Harnessing E-Portfolio Creation for Exam Success, Student Engagement, and Satisfaction

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***Abstract*—Incorporating e-portfolio creation into the educational process can result in substantial gains for students. Yet the literature has presented limited empirical evidence on how to implement e-portfolio creation in classrooms. In this mixed-methods study conducted at a public Japanese university, the performance and participation of 17 students in an online Moodle course where e-portfolio creation was the central learning activity were observed and evaluated. The course adopted a new instructional design model (the CLEAR model) that promotes a constructivist, creation-based learning approach. Students were required to create their own e-portfolio using Mahara, discuss peers' e-portfolios, and post written self-reflections on Moodle forums. As a pre-test–post-test intervention, the course significantly increased students' exam scores on the same test, engaged them intensively online and offline without instructor supervision, and was rated as a positive and satisfying learning experience by participants. Practical implications, limitations, and future research directions are discussed in closing.**

Keywords—constructivism, student engagement, student satisfaction, exam success, e-portfolio, Moodle, Mahara

I. Introduction

Constructivism, as a psychological paradigm, has greatly influenced contemporary educational practices that advocate for active learning. Constructivism is an educational philosophy in which people build knowledge and understanding through interactions with their surroundings [1]. Compared with nativist and empiricist approaches, action-based approaches have been deemed an optimal theoretical framework for explaining development and thinking about constructivism; action-based methods can account for the emergence of representation through (inter)action [2]. Among all actions, involving students in creation has been found to boost students' engagement and satisfaction [3], [4]. Teaching examples include undergraduate students' assembly of an open textbook [5], students' co-creation of e-learning materials [6], a group-based mobile application-creating project [7], and weekly writing tasks paired with a final publication containing all students' writing [8]. These activities suggest that learning through creation entails more sensory stimuli and social settings than traditional learning. Along with a growing need to bring students into digital environments, learning by creating with technology is attracting interest from scholars and educators [9].

Augmented reality/virtual reality and the metaverse have begun to enter the classroom [10], [11]. However, most teachers and students only interact with institutional technologies such as course management systems (e.g., Moodle, Blackboard, and Canvas). Japanese universities widely use Moodle for instruction. Yet the platform's lack of long-term storage for learning artifacts is a limitation [12]. Electronic portfolios were introduced in 1999 to circumvent this problem. These portfolios represent digitized collections of artifacts for teachers, learners, and institutes [13]. Proponents of constructivist theory have pointed out that these tools offer opportunities for reflection on the self-regulated nature of individualized learning [14]. E-portfolios have in fact been deemed one of 34 innovative approaches to teaching in higher education [15] and one of 11 high-impact practices that have the greatest influence on students' learning, comprehension, and engagement [16]. Despite having been used in education for decades with well-documented benefits, few studies have provided empirical evidence on how to implement e-portfolios in the classroom [17]–[19].

This study contributes to the literature by presenting an instructional design model that course developers and instructors can use to leverage e-portfolio creation as the primary learning activity on mainstream course management systems. Using a mixed-methods design, the model was employed and evaluated in an ad hoc online course (facilitated via Moodle and Mahara). Rich qualitative and quantitative data were analyzed to assess the course's effectiveness; data sources included assessment scores, Moodle logs and course output, and an online survey. This empirical research provides valuable insight for scholars and educators based on a theoretical framework and practical teaching case. The following question guided this investigation: How does e-portfolio creation affect exam performance, student engagement, and student satisfaction?

II. Literature Review

A. E-Portfolios

An e-portfolio, as a virtual adaptation of a paper portfolio, is a digital collection of learning artifacts from students (e.g., documents, multimedia projects, speeches, images) and related reflections on learning and growth [20]. E-portfolios can be stored on a variety of media including local hard drives, the cloud, and web-based e-portfolio management systems (e.g., Mahara). Managing these portfolios in accordance with goal setting and self-growth can facilitate skill mastery by offering intended recipients (e.g., teachers, peer learners, employers) tangible evidence of learning achievement. E-portfolios serve numerous purposes for both education (e.g., study planning, progress monitoring, feedback and advice provision, learning output portability, and course evaluation) and professional development (e.g., employment and promotion) [9]. Academic settings feature multiple types of e-portfolios, including showcase portfolios to highlight one's accomplishments, learning portfolios to illustrate learning progress and solicit feedback, and assessment portfolios to evaluate creators' competency [9]. Ciesielkiewicz's review of

portfolio categorization [20] revealed the showcase portfolio to be most common [21]–[23].

B. E-Portfolios and Exam Performance

Students' e-portfolio creation can significantly influence their course performance [17]. For instance, the e-portfolio approach in software engineering labs has been shown to lead to higher student grades, with a 40% rise in the number of students passing the course and a 30% increase in the percentage of students receiving better grades compared with previous academic years [24]. Among 144 prospective teachers in Turkey, integrating an e-portfolio application contributed to significant differences in exam scores between the experimental group and the control group [25].

C. E-Portfolios and Learning Engagement

Physical and psychological involvement in the academic experience characterizes students' learning engagement [26]. Using e-portfolios in classrooms encourages students to become behaviorally, cognitively, and affectively aware of the learning process [17]. A number of studies have confirmed the positive impact of this type of portfolio on learning engagement [21], [27]–[29]. Empirical evidence is nonetheless thin, with many effects having been self-reported by students rather than uncovered with validated measures [18].

D. E-Portfolios and Student Satisfaction

When exploring pedagogical issues in e-portfolio use, the teacher is a decisive variable in students' course satisfaction [30]. Instructors' engagement and dedication are significantly and positively related to student satisfaction; meanwhile, the delivery method and teaching tools positively moderate these relationships [31]. Yet teacher involvement is not the sole determinant of successful e-portfolio implementation. Among three activity domains inherent to portfolios (documentation, reflection, collaboration), research suggests that teachers should be involved in collaboration, while reflection can be facilitated by collaboration and mentoring from both peer learners and teachers [32]. Social interaction influences student satisfaction in general [33], and e-portfolio implementation is no exception.

III. Context of Research

Toyohashi University of Technology (TUT) is a national engineering university in Japan. More than 80% of students have directly transferred from 5-year technical colleges (KOSEN). TUT is one of only two Universities of Technology in the country. The institution had roughly 200 faculty members and 2,027 students as of May 2021 (1,176 undergraduate students, 748 master's students, and 103 doctoral students; 277 international students among all). TUT began hosting Moodle on a university-based virtual machine in April 2011. Faculty members can choose to use it but are not required to do so.

To dedicate more resources to e-learning research and practice, TUT established the Center for IT-based Education (CITE) in April 2020. Two additional virtual machines were procured in December 2020 to test the updated design and development of a bundled learning space that is constructed by both the course management system Moodle (version: 3.10.9+) and the e-portfolio management system Mahara (version: 21.10.1). The two platforms were networked via the mapping technique of "Mahoodle," allowing for reciprocal built-in support in the form of single sign-on and content transfer. The Maharaws plugin (https://github.com/catalyst/moodle-assignsubmission_maharaws) was installed on Moodle to facilitate the creation and delivery of Mahara assignments. Moodle's standard logs were activated to store logs, live logs, activity reports, course participation data, and analytics-related statistics.

The CLEAR Project was launched in 2021 to explore online constructivist creation-based learning design and identify course-design and implementing flows to realize this learning approach by incorporating e-portfolio creation into students' online learning experience. The first step was to establish a novel instructional design model to provide an online constructivist creation-based learning experience. This model was subsequently termed the CLEAR instructional design model [34]. CLEAR originally stood for "Create, Learn, Extend, Apply, and Remember" [35]. It was later altered to "Create, Learn, Extend, Apply, and Reflect" [34]. This study is related to the second step, which consisted of validating the model's effectiveness through an ad hoc Moodle course at TUT.

The ad hoc course, *Creative Commons (CC) Licencing: Create, Distribute, and Use Internet Content* was designed to be a one-month self-directed online course, with no synchronous lectures and with instructor availability upon request. After completing the course, students were expected to be able to identify all types of CC licenses; to describe the meaning of each CC license; to differentiate between CC licenses; to be more aware of copyright; to use and share other people's creations appropriately; and to share their own creations appropriately under CC licenses. Table I summarizes the five cognitive elements of the CLEAR model and their corresponding teaching materials and activities within the Moodle course across three phases: pre-course, CLEAR implementation, and post-course.

In the pre-course phase, learners were required to read about the CLEAR model and the course's learning outcomes and to indicate their familiarity with the topic. They were also required to download and install the Safe Exam Browser (SEB)—a browser environment for conducting online exams securely in Moodle—and take the pre-test quiz via the SEB within 20 minutes to display their mastery of the presented information. The pre-test quiz included 19 multiple-choice questions with a total possible score of 20 points, which was not factored into students' final grades. Each student received automatic feedback on their topic comprehension based on their grade boundary: 0%–20% (0–4.0) indicated poor comprehension, 20%–60% (4.1–12.0) indicated low comprehension, 60%–80% (12.1–16.0) indicated moderate comprehension, and 80%–100% (16.1–20.0) indicated high comprehension.

In the CLEAR implementation phase, the course immediately introduced the "Create" element (i.e., the e-portfolio assignment) at the start of students' learning experience. Learners could freely select a tool from a given list: online video, PowerPoint presentation, podcast, blog article, infographic, brochure, or another creation of personal preference. Students were presented with the grading rubrics (Table II) in advance to facilitate creation. Task 1 was associated with a simpler learning activity in Lecture 1, whereas Task 2 was tied to a more challenging learning activity in Lecture 2. Task 3 asked students to inject creativity

into their output. The e-portfolio outputs were required to be published on Mahara.

TABLE I. THE CLEAR INSTRUCTIONAL DESIGN OF THE AD-HOC COURSE

Phase		In theory	In ad hoc course		
			Moodle resources	***Moodle activities***	***Grade#***
Pre-course		(Course orientation and preparation)	Page: Explain the CLEAR model	Choice: Topic familiarity check	
			Page: Explain learning outcomes	Quiz: Knowledge familiarity (Quiz 1)	20*
			URL: Download the Safe Exam Browser	-	
CLEAR implementation	Create	Request that learners create tangible output as assessment material	-	Mahara assignment: Create Mahara page and submit it	30
	Learn	Provide learners with basic knowledge as must-know content	Page: Lecture 1 with video and script (easy)	-	-
			Page: Lecture 2 with video and script (difficult)	-	-
			URL: Link to a collection of website bookmarks	-	-
	Extend	Provide learners with supplementary learning materials to expand their knowledge of the topic	URLs: Eight links to eight chapters of a relevant online open textbook	-	-
	Apply	Allow social feedback on each student's tangible output and facilitate interaction for peer learning	-	Forum (standard forum displayed in a blog-like format): Peer rating and peer commenting on each other's Mahara pages	10
			-	Forum (standard forum for general use): Questions and answers regarding challenges encountered in the course	-
	Reflect	Encourage self-reflection on the whole learning experience.	-	Forum (Q & A forum): Reflecting posts on learning and difficulties in the course	10
				Quiz: Knowledge retention (same test as Quiz 1)	20
Post-course		(Course evaluation)	-	URL: Course evaluation via SurveyMonkey	-

Note: # Full grade is 70; * Not included into the full grade of 70.

In light of students' varied learning commitment, the CLEAR model labeled foundational content as compulsory for all learners ("Learn") and bonus content as optional for learners with stronger abilities and greater motivation to extend their knowledge ("Extend"). Foundational content and bonus content were both based on the open textbook Creative Commons Certificate for Educators, Academic Librarians and GLAM, which is freely available at https://certificates.creativecommons.org/cccertedu. This textbook is also used in the official training programs of Creative Commons, a non-profit organization. Foundational content was presented in two video lectures: Lecture 1 ran for 6 min and introduced CC licences; Lecture 2 ran for 10 min and explained the compatibility of each license and how to apply CC licenses. Each video contained English and Japanese subtitles and scripts to accommodate speakers of either language. The bonus content featured eight URLs that directed learners to supplementary readings in the textbook. The Mahara e-portfolio assignment only evaluated students' comprehension of foundational content.

TABLE II. GRADING RUBRICS FOR THE MAHARA ASSIGNMENT

Task	Task Type	Task description	Grade
1	Easy task	Introduce each CC license in the given CC License Compatibility Chart	10.0
2	Difficult task	Explain the CC License Compatibility Chart with attention to why one license is compatible with some licenses but incompatible with others; explanation is accessible to people new to this topic	15.0
3	Creativity	Output is highly creative	5.0

The "Apply" and "Reflect" activities occurred in Moodle forums. Learners shared a link to their Mahara output in the "Peer interaction on creation task" forum (Forum 1) to exchange feedback and learn from one another. This activity enabled learners to observe their peers' output in order to enhance their own topical comprehension and to refine their personal output prior to submission. Learners could only access the "Reflection in 300 words" forum (Forum 2) after

submitting the Mahara assignment. This activity asked them to compose a 300-word response to two questions: "What have you learned from this unit?" and "Which portion of this unit do you find difficult to understand?" Both forums were configured to only allow learners to view others' contributions after submitting their own. Due to the whole-forum setting requiring peer ratings (Table III), in addition to posting, learners needed to rate at least two other learners' posts in Moodle in order to complete this activity.

TABLE III. PEER-RATING SCALE IN FORUMS OF THE AD HOC COURSE

Peer-rating item	Point
The statement is written in a very clear and understandable way.	2.0
The statement makes connections between concepts, ideas, arguments, etc.	2.0
The statement is friendly.	1.0
The statement introduces new knowledge to me.	2.0
The statement poses at least one question to stimulate community discussion.	2.0
The statement is on topic.	1.0

In the post-course phase, learners were required to complete a post-test consisting of the same 19 questions as the pre-test. They also needed to complete a survey on SurveyMonkey to provide feedback about the course.

IV. METHOD

This study was grounded in a convergent parallel design with mixed methods [36]. On the TUT research site, three methods were used to gather data at roughly the same time. This method is advantageous for validation and confirmation purposes and for triangulation by directly comparing quantitative and qualitative findings [37]. The approach enabled cross-checking of the efficacy of creation-based learning by first measuring the impact of the ad hoc course on students' grades via a one-group pre-test–post-test pre-experimental design. Next, the relationships among creation activities, learning engagement, and student satisfaction were assessed on the bases of Moodle data, course output analysis, and survey data analysis.

Prior to conducting this study, TUT's Human Research Ethics Committee granted ethical approval to engage in human-related research activities. The online ad hoc course solicited participation from TUT students between November and December 2021 via print posters on campus, the CITE e-newsletter, and the email system of the Academic Affairs Office. Students who signed the online consent form were directed to self-enroll in the ad hoc Moodle course. Participants were required to complete the course within one month (January 1–31, 2022) and to submit assignments and exams by the due dates. Learners received incentives in accordance with TUT regulations upon course completion. Thirty out of 39 course applicants enrolled; however, only 17 students finished the course (Table IV).

TABLE IV. PARTICIPANTS' DEMOGRAPHIC PROFILES

Variable	% (N=17)
Gender	
Female	11.8%
Male	88.2%
Age	
18–23	47.0%
24–29	41.2%
30–35	11.8%
Nationality	
Japanese	23.5%
Non-Japanese	76.5%*
Department/Institute	
Mechanical engineering	35.3%
Applied chemistry and life science	23.5%
Computer science and engineering	17.6%
Electrical and electronic information engineering	11.8%
Architecture and civil engineering	11.8%
Liberal arts and sciences	-
Degree Program's Level	
Undergraduate student	58.8%
Master's student	29.4%
Doctoral student	11.8%

Data were gathered from five sources: (a) exam grades on the pre-test and post-test; (b) grade on the Mahara assignment; (c) posts, replies, and ratings in forums; (d) course visit logs; and (e) an online survey (available at: https://bit.ly/3eudGn1) on SurveyMonkey.

A paired samples t test was performed to compare mean differences between pre- and post-test scores. Wilcoxon signed-rank tests were used to identify significant differences between pre- and post-test grades. Moodle log data, forum data, and survey data were plotted concurrently using descriptive statistical analysis.

V. RESULTS

A. Exam Performance

The first column of Table V shows a statistically significant t value given that the p value is less than 0.05 (p = 0.000, $t = -7.416$). A negative t value indicates that the post-test mean grade exceeded the pre-test mean grade. The second column reveals that participants' post-test grades were significantly higher than their pre-test grades ($Z = -3.572$, p = 0.000; t = 16, $r = -0.61$). The r value surpassed Cohen's recommended threshold of 0.5, denoting a significant effect [38]. Overall, the course intervention resulted in a significant increase in exam scores on the same test.

TABLE V. STATISTICAL TEST RESULTS OF PRE-TEST–POST-TEST MEAN SCORES COMPARISON

	Paired samples *t* test	Wilcoxon signed-rank test (Post-test–Pre-test) #
Mean (Pre-test)	8.46	-
Mean (Post-test)	15.45	-
t	−7.416	-
Sig. (2-tailed)	0.000	-
Positive ranks (*T*)	-	16
Z	-	−3.572

Exact *p* (1-tailed)	-	0.000
Effect size (*r*)	-	−0.61 (large effect)

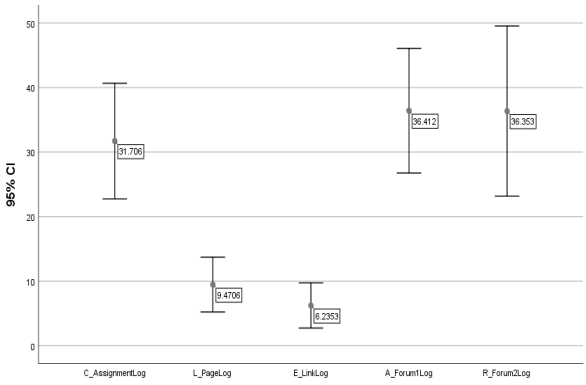
[#] H0: test if 0, H1: test if >0

B. Learning Engagement

Students engaged with the course for an average of 6 hours (*M* = 6.1, range: 1.9–13.4). The frequency distribution of course visit duration was as follows: 0–3 hours (*n* = 2), 3–5 hours (*n* = 6), 5–7 hours (*n* = 3), 7–9 hours (*n* = 1), 9–11 hours (*n* = 2), and greater than 11 hours (*n* = 2).

Fig. 1 illustrates the frequency with which learners visited the five primary CLEAR-aligned resources and activities. The error bar represents the confidence interval for the mean at a 95% level. Learners engaged significantly more with activities (e.g., assignments, forums) than with resources (e.g., lecture pages, URLs) on Moodle. Students' participation in forum activities ("Apply" and "Reflect") and visits to the Mahara assignment page ("Create") were most prominent. The video lecture pages ("Learn") and bonus links ("Extend") received significantly less traffic than the rest of the course.

Fig. 1. Error Bar of Course Visit Frequencies.



Survey responses indicated that the Mahara assignment was the most time-consuming activity in the course, suggesting its heavy demand on offline hours. This assignment was followed by watching lecture videos, reading foundational materials, posting in forums, reading bonus materials, taking quizzes, and learning how to use Mahara and Moodle. Therefore, creation-based activities (i.e., the e-portfolio assignment and the two forum activities) effectively engaged learners online and offline.

C. Performance in Creation Activities

In Task 1 (easy) of the Mahara assignment, all participants received a perfect score of 10.0. Slightly more than half (53%) scored below the passing threshold of 9.0 out of 15.0 on Task 2 (difficult). Nine out of 17 students earned a perfect score on Task 3 (creativity). Only three students received perfect marks on all tasks.

Although students were free to choose the technology they would use to complete their Mahara assignment, 71% (*n* = 12) selected PowerPoint. Seven static presentations, two voiceover presentations, two oral presentation videos, and one animated drawing were produced via this mode. Students who used other tools such as FireAlpaca, Adobe, Videoleap, Phonto, and Apple Pages created significantly more creative output such as manga, Netflix-style videos, and posters. Most tools used by students were offline applications. Students likely created output offline and then used Mahara as the publishing terminal. This trend was presumably due to the tutorial video accompanying the assignment, which only showed how to add a file to a Mahara page.

Students were courteous in both forums and rated their peers highly on a scale of 0 to 10: the average rating was 10.0 for Forum 1 and 9.0 for Forum 2. Learners were especially engaged with discussions about Mahara assignments (15 replies on 17 individual posts) compared with discussions regarding self-reflection (9 replies on 17 individual posts). The level of creativity in forum output appeared positively related to the number of responses from others. For instance, in response to one student's comics presentation, another student commented: "I don't think I will be able to forget CC explanation in the future thanks to your Manga. It was very fun, and your way of illustration was a bit exciting to read and watch."

D. Student Satisfaction

All learners who completed the final survey agreed that the course was well-designed, interesting, and intellectually challenging and declared it a success. Approximately three-quarters of respondents (76.4%) reported being either satisfied or moderately satisfied with the course and having enjoyed the experience; 17.6% slightly agreed and 5.9% slightly disagreed. Roughly half of learners (52.9%) either strongly or moderately agreed that they would like to take more courses such as this at TUT, whereas 41.2% slightly agreed and 5.9% slightly disagreed. In essence, despite respondents' predominantly high satisfaction, only 50% of students wished to continue learning in this manner.

As for the two types of creation (i.e., the Mahara assignment and forum activities), 94% of learners agreed that the assignment was beneficial and enhanced their learning in the course. However, only 71% agreed that the assignment was simple to complete, and 47% did not find the Mahara platform user-friendly. Around 88% of learners enjoyed working on the Mahara assignment, were satisfied with it, and wanted to complete similar activities in the future. Most learners established a sense of community through online discussion activities in forums; approximately 94% indicated that the activities helped them gain a deeper understanding of the subject matter. About 76% of learners found the activity simple and said they would enjoy partaking in similar activities in future classes. Compared with the entire course, creative activities were associated with greater student satisfaction and a higher likelihood of continued use.

VI. Discussion and Conclusion

The ad hoc course described herein, which bundled Moodle and Mahara, delivered an online constructivist creation-based learning experience. Taking e-portfolio creation as the central learning activity, this paper has outlined an online teaching case with regards to design, implementation, and evaluation. The case resulted in high-performing, engaged, and satisfied self-paced learners with no instructor intervention. These findings confirm the positive educational outcomes of incorporating e-portfolio creation into the educational process. Results also imply that relevant creative activities can be reliable and appealing aspects of education programs that require high learner autonomy. For example, flipped and blended learning modes call for self-regulation: students must learn independently prior to lessons [17], [39].

This study also unearthed technical difficulties students faced when navigating Mahara, which can pose a major barrier to use of the tool. Implementation teams would need to give this issue serious consideration as indicated in earlier work [40], [41]. Educational institutions using e-portfolios should select user-friendly technologies, devise student support strategies for delivering online modules [19], and offer training for teachers and students [9].

Learners' relatively similar scores on the easy task compared with heterogenous scores on the challenging task in the Mahara assignment could be rationalized as follows: (a) students struggled to demonstrate more complex knowledge through e-portfolio creation; and (b) the e-portfolio assessment was better matched with challenging cognitive tasks because it could distinguish student achievement more readily at greater difficulty levels. Learners' cognitive load may partly explain their inability to earn high scores on thought-provoking e-portfolio creation tasks. As the expectations associated with learning tasks increased, so did students' cognitive load. However, a rising cognitive load compromises creative thinking [42]. Furthermore, widespread dedication to "learning by doing" may not manifest from advantages in recall but instead from sustained feedback on one's performance received through enactment [43]. The instructional design of the profiled ad hoc course could be improved by dividing the Mahara assignment into separate but interconnected creation tasks on which students acquire commentary from peers and the instructor throughout the course.

Along with e-portfolio creation, forum discussions appeared intriguing and well-received in this course. Scholars have employed online discussion forums to examine students' content creation [44], [45]. Interestingly, these two activity types have the least in common in terms of group interaction: production tasks are outcome-focused, whereas discussion tasks are process-focused [46]. Participants in this study appreciated the peer-feedback forum, which presented an online channel to exchange opinions on each other's e-portfolios. The forum was also associated with high student satisfaction and learning engagement, corroborating earlier work [47], [48]. Prior to contributing to forum discussions, all learners were attentive to lectures through the e-portfolio creation activity. This tendency may have influenced the discussion activity's success. Self-study (vs. simply listening to lectures) enhanced discussions' effectiveness; indeed, when self-study precedes conversation, learning is more robust and academic outcomes are better [49].

Students' apparent preference for familiar digital tools in e-portfolio creation may have arisen from a lack of confidence or experience with digital technologies [50]–[52]. Although many university students possess basic digital literacy skills, they usually lack digital content creation abilities [53]. Co-creation with classmates appears rare in higher education [54]. Several scientific disciplines are seeking to integrate information and communications technology in academic settings; however, the associated training available to higher education students remains insufficient [55]. By aligning mismatched technologies, knowledge, and learners, the constructivist creation-based learning approach can prepare students with numerous technology-based skills and demonstrate how these tools can be applied to generate digital products, which is a common workforce practice.

This research is not without limitations. First, a small sample size constrained methodological options. Randomized controlled trials could not be conducted to assess the course's learning effectiveness. Although the course was well-received by students, additional evaluation is needed to determine its utility for a larger audience and to discern the impacts of its design on exam performance, learning engagement, and student satisfaction. Second, this research was intended to contribute empirical evidence to the e-portfolio literature. Miscommunication in the Mahara assignment misled students to believe they were expected to interact with Mahara by uploading files. Subsequent work should thus include technical training in Mahara. Alternatively, students could be presented with a pre-selected list of content types (e.g., journal, image gallery, embedded media, PDF) and taught how to use them on the platform. Differentiating online/offline or easy/difficult creation activities in the course would also serve as noteworthy experimental conditions. Third, participants' relative lack of engagement with bonus learning content impeded the instructional design flow based on the CLEAR model: it remains ambiguous whether the "Extend" component should eliminated or revised. Follow-up research could incorporate bonus learning content into the cognitive requirement of completing the e-portfolio assignment. Scholars could also use a larger participant sample to further investigate whether "Extend" is vital to this model.

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REFERENCES

[1] T. Harrison and D. Laco, 'Where's the character education in online higher education? Constructivism, virtue ethics and roles of online educators', *E-Learn. Digit. Media*, vol. 19, no. 5, 2022, doi: https://doi.org/10.1177%2F20427530221104885.

[2] J. W. P. Allen and M. H. Bickhard, 'Emergent constructivism: Theoretical and methodological considerations', *Hum. Dev.*, Jul. 2022, doi: 10.1159/000526220.

[3] C.-L. Lin and J. K. Chiang, 'Using 6E model in STEAM teaching activities to improve university students' learning satisfaction: A case of development seniors IoT smart cane creative design', *J. Internet Technol.*, vol. 20, no. 7, Art. no. 7, Dec. 2019.

[4] R. Maxwell-Stuart, B. Taheri, A. S. Paterson, K. O'Gorman, and W. Jackson, 'Working together to increase student satisfaction: exploring the effects of mode of study and fee status', *Stud. High. Educ.*, vol. 43, no. 8, pp. 1392–1404, Aug. 2018, doi: 10.1080/03075079.2016.1257601.

[5] J. S. Kruger and C. Hollister, 'Engaging undergraduate public health students through a textbook creation project', *Pedagogy Health Promot.*, vol. 7, no. 3, pp. 226–234, Sep. 2021, doi: 10.1177/2373379920962416.

[6] R. Wegener and J. M. Leimeister, 'Do student-instructor co-created eLearning materials lead to better learning outcomes? Empirical results from a German large scale course pilot Study', in *2012 45th Hawaii International Conference on System Sciences*, IEEE, Jan. 2012, pp. 31–40. doi: 10.1109/HICSS.2012.227.

[7] H. Gong, H. Park, and T. Hagood, 'Peer learning in STEM: a qualitative study of a student-oriented active learning intervention program', *Interact. Learn. Environ.*, pp. 1–11, 2020, doi: 10.1080/10494820.2020.1863235.

[8] H. K. Moonaghi and K. Shariati, 'Content creation based learning: scholarship of teaching and learning', *Res. Dev. Med. Educ.*, vol. 7, no. 1, pp. 52–57, 2018, doi: https://doi.org/10.15171/rdme.2018.010.

[9] Z. Syzdykova, K. Koblandin, N. Mikhaylova, and O. Akinina, 'Assessment of E-portfolio in higher education', *Int. J. Emerg. Technol. Learn. IJET*, vol. 16, no. 2, pp. 120–134, 2021.

[10] H. Gao, E. Bozkir, L. Hasenbein, J.-U. Hahn, R. Göllner, and E. Kasneci, 'Digital transformations of classrooms in virtual reality', in *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, 2021, pp. 1–10. doi: https://doi.org/10.1145/3411764.3445596.

[11] A. Scavarelli, A. Arya, and R. J. Teather, 'Virtual reality and augmented reality in social learning spaces: a literature review', *Virtual Real.*, vol. 25, no. 1, pp. 257–277, 2021.

[12] D. Gillet, M. J. Rodriguez-Triana, A. Holzer, A. Vozniuk, J. C. Farah, and R. Matsuba, 'Beyond ePortfolios: Creating, exploiting, and archiving activity traces, learning outcomes, and learning analytics as personal shareable online spaces', presented at the Proceedings - 2017 7th World Engineering Education Forum, WEEF 2017- In Conjunction with: 7th Regional Conference on Engineering Education and Research in Higher Education 2017, RCEE and RHEd 2017, 1st International STEAM Education Conference, STEAMEC 2017 and 4th Innovative Practices in Higher Education Expo 2017, I-PHEX 2017, 2018, pp. 43–48. doi: 10.1109/WEEF.2017.8466972.

[13] M. Gourmaj, A. Naddami, A. Fahli, and A. Berqia, 'Teaching power electronics and digital electronics using personal learning environments. from traditional learning to remote experiential learning', *J. Mob. Multimed.*, vol. 13, no. 3–4, pp. 244–255, 2017, doi: https://doi.org/10.3991/ijoe.v13i08.6840.

[14] I. Kecik *et al.*, 'Determining the feasibility of an e-portfolio application in a distance education teaching practice course', *Int. Rev. Res. Open Distrib. Learn.*, vol. 13, no. 2, pp. 160–180, Apr. 2012, doi: 10.19173/irrodl.v13i2.1160.

[15] L. Guàrdia, D. Clougher, T. Anderson, and M. Maina, 'IDEAS for transforming higher education: An overview of ongoing trends and challenges', *Int. Rev. Res. Open Distrib. Learn.*, vol. 22, no. 2, pp. 166–184, Jan. 2021, doi: 10.19173/irrodl.v22i2.5206.

[16] C. E. Watson, G. D. Kuh, T. Rhodes, T. P. Light, and H. L. Chen, 'ePortfolios–The eleventh high impact practice', *Int. J. EPortfolio*, vol. 6, no. 2, pp. 65–69, 2016.

[17] I. Kusuma, N. W. S. Mahayanti, L. D. S. Adnyani, and L. G. R. Budiarta, 'Incorporating e-portfolio with flipped classrooms: An in-depth analysis of students' speaking performance and learning engagement.', *JALT CALL J.*, vol. 17, no. 2, pp. 93–111, 2021.

[18] G. López-Crespo, M. C. Blanco-Gandía, S. Valdivia-Salas, C. Fidalgo, and N. Sánchez-Pérez, 'The educational e-portfolio: preliminary evidence of its relationship with student's self-efficacy and engagement', *Educ. Inf. Technol.*, vol. 27, no. 4, pp. 5233–5248, 2022, doi: 10.1007/s10639-021-10827-2.

[19] M. P. Modise, 'Postgraduate students' perception of the use of e-portfolios as a teaching tool to support learning in an open and distance education institution', *J. Learn. Dev.*, vol. 8, no. 2, pp. 283–297, 2021.

[20] M. Ciesielkiewicz, 'Education for employability: the ePortfolio from school principals' perspective', *Horiz.*, vol. 27, no. 1, pp. 46–56, Jan. 2019, doi: 10.1108/OTH-01-2019-0001.

[21] P. Abrami and H. Barrett, 'Directions for research and development on electronic portfolios', *Can. J. Learn. Technol.*, 2005, doi: 10.21432/T2RK5K.

[22] G. Greenberg, 'The digital convergence: Extending the portfolio model', *EDUCAUSE Review*, vol. 39, no. 4, pp. 28–37, 2004.

[23] K. Zeichner and S. Wray, 'The teaching portfolio in US teacher education programs: what we know and what we need to know', *Teach. Teach. Educ.*, vol. 17, no. 5, pp. 613–621, Jul. 2001, doi: 10.1016/S0742-051X(01)00017-8.

[24] J. A. Macias, 'Enhancing project-based learning in software engineering lab teaching through an e-portfolio approach', *IEEE Trans. Educ.*, vol. 55, no. 4, pp. 502–507, 2012.

[25] A. Yilmaz, 'The effect of technology integration in education on prospective teachers' critical and creative thinking, multidimensional 21st century skills and academic achievements', *Particip. Educ. Res.*, vol. 8, no. 2, pp. 163–199, 2021.

[26] A. W. Astin, 'Student involvement: A developmental theory for higher education', *J. Coll. Stud. Pers.*, vol. 25, no. 4, pp. 297–308, 1984.

[27] M. M. Abuzaid, W. Elshami, and Z. Noorajan, 'The impact of clinical practice E-portfolio in radiology education during COVID-19 outbreak', *Int J Cur Res Rev*, vol. 13, no. 06, p. 115, 2021.

[28] B. Hegarty and M. Thompson, 'A teacher's influence on student engagement: Using smartphones for creating vocational assessment ePortfolios', *J. Inf. Technol. Educ.-Res.*, vol. 18, pp. 113–159, 2019, doi: 10.28945/4244.

[29] G. Ring, B. Weaver, and J. J. Jones Jr, 'Electronic portfolios: engaged students create multimedia-rich artifacts', *J. Res. Cent. Educ. Technol.*, vol. 4, no. 2, pp. 103–114, 2009.

[30] V. Gámiz-Sánchez, E. Gutiérrez-Santiuste, and E. Hinojosa-Pareja, 'Influence of professors on student satisfaction with e-portfolio use', *J. Educ. Comput. Res.*, vol. 57, no. 3, pp. 646–669, 2019, doi: https://doi.org/10.1177%2F0735633118757016.

[31] T. Shea and S. Parayitam, 'Antecedents of graduate student satisfaction through e-portfolio: content analysis', *Educ. Train.*, vol. 61, no. 9, pp. 1045–1063, Jan. 2019, doi: 10.1108/ET-04-2019-0064.

[32] N. Garrett, 'An e-portfolio design supporting ownership, social learning, and ease of use', *J. Educ. Technol. Soc.*, vol. 14, no. 1, pp. 187–202, 2011.

[33] R. Mobarhan and A. A. Rahman, 'A conceptual model for e-Portfolio continuous use among students integrating Uses and Gratification theory and Information system continuance model', in *2014 IEEE Conference on e-Learning, e-Management and e-Services (IC3e)*, Dec. 2014, pp. 12–17. doi: 10.1109/IC3e.2014.7081234.

[34] Deleted for peer review.

[35] Deleted for peer review.

[36] J. W. Creswell and V. L. P. Clark, *Designing and conducting mixed methods research*. Sage publications, 2017.

[37] S. B. Demir and N. Pismek, 'A convergent parallel mixed-methods study of controversial issues in social studies classes: A clash of ideologies', *Educ. Sci. Theory Pract.*, vol. 18, no. 1, pp. 119–149, 2018, doi: https://doi.org/10.12738/estp.2018.1.0298.

[38] A. Field, *Discovering statistics using IBM SPSS statistics*, 4th ed. London: Sage, 2013.

[39] K. K. Hewitt, W. Journell, and R. Zilonka, 'What the flip: Impact of flipped instruction on self-regulated learning', *Int. J. Soc. Media Interact. Learn. Environ.*, vol. 2, no. 4, pp. 303–325, 2014, doi: https://dx.doi.org/10.1504/IJSMILE.2014.067638.

[40] M. McNeill and A. Cram, 'Evaluating e-portfolios for university learning: Challenges and opportunities', in *Proceedings of ASCILITE - Australian Society for Computers in Learning in Tertiary Education Annual Conference 2011*, Australasian Society for Computers in Learning in Tertiary Education, 2011, pp. 862–873. [Online]. Available: https://www.learntechlib.org/p/43635/

[41] M. Pellerin, J. Branch-Mueller, P. Nicholas, and W. Wei, 'The integration of eportfolios in higher education, and students' perceptions', *J. Interact. Learn. Res.*, vol. 29, no. 4, pp. 529–544, 2018.

[42] J. L. Redifer, C. L. Bae, and Q. Zhao, 'Self-efficacy and performance feedback: Impacts on cognitive load during creative thinking', *Learn. Instr.*, vol. 71, p. 101395, Feb. 2021, doi: 10.1016/j.learninstruc.2020.101395.

[43] R. von Stülpnagel, J. C. Schult, C. Richter, and M. C. Steffens, 'Cognitive costs of encoding novel natural activities: Can "learning by doing" be distracting and deceptive?', *Q. J. Exp. Psychol.*, vol. 69, no. 8, pp. 1545–1563, 2016, doi: 10.1080/17470218.2015.1087581.

[44] V. Kalmus, P. Pruulmann-Vengerfeldt, P. Runnel, and A. Siibak, 'Mapping the terrain of "generation C": Places and practices of online content creation among estonian teenagers', *J. Comput.-Mediat. Commun.*, vol. 14, no. 4, pp. 1257–1282, 2009, doi: 10.1111/j.1083-6101.2009.01489.x.

[45] O. H. T. Lu, A. Y. Q. Huang, and S. J. H. Yang, 'Impact of teachers' grading policy on the identification of at-risk students in learning analytics', *Comput. Educ.*, vol. 163, 2021, doi: 10.1016/j.compedu.2020.104109.

[46] C. G. Morris, 'Task effects on group interaction', *J. Pers. Soc. Psychol.*, vol. 4, no. 5, p. 545, 1966, doi: 10.1037/h0023897.

[47] D. G. B. Krisnamurti, A. Kekalih, W. Fachri, and P. Rahadiani, 'Which activity maintain engagement in distance learning and how it can increase student achievement? Lesson learned from herbal medicine module in Indonesia', *Int. J. E-Learn. Corp. Gov. Healthc. High. Educ.*, vol. 21, no. 1, pp. 61–78, 2022.

[48] D. Ye and S. Pennisi, 'Analysing interactions in online discussions through social network analysis', *J. Comput. Assist. Learn.*, vol. 38, no. 3, pp. 784–796, 2022, doi: 10.1111/jcal.12648.

[49] H. Lim, S. Kim, K.-M. Chung, K. Lee, T. Kim, and J. Heo, 'Is college students' trajectory associated with academic performance?', *Comput. Educ.*, vol. 178, 2022, doi: 10.1016/j.compedu.2021.104397.

[50] S. K. Howard, J. Ma, and J. Yang, 'Student rules: Exploring patterns of students' computer-efficacy and engagement with digital technologies

in learning', *Comput. Educ.*, vol. 101, pp. 29–42, Oct. 2016, doi: 10.1016/j.compedu.2016.05.008.

[51] A. Margaryan, A. Littlejohn, and G. Vojt, 'Are digital natives a myth or reality? University students' use of digital technologies', *Comput. Educ.*, vol. 56, no. 2, pp. 429–440, 2011, doi: https://doi.org/10.1016/j.compedu.2010.09.004.

[52] M. Warschauer and T. Matuchniak, 'New technology and digital worlds: Analyzing evidence of equity in access, use, and outcomes', *Rev. Res. Educ.*, vol. 34, no. 1, pp. 179–225, 2010, doi: https://doi.org/10.3102%2F0091732X09349791.

[53] T. K. Arslantas and A. Gul, 'Digital literacy skills of university students with visual impairment: A mixed-methods analysis', *Educ. Inf. Technol.*, vol. 27, no. 4, pp. 5605–5625, 2022, doi: 10.1007/s10639-021-10860-1.

[54] I. Blau and T. Shamir-Inbal, 'Re-designed flipped learning model in an academic course: The role of co-creation and co-regulation', *Comput. Educ.*, vol. 115, pp. 69–81, Dec. 2017, doi: 10.1016/j.compedu.2017.07.014.

[55] J. Gómez-Galán, J. Á. Martínez-López, C. Lázaro-Pérez, and M. del Mar Fernández-Martínez, 'Usage of internet by university students of Hispanic countries: Analysis aimed at digital literacy processes in higher education', *Eur. J. Contemp. Educ.*, vol. 10, no. 1, pp. 53–65, 2021, doi: 10.13187/ejced.2021.1.53.