 students who were not part of the research group but had the same qualifications as the research group in order to determine the tests' reliability. The researchers used the Cronbach's Alpha Coefficient method to determine the internal consistency of the test, and the alpha coefficient of the test was .822, indicating a high level of reliability. In this test, there are three parts with subjective questions: 1. Cultural learning and teaching, 2. Cultural assimilation, and 3. Integrating culture into the lesson. There are a total of six parts totaling 100 points.

3.5.3 Subjective Cognitive Load Measure

In this study, the researchers employed a 5-scale Likert Cognitive Load Scale, which was developed based on previous works by Kanokpermpoon (2019) and Chairat and Chomeya (2020). The decision to utilize these measures was motivated by their demonstrated high reliability (0.815 and 0.92, respectively), their construct validity as established through component analysis, and their alignment with empirical data (Chairat & Chomya, 2020). The scale consists of questions that are categorized into three distinct components, as outlined by Sweller (1994):

- **Component 1:** Intrinsic cognitive loads pertain to the capacity of sensory nerves to overload memory due to the difficulty or complexity of the acquired content. It also encompasses any obstacles that hinder learners' comprehension of challenging material, thereby impacting memory retention.
- **Component 2:** Extrinsic cognitive loads refer to the cognitive burdens imposed on the brain by the instructional methods employed by teachers and learners' attitudes towards them. This component also takes into account instances where instructors use inappropriate instructional media that lacks the necessary balance.
- **Component 3:** Germane cognitive loads arise from the effort required to accumulate and comprehend knowledge, which is stored in long-term memory.

By utilizing this comprehensive scale and its three components, the researchers aimed to capture and evaluate the different dimensions of cognitive load experienced by participants in the study. Three experts with at least five years of experience teaching English and psycholinguistics were invited by the researchers to validate the content validity and language of the cognitive load measure using the Index of Item Objective Congruence (IOC). The expert evaluation found that the $IOC = 0.83$, which is greater than 0.50, indicates that this measure is appropriate and can be used in the study. Moreover, reliability of the cognitive load measure is demonstrated in Table 2.

Table 2. Reliability of a cognitive load measure

Instrument	Cronbach's Alpha	Cronbach's Alpha based on Standardized Items	N of Items
Cognitive load measure	.809	.835	30
Component 1: Intrinsic cognitive loads	.869	.854	11
Component 2: Extraneous cognitive loads	.591	.701	10
Component 3: Germane cognitive loads	.685	.784	10

3.5.4 Focus Group Interviews

After completing the data collection process, the researchers conducted focus-group interviews with the participants to explore the perspectives of undergraduate students on reflection through e-portfolios. The focus-group interview questions are:

1. What do you think about reflecting on the content after learning through Google Site? (*Perspectives*)
2. Do you believe that such practice improves your learning, and if so, how? (*Perceived benefits*)
3. What are your thoughts if, in the future, reflections are used to review knowledge learned through Google Site in other courses? (*Perceived benefits*)
4. Do you encounter any problems in reflecting and summarizing the content after studying through Google Site? (*Perceived challenges*)
5. What recommendations do you have for integrating reflection and summarizing content after Google Site learning? (*Recommendations*)

3.6 Data Collection

In this study, data collection took place during the first semester of the academic year 2022 and was carried out through a series of well-defined stages:

1. The researchers initially informed the participants about the research project and its objectives, emphasizing the voluntary nature of their involvement.
2. In the first week of the semester, participants were instructed to complete a pre-test and a subjective cognitive load measure, providing a baseline for their initial cognitive load experiences.

3. From weeks 2 to 9, participants were actively engaged in reflecting on their learning experiences using Google Sites e-portfolios after each weekly lesson. This allowed for the systematic capture of their evolving reflections throughout the course.
4. In the tenth week, participants were again requested to complete a post-test and a subjective cognitive load measure. This enabled the researchers to compare the participants' cognitive load levels before and after the intervention.
5. In the subsequent week, a focus group interview was conducted, involving five selected participants. The purpose of this interview was to delve deeper into the participants' perspectives, gathering their insights and opinions regarding the process of reflection through e-portfolios.

By implementing this methodical data collection approach, the researchers aimed to obtain comprehensive and meaningful insights into the participants' cognitive load experiences and their perceptions of the reflective practice facilitated by e-portfolios.

3.7 Data Analysis

After data collection was completed, researchers continued to analyze collected data using various kinds of statistics (See Table 3). The researchers estimated the mean scores and standard deviations using the pre- and post-test scores to provide an overview of student learning efficacy. The researchers then used the Wilcoxon Signed Rank Test to the scores obtained from the pre- and post-test in order to examine the effect that reflection via the e-portfolio had on students' learning performance. The Wilcoxon Signed Rank Test was used since the sample size was just twenty participants, prompting a non-parametric test. In addition to the Wilcoxon Signed Rank Test, the researchers adopted Spearman's rho correlation to determine the relationship between post-learning achievement scores and reflection scores.

For the cognitive load measure, the researchers interpreted the cognitive load measure results using the mean scores and standard deviation and their relationship before and after the intervention using Wilcoxon signed rank test. The researchers interpreted the mean scores as follows:

4.21 – 5.00 = very high

3.41 – 4.20 = high

2.61 – 3.40 = moderate

1.81 – 2.60 = low

1.00 – 1.80 = very low

For the qualitative data obtained from the focus group interviews, the researchers transcribed the interviews and used content analysis to analyze, synthesize and consolidate the data. The content analysis involved a systematic examination and interpretation of the qualitative data obtained from the interviews. The goal was to identify recurring themes, patterns, and categories within the data set. This approach allowed for a comprehensive exploration of the participants' perspectives on the topic of interest. In this study, a coding scheme was developed to facilitate the organization and analysis of the interview data. The coding scheme consisted of a set of predefined categories or themes that represented key concepts or ideas related to the research objectives. The coding scheme was created based on an initial review of the interview transcripts and relevant literature.

In the content analysis phase, the interview transcripts underwent a rigorous and systematic analysis, with careful coding applied based on the predefined categories. Each segment of the text was assigned relevant codes that aligned with the identified themes. This meticulous coding approach facilitated the identification of shared patterns, distinctions, and emerging trends in the data. To enhance the reliability of the analysis, three coders independently participated in the coding process, ensuring consistency and reducing the potential for bias.

Table 3. Summary of data analysis

Research questions	Research Instruments	Statistics
1. To what extent does reflection through e-portfolio affect students' learning efficiency?	- Pre-test - Post-test	- Descriptive statistics (mean, standard deviation) - Wilcoxon signed rank test - Spearman's rho
2. To what extent does reflection through e-portfolio affect the students' cognitive loads?	- Cognitive load measure	- Descriptive statistics (mean, standard deviation) - Wilcoxon signed rank test
3. What are students' perspectives towards reflection through e-portfolio?	- Focus-group interviews	- Content analysis

3.8 Ethical Consideration

The study recognizes the potential ethical challenges that may emerge and underscores the significance of addressing these issues proactively to avoid inadvertent harm to the participants. To initiate the research, ethical approval was secured from the Institutional Review Board (IRB) at the university of the first and second authors. In adherence to ethical research standards, securing informed consent from the participants is paramount. Ensuring that participants had a comprehensive understanding of the research objectives, the level of commitment

expected, and the potential benefits is imperative. Additionally, upholding participant confidentiality is a crucial ethical consideration. Preserving the anonymity of the data sources is an integral aspect of the research methodology, aimed at preventing the identification of individuals through the collected data. In this investigation, pseudonyms were employed to mask the true identities of the subjects, reinforcing the commitment to ensuring anonymity. Moreover, the acquired original data will be stored securely to mitigate the risk of data breaches.

4. Findings and Discussion

The purpose of this experimental mixed-methods research was to investigate the effects of reflection via e-portfolios on the learning efficiency and cognitive loads of Thai undergraduates. In this respect, the following findings are presented:

4.1 Students' Learning Efficacy

In this study, scores of the pre-test and the post-test were calculated through descriptive statistics (e.g., mean and standard deviation), and compared by adopting Wilcoxon signed rank test to examine the effect that reflection through the e-portfolios had on students' learning efficacy as in Table 4 below.

Table 4. A comparison of mean scores obtained from the pre- and post-tests

	<i>N</i>	<i>M</i>	<i>S.D.</i>	<i>Z</i> -statistics	<i>Sig.</i>	Effect size (Cohen's <i>d</i>)
Before	20	55.10	14.323	3.717	0.000*	0.891
After	20	70.20	19.944			

* $p < 0.5$

		Ranks		
		<i>N</i>	Mean Rank	Sum of Ranks
After-Before	Negative Ranks	1 ^a	5.50	5.50
	Positive Ranks	19 ^b	10.76	204.50
	Ties	0 ^c		
	Total	20		

- a. After < Before
- b. After > Before
- c. After = Before

Test Statistics^a

	After - Before
<i>Z</i>	-3.717 ^b
Asymp. Sig. (2-tailed)	.000

- a. Wilcoxon Signed Ranks Test
- b. Based on negative ranks.

From Table 4, the results revealed that post-test scores ($M=70.20$, $S.D.=19.944$) were significantly higher than pre-test scores ($M=55.10$, $S.D.=14.323$) at the significance level of .05. It should be emphasized, however, that a p-value reflects only the statistical significance of the relationship between two variables; hence, a p-value can only tell whether the intervention impacts the dependent variable or not. If the same research investigations are replicated, they may return the same findings, but they will not demonstrate how much magnitude of the intervention is (Sullivan & Feinn, 2012). With this concern in mind, the researchers examined the effect size to determine the magnitude of the intervention's effect on the experimental variable. In this study, Cohen's *d* effect size is .891, suggesting a significant effect size (Cohen, 1988). This effect size could also address the issues of weaknesses of a one-shot design.

The findings indicate that reflections through e-portfolios lead to improved learning efficiency since the reflection process encourages students to develop their learning. Hence, learning experiences are correlated with students' learning goals (Turpin & Higgs, 2010). In this aspect, reflection enables students to analyze the lesson and learn concurrently with their learning development (Cassidy et al., 2006). Moreover, writing a reflection after a lesson allows students to review and reflect on their own learning. This is in line with Argyris and Schön (1978) and Gibbs (1988) who indicated that the reflective process takes place by using knowledge, skills, and past experiences to make decisions to solve problems. In addition, Finlay (2008) and Forrest (2008) suggested that reflection might increase learner self-awareness and learning efficacy by strengthening the connection between acquired knowledge and previous experiences. Consequently, reflection may enhance students' ability to think critically and their capacity for continuous learning.

Kolb (1984) indicated that reflections facilitate the creation of abstract concepts and generalization via the process of relearning. Students were required to relearn, reread, and reflect on their own learning in order to generalize the concepts; as a result, their post-test scores were higher than their pre-test scores. This also reflects the study by Han (2014) revealing that, when learners have written and reflected on their own learning for a period of time, they gain more insight and a deeper understanding of that knowledge. Clearly, this study's findings align closely with the theoretical framework, corroborating the assertions made by Cheng and Chan (2019), Finlay (2008),

Forrest (2008), and Reis et al. (2010), who suggested that reflection might increase learning efficacy by strengthening the connection between acquired knowledge and previous experiences.

Table 5. Correlational analysis of post-test scores and reflection scores

Correlations			Post-test	Reflection
Spearman's rho	Post-test	Correlation Coefficient	1.000	.671**
		Sig. (2-tailed)	.	.001
		N	20	20
	Reflection	Correlation Coefficient	.671**	1.000
		Sig. (2-tailed)	.001	.
		N	20	20

** . Correlation is significant at the 0.01 level (2-tailed).

From the Table 5, a correlational analysis of post-test scores and reflection scores using Spearman's rho indicated that there was a positive correlation between post-test scores and reflection scores ($r = .671$), indicating a very high correlation.

Table 6. Correlational analysis of post-test scores and reflection ability

Correlations			Post-test	Reflection ability
Spearman's rho	Post-test	Correlation Coefficient	1.000	.609**
		Sig. (2-tailed)	.	.004
		N	20	20
	Reflection ability	Correlation Coefficient	.609**	1.000
		Sig. (2-tailed)	.004	.
		N	20	20

** . Correlation is significant at the 0.01 level (2-tailed).

From the Table 6, a correlational analysis of post-test scores and reflection scores in the aspect of reflection ability using Spearman's rho indicated that there was a positive correlation between post-test scores and reflection ability ($r = .609$), indicating a rather high correlation.

Table 7. Correlational analysis of post-test scores and a meaning-making ability

Correlations			Post-test	Meaning-making
Spearman's rho	Post-test	Correlation Coefficient	1.000	.517*
		Sig. (2-tailed)	.	.020
		N	20	20
	Meaning-making	Correlation Coefficient	.517*	1.000
		Sig. (2-tailed)	.020	.
		N	20	20

* . Correlation is significant at the 0.05 level (2-tailed).

From the Table 7, a correlational analysis of post-test scores and reflection scores in the aspect of a meaning-making ability using Spearman's rho indicated that there was a positive correlation between post-test scores and meaning-making scores ($r = .517$), indicating a moderate correlation.

In short, post-test scores were significantly higher than a pre-test score at the significance level of .05 with a large effect size. Moreover, there were a very high and positive correlation between post-test scores and reflection scores, a rather high and positive correlation between post-test scores and reflection scores, and a moderate and positive correlation between post-test scores and meaning-making scores.

From these findings, they seem to be in line with Park et al. (2008) indicating that the learning outcomes of students are enhanced by systematic reflection and frequent knowledge review. Moreover, Chou and Chang (2011) affirm that there was a positive correlation between learning achievement and reflection skills, and Chang et al. (2014) support that reflection skills have a direct correlation with achievement tests and learning achievements. Furthermore, learning achievement and reflective skills are correlated due to the fact that reflection allows students to assess and reflect on their own thoughts. With this concern, reflections could be useful for learning (Etkina et al., 2010; Quinton & Smallbone, 2010). In addition, Gibson et al. (2001) and Yancey (2001) demonstrate that reflective writing also

increases students' literacy and enhances students' self-learning efficiency. However, these findings must be interpreted with caution because of possible methodological differences – such as designs and data collection – in those studies and this study.

4.2 Students' Cognitive Loads

In this study, the researchers interpreted the cognitive load measure results using descriptive statistics (e.g., mean scores and standard deviation) and inferential statistics (i.e., Wilcoxon signed rank test) to examine their relationship before and after the intervention whether reflections through e-portfolio affect the students' cognitive loads or not. The results of data analysis are described in Table 8.

Table 8. Students' cognitive loads before and after the intervention

Cognitive loads (N=20)			Ranks		Test Statistics	
Measures	M	S.D.	Mean Rank	Sum of Ranks	Z	Asym. Sig. (2-tailed)
Intrinsic cognitive load status						
Before	4.054	.388	10.50 ^a	210.00	-3.931	.000
After	3.618	.697				
Extraneous cognitive load status						
Before	4.525	.192	7.00 ^a	91.00	-3.190	.001
After	4.255	.401				
Germane cognitive load status						
Before	4.065	.201	10.50 ^b	210.00	-3.932	.000
After	4.520	.278				

a. After < Before

b. After > Before

c. After = Before (No Differences)

As shown in Table 8, the comparison of intrinsic cognitive load statuses between before and after an intervention revealed that the mean score of an intrinsic cognitive load status after the intervention was significantly lower at significance level of .05, indicating there was a reduction in the intrinsic cognitive load status. Moreover, the comparison of extraneous cognitive load statuses between before and after an intervention revealed that the mean score of an extraneous cognitive load status after the intervention was significantly lower at significance level of .05, indicating there was a reduction in the extraneous cognitive load status. In addition, the comparison of germane cognitive load statuses between before and after an intervention revealed that the mean score of a germane cognitive load status after the intervention was significantly higher at significance level of .05, indicating there was no reduction in the germane cognitive load status.

From the aforementioned results, after implementing e-portfolio reflection, both the intrinsic cognitive load status resulting from content difficulty and the extraneous cognitive load status resulting from memory overload of the participants could decrease. This finding seems to support a previous work of Shepherd and Bolliger's (2011), demonstrating that the adoption of e-portfolios did not increase cognitive loads of students. Possible explanations for these results include the fact that the platform used in this research, i.e., Google sites, was comparable enough to word processing for skills to be easily transferred. Germane cognitive load after the intervention was significantly higher, meaning that there is there was no reduction in the germane cognitive load status. To elaborate, germane cognitive load refers to the process of long-term memory (Labmala, 2012). With this in mind, the higher mean scores on the status of germane cognitive loads after the intervention were the consequence of students' attempts to retain and learn the knowledge so that they might be stored in long-term memory. The instructors might conduct an analysis of students' prior knowledge (schemata) related to the subject matter in order to manage and deliver more relevant teaching and learning for students. Significantly, the study's findings on cognitive loads resonate with Sweller's (1994, 2016) propositions in the theoretical framework, substantiating their enduring value in understanding that cognitive loads can be shaped by instructional materials are designed. Of which, the design of reflection activities and the presentation of information within e-portfolios in this study could minimize extraneous cognitive load while enhancing germane cognitive load, thereby promoting more efficient learning.

4.3 Students' Perspectives towards Reflection through e-Portfolio

A preliminary conclusion may be drawn from quantitative data that reflections via e-portfolios may assist in reducing the cognitive load produced by content difficulty and memory overload. To support the findings of this study, the researchers performed a focus group interview with five participants to investigate their attitudes and perspectives towards reflection through e-portfolios.

Regarding their thoughts on reflections using e-portfolios, most students reported favourable attitudes towards reflection through e-portfolios as they indicated:

"I think it is a good idea to have reflections through e-portfolios, because it helps me summarize and review the lesson learned. This is also easy for me to go back and study for the exam too." (Student A)

“Reflections through e-portfolios allowed me to review what I have learned and, I believed, they could help me recall the content more easily.” (Student B)

“I think writing a reflection is one of the effective ways to assess and monitor our own learning. Writing a reflection allows me to review, analyze and synthesize what I have learned and enables me to systematically link it to my own experience.” (Student C)

“Writing a reflection not only helps me to review the lesson, but it also enables me to find the gap in learning and what should be improved.” (Student D)

Moreover, students believed that reflections through e-portfolios could help them learn better.

“In my opinion, it helps me learn better because it allows me to go back and review the lesson. This allows me to see what I missed from the class when writing a reflection.” (Student E)

“I agree with [Student E] that writing a reflection helps us learn better. Writing a reflection allows me to recall and note down what I have learned. If I do not get chances to reflect my own learning, I would forget and be unable to recall it when needed. Also, writing a reflection can help me visualize the overview of the lesson more clearly.” (Student C)

However, some students reported some issues about the utilization of reflections through e-portfolios in the future.

“Writing a reflection on e-portfolios is relatively new to me, and that is why I enjoyed doing it. With this, I started to question if we will still enjoy it when we are used to doing it. Will it be a burden like homework?” (Student B)

“I really like the way the instructor requested everyone to share their Google Sites. This helps me a lot in the way that we could also learn from others’ reflections. It is like peer-learning. If it is possible, I would suggest that we should be able to comments on our peers’ reflections so that we learn more from peers.” (Student A)

From the focus-group interviews, some students reported that the possibility to view reflections in peers’ e-portfolios is comparable to peer learning and encourages enhanced learning. This finding corroborates Chang et al. (2014) indicating that students’ learning skills improve when they spend time learning from peer reflections, since reading and learning from peer reflections increase their awareness of what needs to be learnt. In addition, since students are required to reflect through e-portfolios, they are able to gather, access, and present their work more systematically, which is advantageous for peer-review and peer-learning. This is in line with Shroff et al. (2011) who indicated that reflection on e-portfolios enables students to self-assess in order to recognize their own strengths and weaknesses as well as opportunities to develop. It can also be seen that these research findings lend support to the established theories of Finlay (2008) and Forrest (2008), reinforcing their applicability in the current context. To elaborate, Finlay (2008) and Forrest (2008) suggested that reflection might increase learner self-awareness and learning efficacy; thus, reflection may enhance students’ ability to think critically and their capacity for continuous learning.

5. Conclusion

This study aimed to investigate the impact of reflection through e-portfolios on the learning efficiency and cognitive load of Thai undergraduate students. A purposive sample of twenty students majoring in English language teaching from a Thai university, enrolled in a Language and Culture for English Language Teaching course in the first semester of 2022, participated in this mixed-methods experimental study. The intervention involved the use of e-portfolios as a platform for reflection, alongside pre- and post-tests and a cognitive load survey. Following the intervention, focus-group interviews were conducted to gather students’ perspectives. The analysis revealed a significant increase in post-test scores compared to pre-test scores, indicating improved learning outcomes. Cohen’s *d* effect size of 0.891 further supported the substantial impact of the intervention. Moreover, the average cognitive load levels demonstrated a reduction in intrinsic and extraneous load, along with changes in germane load. Regarding students’ perceptions, most students reported favorable attitudes towards reflection through e-portfolios and believed that such reflections could help them learn better. However, some students expressed concerns about the future utilization of reflections through e-portfolios, questioning whether it might result in additional burdens, akin to homework assignments.

6. Pedagogical Implications

The findings of this study have significant implications for educators, both theoretically and practically. Firstly, the integration of reflection activities through e-portfolios has shown to enhance students’ learning efficacy. Educators should recognize this and encourage students to participate in reflective practices more consistently. By guiding students through structured reflection processes, educators can assist them in deepening their understanding of course content and improving their academic performance. Additionally, e-portfolios can act as a platform for students to engage in self-reflection, allowing them to identify areas for improvement and develop strategies to enhance their learning. It is imperative for educators to stress the importance of metacognitive awareness and provide support to facilitate students’ reflection on their learning experiences. This approach can lead to continuous academic improvement and a deeper comprehension of course concepts.

Furthermore, in terms of fostering self-monitoring and self-directed learning, e-portfolios empower students to monitor their own learning progress and take control of their learning journey. Educators should motivate students to establish learning goals, monitor their progress, and adapt their strategies accordingly. By cultivating self-monitoring and self-directed learning skills, educators enable students to become more independent and motivated learners. E-portfolios also offer opportunities for students to share their reflections and learn from their peers' experiences. Educators should create collaborative learning environments where students can engage in peer feedback and discussion within e-portfolio platforms. By promoting a sense of community and collaboration, educators can enhance students' learning experiences and facilitate knowledge sharing among peers.

Regarding assessment, reflections through e-portfolios should be integrated into authentic assessment practices across different subjects. Educators should design assessment tasks that require students to demonstrate their understanding and critical thinking skills through reflective practice. By incorporating e-portfolios into assessment practices, educators can gain valuable insights into students' learning processes and encourage deeper engagement with course content.

In summary, the pedagogical implications of incorporating reflection through e-portfolios are multifaceted, offering educators practical strategies to enhance teaching practices and foster student learning and development. By embracing e-portfolios as a versatile educational tool, educators can create dynamic learning environments that support students' continuous growth and academic success.

7. Limitations and Recommendations

While this research uncovers the potential benefits of e-portfolio reflections in reducing cognitive loads and enhancing students' learning efficacy, it is important to acknowledge its limitations. The selection of teacher students pursuing a bachelor's degree in English language teaching as the target group restricts the generalizability of the findings. Additionally, this study relied on a single intact group with a small sample size ($N=20$), which limits the external validity of the results. The absence of a control group in classroom research raises concerns about establishing causality. Without a control group, it becomes challenging to ascertain whether the observed changes can truly be attributed to the intervention or if they are influenced by external factors. Therefore, it is imperative to include a control group in future research to ensure a rigorous and valid research design. Furthermore, this study examined the impact of e-portfolio reflections on student learning efficacy and cognitive load immediately after a semester. By addressing these limitations and incorporating the suggested improvements, future research can provide a more comprehensive understanding of the benefits and potential applications of e-portfolio reflections in various educational contexts.

8. Recommendations for Future Research

With the acknowledged limitations, future research should encompass participants from diverse academic disciplines and educational levels. Moreover, with a lack of a control group, to enhance the robustness of the findings, it is recommended to include a larger sample size and incorporate a control group for comparison when investigating the effects of e-portfolio reflections. In addition, for more precise findings, it is advised that researchers conduct a delayed post-test to assess whether there are any sustained changes in students' cognitive load after a period of time has passed since the semester ended.

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Authors contributions

In this paper, Chain Chuanchom and Peerada Wichamuk took part in conceptualizing the study, develop a proposal, and writing an original draft. Asst. Prof. Dr. Pariwat Imsa-ard took part in conceptualizing the study, designing a methodology, conducting an analysis, and writing an original draft.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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