Journal of Theoretical and Applied Information Technology
31st January 2026. Vol.104. No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

REVISITING MOTIVATION IN DIGITAL LEARNING: THE INTERPLAY OF OERS INTERACTIVITY AND SELF-REGULATED LEARNING AMONG THAI PRE-SERVICE TEACHERS

PHENNAPA SUWANWONG[1], NURULLIZAM BINTI JAMIAT[2*]

[1]Postgraduate Student, Centre for Instructional Technology and Multimedia, Universiti Sains Malaysia, Malaysia
[2*]Dr, Senior Lecturer, Centre for Instructional Technology and Multimedia, Universiti Sains Malaysia, Malaysia
E-mail: [1]sphennapa@student.usm.my, [2*]nurullizamj@usm.my

ABSTRACT

Perceived motivation plays an essential role in digital learning, particularly for pre-service teachers who often struggle with self-paced environments, limited digital literacy, and insufficient self-regulated learning (SRL) skills. These factors can hinder their engagement and persistence in online courses. Interactive Open Educational Resources (I-OERs) have been proposed as a promising approach to enhance motivation because some of its features such as learner control, embedded questions, and feedback are presumed to support attention, confidence, and satisfaction. However, research exploring how interactivity interacts with different levels of learners' self-regulated learning on their perceived motivation remains limited. Therefore, this study investigated main effects of Interactive Open Educational Resources (I-OERs) and Non-Interactive Open Educational Resources (N-I-OERs) and self-regulated learning as well as their interaction effect on perceived motivation among 117 pre-service teachers. Using a quasi-experimental design with a three by two factorial design, each student as determined by self-regulated learning questionnaire was categorized into high, moderate, and low groups and purposively assigned to study with either an I-OERs or N-IOERs course materials available on a MOOC platform. Then, perceived motivation was measured by using the Instructional Materials Motivation Scale (IMMS), and data was analyzed with two-way ANOVA and descriptive statistics including mean and standard deviation. The key findings showed that significant main effects of different learning materials and varying degrees in self-regulated learning on perceived motivation among participants were evidently observed. The students who used interactive materials and possessed higher self-regulated learning exhibited greater motivation. Additionally, an interaction effect between types of learning materials and regulated learning control significantly affected the rise in learning motivation. The study highlights the importance of incorporating interactive and motivational features into open educational resources while offering adequate support for learners with lower self-regulation.

Keywords: *Open Educational Resources; Perceived Motivation; Self-Regulated Learning; H5P; Multimedia Learning; Pre-Service Teachers*

1. INTRODUCTION

Perceived motivation, extensively explored in educational research, is regarded as one of the significant determinants affecting learning quality in digital space. It refers to students' personal experience of interest, relevance and satisfaction which facilitates their desire to engage and in sustain learning activities [1], [2]. Students who find an experience to be meaningful and motivating are more likely to self-initiate, self-regulate their effort and maintain their attention. Motivation could considerably affect learners' academic performance since their low motivation with superficial participation prevents them to achieve target learning outcomes. Despite well-designed courses, this phenomenon always happens in asynchronous online and open learning where instructors' supervision is less feasible.

Pre-service teachers are a unique group of learners to consider with respect to motivation given in their pursuit of teaching professional career in higher

education. As pre-service teachers, they are expected to understand both content knowledge and realize how to apply technology to expand their learning. Teachers working in this new digital age require to have fundamental professional traits such as adaptability, creativity, and lifelong learning. However, research in Thailand has shown that pre-service teachers have difficulties with digital learning because of insufficiency of self-regulated skills and lack of digital literacy as well as over-reliance on instructor guidance [3], [4]. Furthermore, learners frequently become disengaged in self-directed environments with limited interaction and consider learning as a requirement imposed on subject courses rather than an opportunity for personal growth.

The development of I-OERs has potential to increase learner participation and learning motivation. The I-OERs offer users' control, feedback and interactive tasks which can encourage curiosity and participation [5]. An alignment with these characteristics connected to learner autonomy and reflective learning enables pre-service teachers to self-regulate their own learning. Nevertheless, the effects of interactivity on motivation may vary according to learners' self-regulated learning (SRL) skills. High SRL students maintain their motivation through goal-setting and self-monitoring, whereas low SRL counterparts respond positively to external reinforcement in order to be motivated [6], [7], [8].

Although previous studies have widely explored OERs and learner motivation, most existing research has examined these constructs separately, with limited empirical attention to how instructional interactivity and learners' SRL skills operate together to shape perceived motivation [9], [10]. In addition, prior investigations have tended to focus on cognitive or achievement outcomes, while motivation has often been treated as a secondary or supportive variable, particularly in open and asynchronous learning environments. Moreover, there is a lack of empirical evidence that systematically compares interactive and N-I-OERs designed under different multimedia learning theories, especially within the context of pre-service teacher education. To address these gaps, the present study offers a novel contribution by examining the interaction effect between OER design types and learners' levels of SRL on perceived motivation. Guided by the Cognitive Theory of Multimedia Learning (CTML) [11] and the Cognitive Affective Theory of Learning with Media (CATLM) [12], this study compares I-OERs and N-I-OERs developed using the H5P platform [13] and grounded in Keller's ARCS motivational framework [15]. By integrating motivational design principles with open educational practices, this research extends current understanding of how multimedia instructional design and learner characteristics jointly influence motivational experiences in digital learning environments, while also providing practical insights for designing effective and motivating OERs in teacher education.

Despite the widespread adoption of OERs and instructional videos in MOOCs, many learning materials remain largely lecture based and offer limited interactivity, which can reduce learners' engagement and perceived motivation in online learning environments. Previous studies have indicated that the lack of interactive and multimedia enriched designs constrains learners' attention, persistence, and meaningful participation, particularly in self-directed and asynchronous contexts [16], [17]. This issue is further compounded among pre-service teachers, who often demonstrate insufficient SRL skills and digital competencies, leading to difficulties in sustaining motivation and effectively engaging with open learning resources [18], [19], [20]. Research has also highlighted that motivation in MOOCs is strongly influenced by course design, learner support, and opportunities for feedback and control, with motivation identified as a critical barrier to successful learning outcomes [21], [22]. Although OERs are widely recognised for their potential to promote equitable access to education, empirical evidence examining how different OER design approaches support learner motivation remains limited, particularly when learners' SRL characteristics are considered. This unresolved issue underscores the need for systematic investigation into how interactive and non-interactive OER designs influence perceived motivation among pre-service teachers in higher education.

Therefore, to bridge the gap, the research objectives (ROs) and hypotheses included in this study are as follows:

RO1: to determine the main effect of Interactive OERs (I-OERs) and Non-Interactive OERs (N-I-OERs) on pre-service teachers' perceived motivation.

RO2: to determine a main effect of self-regulated learning (SRL) levels on pre-service teachers' perceived motivation.

RO3: to examine an interaction effect between I-OERs and N-I-OERs on perceived motivation among pre-service teachers with different SRL levels.

Based on the research objectives and the theoretical foundations of multimedia learning, motivation, and SRL, the following hypotheses are formulated:

$H_0$1. There is no statistically significant main effect of N-I-OERs and the I-OERs on students' perceived motivation

$H_0$2. There is no statistically significant main effect of SLR levels on students' perceived motivation.

$H_0$3. There is no statistically significant interaction effect of N-I-OERs and the I-OERs on perceived motivation of different SRL levels.

Nevertheless, this study is situated within the context of higher education and focuses on pre-service teachers participating in a MOOC based learning environment in Thailand. The scope of the investigation is limited to examining perceived motivation as influenced by interactive and non-interactive Open Educational Resources, as well as learners' levels of SRL. The study assumes that perceived motivation can be reliably measured through self-report instruments and that participants possess sufficient access to digital learning technologies. Accordingly, the findings should be interpreted within these boundaries and are not intended to be generalized beyond similar educational contexts.

2. LITERATURE REVIEW

2.1 Motivation

Motivation is one of the key elements that promotes people to learn. The learners can put into what they learn and keep them moving forward even when learning becomes difficult. According to [13], motivation empowers people the energy to work toward success and overcome obstacles. It can be understood in two forms: intrinsic motivation and extrinsic motivation. Intrinsic motivation comes from inside, such as curiosity or the enjoyment of learning itself, while extrinsic motivation comes from outside factors like grades, money, or rewards [23], [24].

The authors [25] explained that when learners believe they can succeed in education, they will not give up and try to overcome difficult obstacles. Regarding this, motivation can help people set learning goals by themselves. The finding relates to Bandura's social cognitive theory which presents that motivation is not only from social experiences but also from teachers, peers, and environment. In the process of designing learning support, however, the important factor that can increase learners' confidence and motivation should be prioritised is feedback. On the other hand, the negative learning environment can reduce learners' motivation. The supportive and engaging learning environment is, therefore, essential for increasing students' motivation.

Providing learners with freedom to learn enables them to be more respectful and self-directed [1]. Hence, intrinsic motivation plays the key role in long-term learning. Students tend to stay more motivated and are autonomous, competent, and connected with others. In contrast, learning environment controlled by teachers pressured students and increased their learning demotivation [23], [24]. In this sense, teaching that allows SRL helps learners develop stronger motivation and commitment [25].

Nevertheless, in online learning environment, motivation not only depends on intrinsic motivation, but a helpful and easy-to-use technology also impacts learner motivation improvement [7]. Likewise, the researchers [26] discovered that technology integration with clear guidance can promote learner motivation, self-efficacy, and academic performance. Moreover, independent activities tend to make learners more confident and satisfied with their progress [27].

While extrinsic motivation (e.g., grades, praise, or punishment) catching learners' more attention to rewards may reduce their internal interest [13]. Especially in university learners, the researcher [28] suggests that there are several factors contributing to motivation including good teaching, useful curriculum, interactive classrooms, constructive feedback, and self-directed learning. These conditions are meaningful and joyful learning.

Keller's ARCS model proposed in 2010 is one of the most practical models available to help educators develop learner's motivation. It has four key components: attention, relevance, confidence, and satisfaction. These components enable teachers to capture students' attention through engaging visuals, audio, and activities. Relevance involves

connecting lessons to learning objectives and students' interests so that students perceive the value of learning. Confidence involves helping students believe they can succeed in their learning. Finally, satisfaction involves students' positive feelings in learning experience when they succeed and are fairly assessed and learned. These four components work together to maintain level of motivation throughout learning process.

In summary, motivation is the core of learning. Intrinsic motivation plays a crucial role in supporting long-term development due to its power in enabling learners to self-regulate their learning. Extrinsic motivation plays an equally important role, but its implementation must be carefully considered. However, both forms of motivation can contribute to good instructional design. This research utilizes the ARCS model as a guideline for designing engaging lessons that meet learners' motivational needs. This model is applied to I-OERs and N-I- to explore how the design of these two learning resource formats influences learners' motivation.

Although motivation has long been recognized as a central factor influencing learning behavior, the literature suggests that its role becomes more complex in online and open learning environments. In such contexts, learners are required to sustain engagement with limited direct instructional support, making motivation closely intertwined with instructional design and learning conditions rather than personal disposition alone [7], [15]. Previous studies highlight that feedback quality and a supportive learning environment play a decisive role in shaping learners' confidence and persistence, while overly controlled or unsupportive environments may undermine motivation and commitment [11], [13], [14]. This challenge is particularly evident in online learning, where learners must assume greater responsibility for managing their own learning processes. Although the ARCS model offers a practical framework for designing motivational instruction, existing research implies that its effectiveness may depend on learners' capacity for self-regulation, especially in settings that demand autonomy and sustained effort [1], [17]. Consequently, there remains limited empirical understanding of how motivational design interacts with learners' SRL characteristics to influence perceived motivation in digital learning environments.

2.2 Open Educational Resources (OERs)

Within Open Educational Resources (OERs), videos, quizzes, e-books, or full online courses offer freedom to educators, students, and instructors to adapt tailored content with respect to learning objectives, and teaching contexts. The OERs are unique in the way that they are disseminated under an open license, allowing everyone to use, modify, and edit without required permission from creators [29]. Consequently, the materials on this platform are more flexible and accessible.

Wiley [29] proposed the 5R framework, which describes the OERs process consisting of five steps: retain, reuse, revise, remix, and redistribute. Retaining means that users can keep and make copies of the contents. Reusing allows users to use the resources in various ways, such as in the classroom or on the web. Revising means that users can improve and update the contents. Remixing, which is particularly interesting, allows users to combine contents from different sources to create new innovations. Finally, redistributing allows the original or modified content to be shared with others [29]. These rights provide educational benefits, leading to creativity, collaboration, and unlimited sharing.

Nevertheless, there is a common misconception about OERs since many scholars think it is similar with e-learning and open education. In fact, OERs are an integral part of both systems as their unique functionalities by allowing learners accessing quality learning materials can minimise barriers in learning. While open education is an educational philosophy that emphasizes equal access to learning for all [30], [31], and e-learning is only viewed as a method of teaching.

In higher education, OERs play an important role in promoting sustainable learning. The idea began in 1999 through projects by the Hewlett Foundation and Rice University, which introduced thousands of open courses and learning materials. Organizations such as UNESCO and the Creative Commons Foundation have expanded because of this influence on supporting worldwide open access. However, developing OERs requires time, expertise, and technical resources. It is impractical for teachers alone to create them. The researchers [32] pointed out that universities need financial and institutional support for the

development, revision, and maintenance of high-quality OERs.

In developing countries, there are constraints in designing and developing materials such as language, culture, and budget constraints. Therefore, the academicians [33] proposed a community-based model where teachers, students, and institutions work together to create and share teaching materials, so that these countries have learning resources that meet the needs of learners, resulting in sustainable development and adoption of OERs.

The OERs are beneficial for educators to share their knowledge globally and students can receive up-to-date studying materials without payment for expensive learning materials. Furthermore, the OERs promote diversity and equity in education by supporting educators to adjust contents used for their own settings [34]. The study from the University of Edinburgh suggests that OERs also promote digital skills and creativity by encouraging learners to remix and co-create resources with others [35]. Especially in university level, thus, demands for sharing and collaboration on learning resources have been rising [36]. Moreover, people can easily obtain education since open and low-cost learning resources are free for learners of all levels in education system and ordinary individuals and this aligns with the government policies to enhance access to learning opportunities and free educational resources [34].

However, challenges remain in less developing countries. Generally, such materials cannot be localised according to national regulations or user preferences [37], when adopting the OERs lesson plans derived from other nations internationally. Because it is irrelevant to local educational contexts. Thus, Thailand should establish the localized OERs that matches the national curriculum and local cultures [38]. Teachers also require training for adaptation and meaningful use of the OERs with open licenses [39].

In conclusion, the OERs have challenges in sharing and distributing education to both teachers and learners. In this regard, it allows teachers to innovate and support independent student learning and cultivate a culture of collaboration. For universities to fully leverage the potential of OERs, however, they require ongoing support for teachers and created localised contents. As long as the OERs are developed and used effectively, it can be a sustainable resource helping students and teachers be better motivated to learn, more creative, and engaging in lifelong learning.

2.3 Multimedia Learning in the Design of OERs

Media has been widely recognised and utilized in modern teaching to make learning process more interesting and flexible. Multimedia has the capability to integrate multiple forms of content (e.g., text, images, sound, and video) so that lessons are more interesting and effective. The well integrated design of the OERs can facilitate an increase in learners' motivation. In this study, the OERs are regarded as the forms of multimedia learning materials that can be reused, shared, and modified under the Creative Commons licenses. The design follows two main categories. The first is the N-I-OERs, developed using the Cognitive Theory of Multimedia Learning (CTML), and the latter is the I-OERs, developed under the Cognitive-Affective Theory of Learning with Media (CATLM). Both theories share a similar foundation in cognitive psychology but differ in their focus on motivation, interaction, and learner control.

2.3.1 Cognitive theory of multimedia learning (CTML)

The educators [11], [40], [41] proposed the CTML to explain how people learn more effectively when information is presented through both words and pictures. This theory is based on three key assumptions: dual channels, limited capacity, and active processing as described as follows:

- Dual channels refer to how humans process information through two systems including visual and auditory.
- Limited capacity means working memory that can only handle a small amount of information at a time.
- Active processing involves selecting, organizing, and integrating new knowledge with what learners have already know.

Mayer also listed twelve design principles for assisting educators to produce efficient multimedia lessons. These tenets could be classified into three themes:

- Minimising useless cognitive load by ignoring irrelevant elements like (e.g.,

unnecessary pictures and sounds) and using visible cues to attract attention to essential details akin to (signaling principle).
- Controlling fundamental processing, including chunking (i.e., segmenting principle) and pre-training for more complex lessons.
- Facilitating generative processing by presentation of words accompanied by visuals (i.e., multimedia principle), conversational language (i.e., personalization principle), and narration with a natural human voice (i.e., voice principle).

CTML is well-implemented for non-interactive OERs where learners simply receive information from the structured multimedia lessons. By adhering to these principles, educators can alleviate cognitive overload, support clear processing of information digestion and enhance learners' comprehension in self-paced online learning contexts such as MOOCs platform.

2.3.2 Cognitive-affective theory of learning with media (CATLM)

While the CTML focuses primarily on cognitive processes, the CATLM, proposed by Moreno [12], [42] extends this idea by adding the role of emotion, motivation, and self-regulation in multimedia learning. This theory suggests that meaningful learning happens when learners actively select, organize, and integrate new information as well as manage both cognition and emotion concurrently. In other words, effective multimedia learning requires not only mental efforts but also motivation and metacognitive awareness.

The educator [42] identified five main design principles based on the CATLM involving guided activity, reflection, feedback, pacing, and pre-training as explained as follows:

- *Guided activity* helps learners engage with content through questions or interactive guidance.
- *Reflection* encourages learners to think about what they have learned.
- *Feedback* provides explanations that correct misconceptions rather than just showing right or wrong answers.
- *Pacing* allows learners to control the speed of their learning.
- *Pre-training* gives learners background knowledge before they encounter complex topics.

The CATLM also emphasizes that overly stimulating or irrelevant elements can distract learners and increase cognitive load. Therefore, instructional design should maintain balance by providing clear structure and interactive opportunities that foster motivation and autonomy.

In this study, the CATLM guides the design of the I-OERs, where learners can make choices, control the pace, and receive feedback. These interactive features help support SRL and enhance perceived motivation by giving learners an ownership of their learning experience.

2.3.3 Interactive and non-Interactive multimedia in learning

Multimedia can be categorised as interactive and non-interactive, depending on whether learners can actively participate. Interactive multimedia allows learners to click, navigate, and control content according to their needs, while non-interactive multimedia can automatically play videos and animations without users' engagement. Research has shown that interactive multimedia tends to improve motivation and learning outcomes because it offers personalization and active engagement [43], [44]. The INTERACT model as explained by the educators [43], can be successful interactivity depending on the balance of its six components, that is, learning environment, behavioral activity, cognitive and metacognitive activity, emotion and motivation, learner characteristics, and mental model. When these components work together, learners are more motivated and able to construct knowledge effectively.

However, non-interactive multimedia such as videos or recorded lectures can also play an important role in learning. Researchers [45] found that students enjoyed video-based learning and found it useful for study review and revision. Well-structured non-interactive media can improve learners' understanding by allowing them to revisit lessons and learn at their own pace [46], [47]. Therefore, both formats have unique strengths; interactive designs promote engagement and motivation, while non-interactive designs support clarity and knowledge consolidation.

The comparison between the Cognitive Theory of Multimedia Learning and the Cognitive-affective Theory of Learning with Media reveals important theoretical distinctions relevant to the design of digital learning resources. The Cognitive Theory of Multimedia Learning places strong emphasis on cognitive efficiency by minimizing extraneous cognitive load and supporting structured information processing [29], [30], [31]. This approach has proven effective for promoting comprehension and clarity in non-interactive learning materials. However, the literature suggests that CTML offers limited guidance regarding affective engagement, learner motivation, and self-regulatory processes, which are increasingly important in online learning environments where learners operate with greater independence [30], [37]. In contrast, the CATLM explicitly integrates emotional, motivational, and metacognitive dimensions into multimedia learning design [32], [33]. By emphasizing guided activity, reflection, feedback, and learner-controlled pacing, CATLM addresses aspects of learning that extend beyond cognitive processing alone. This theoretical extension suggests that while CTML provides a strong foundation for non-interactive OERs, CATLM may offer a more suitable framework for interactive learning resources intended to support motivation and self-regulated learning.

2.4. H5P as a Tool for Designing Interactive Open Educational Resources

H5P is an open source used for content creating, sharing, and reusing in the realm of open educational technology. Teachers can create an interactive piece of digital learning content from the H5P program and choose where and when to share their materials. The name H5P signifies "HTML5 Package" which indicates that the materials are all built on modern web technology and work well on computers, tablets, and mobile phones. One of the greatest strengths H5P possesses is that it enables educators to create interactive learning content without required programming skills [14]. Using this tool, teachers can create interactive videos, online quizzes, drag and drop items, timelines, memory games and etc. These facilities render lectures more dynamic and interesting and promote learner participation.

H5P has a similar philosophy with the OERs, as they are both advocating openness, cooperation and sharing of educational resources for free. H5P can be used by educators to develop lessons that learner can reuse, revise, and share by using a Creative Commons license which is in line with the Five "R" principles of the OERs (i.e., Retain, Reuse, Revise, Remix, and Redistribute) [30]. The resources can be incorporated into other learning management systems, including Moodle, WordPress and Drupal. Extension of interactive learning materials is offered to a broader learner profile [14]. This openness and interactivity enable educators to build contextually relevant digital learning resources that are both usable and effective.

An excellent feature about H5P is that it reinforces students to engage in the lesson rather than simply to absorb information. Students rely on H5P activities to self-control choices, answer questions, receive immediate feedback, and reflect on what they know and learn about the topics. This phenomenon is directly related to the CATLM, which states that motivation, emotional involvement and self-regulation are the necessary conditions for learning [42]. In this way, H5P contributes to motivation and positive effects, enhancing students' attention when engaging in a learning activity. These constructs are also consistent with Keller's ARCS Model, in which attention, relevance, confidence and satisfaction are the principal components to foster motivation [15].

H5P has been used to enhance learning design and motivate learners in digital lessons. The colleagues [48] reported that the students who engaged with H5P lessons interactively were more interested and understood better than those using traditional learning materials. Students in the study used the H5P activities were more control of their progress, which is consistent with the findings from the researchers [14], suggesting that when students received immediate feedback and were able to backtrack, they seemed able to manage their own progress better. These results indicated that H5P was beneficial for SRL where learners could exercise control over their pace, monitor comprehension, and review the lessons on demand.

In this research, H5P is used as the main tool for designing and developing the I-OERs, also known as I-OERs. The design of these materials follows the CATLM, which focuses on both cognitive and emotional processes in learning. Interactive components such as clickable images, branching activities, and feedback dialogues are integrated into the lessons to help learners build understanding through active engagement. These design features encourage curiosity, reflection, and

persistence, which are the foundation of perceived motivation. For pre-service teachers, this type of interactive learning can increase their confidence in using technology, support independent learning, and prepare them for integrating digital tools into their future classrooms.

The review of related literature emphasises that motivation is one of the most important factors influencing learning behavior and achievement. It determines how learners focus, persist through challenges, and take responsibility for their own learning. When learners perceive learning as meaningful and engaging, they are more likely to sustain their efforts and achieve long-term success. This becomes especially important in online learning environments, where direct teacher supervision is limited and learners must rely on internal motivation to continue learning. Therefore, instructional design that fosters both intrinsic and extrinsic motivation is essential for effective learning.

Overall, the reviewed literature indicates that motivation, OERs, multimedia learning theories, and SRL learning have largely been examined as distinct lines of inquiry. Research on OERs has primarily focused on issues of access, openness, and content reuse, while studies grounded in multimedia learning theories have emphasized cognitive outcomes such as comprehension and cognitive load management [18], [29], [30], [37]. At the same time, SRL has been widely acknowledged as a key learner characteristic influencing motivation and academic success, yet it is often treated independently from instructional design considerations [1], [42]. Although interactive multimedia tools and platforms such as H5P have demonstrated potential for enhancing engagement and motivation, empirical evidence remains limited regarding how different OER design approaches interact with learners' SRL levels to shape perceived motivation [33], [41]. This gap is particularly salient in pre-service teacher education, where learners are expected to develop both digital competencies and autonomous learning skills. Addressing this gap, the present study integrates motivational theory, multimedia learning design, and SRL within a unified framework to examine the main and interaction effects of OER design and SRL levels on perceived motivation.

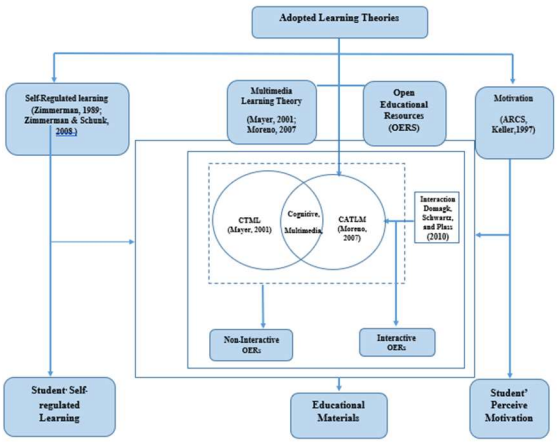

Figure 1: The Research Framework

3. METHODOLOGY

3.1 Research Design

The quasi-experimental research with a 3 x 2 factorial design was employed in this study to examine the main and interaction effects of two learning materials, namely, I-OERs and N-I-OERs and three different levels of SRL (i.e., low, moderate, and high) on students' perceived motivation. This research design is appropriate because the present study used existing participants without true randomization.

3.2 Participants

The participants were 117 first- and second-year pre-service teachers enrolled in the "Digital Way with Learning" course at a public university in southern Thailand. Purposive sampling was used based on three levels of SRL (high, moderate and low) and students were assigned to two different instructional groups within 3x2 factorial structures.

3.3 Variables

In this study, two types of learning materials (i.e., I-OERs and N-I-OERs) are independent variables. Meanwhile, a dependent variable is perceived motivation measured by the Instructional Materials Motivation Scale (IMMS), which was used after students immersed themselves in learning activities through the I-OERs and the N-I-OERs. SRL, used to classify students into high, moderate, and low groups, is a moderating variable.

3.5 Research Instruments

There are two main instruments used to collect data from the participants. First, self-regulated learning questionnaire which was adapted from Motivation Strategies for Learning Questionnaire (MSLQ). It consisted of thirty-one items within five subscales (i.e., metacognitive self-regulation, time and study environment, peer learning, effort regulation, and help seeking). Second, Instructional Materials Motivation Scale (IMMS) underlying on Keller's ARCS model included thirty-six items used to determine students' attention, relevance, confidence, and satisfaction. Both instruments were also validated by experts using the Index of Item Objective Congruence (IOC) and translated into Thai to ensure that students fully understand and can respond to them with ease. The IOC results obtained from the experts were in a range between 0.50 and 1.00, which achieved a well-established acceptance. The two research instruments were also pilot tested to examine their reliability prior to actual data collection. The results show that reliability coefficient of Cronbach's alpha for MSLQ and IMMS were accepted at 0.84 and 0.96 respectively.

3.6 Data Collection Procedures

The developed OERs used by the students could last for 4 to 6 weeks based on their pace in learning. Students were first classified into three levels of SRL (i.e., high, moderate, and low). Then, they were purposively assigned to study through either the I-OERs or N-I-OERs on the MOOC platform. After they had completed the lessons, they were asked to respond to the motivation scale. Two-way ANOVA or two-factor analysis of variance was used to examine the main and interaction effects of the instructional materials and SRL levels on perceived motivation.

Before conducting the analysis, the preliminary tests of normality and the homogeneity of variances were performed in the SPSS program. The data for perceived motivation from the I-OERs and the N-I-OERs groups showed normal distribution, as supported by skewness and kurtosis values within acceptable ranges between -1.00 and 1.00. The Levene's test based on mean showed a significant difference (p = .026), suggesting unequal variances between the two groups. However, when considering the variances in the two groups based on median (p=0.279) and trimmed mean (p=0.06), the results indicate that no signigicant difference was found. Hence, the between-groups variances was equal and reasonably accepted, confirming an relevant statistical analysis to proceed.

4. RESULTS

A two-way analysis of variance or two-way ANOVA in the SPSS program was employed to examine the main effects of the types of OER (i.e., I-OERs and N-I-OERs) and the levels of SRL learning (i.e., low, moderate, and high) as well as the interaction effect between the types of OERs (I-OERs and N-I- OERs) and the levels of SRL (i.e., low, moderate, and high) on students' motivation, as measured by the Instructional Materials Motivation Scale (IMMS). The results of two-way ANOVA in Table 1 are presented along with descriptions following each research objective.

Table 1: Results of Two-way ANOVA.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3.314[a]	5	.663	14.370	.000	.393
Intercept	2205.840	1	2205.840	47819.507	.000	.998
SRLGroup	1.432	2	.716	15.517	.000	.218
TreatmentGroup	1.579	1	1.579	34.232	.000	.236
SRLGroup* TreatmentGroup	.337	2	.168	3.650	.029	.062
Error	5.120	111	.046			
Total	2254.061	117				
Correct Total	8.434	116				

Table 2: Results of Descriptive Statistics for Motivation.

SRL Groups	Treatment Groups	Mean	SD	N
Low	I-OERs	4.44	0.15	21
	N-I-OERs	4.07	0.26	18
	Total	4.27	0.28	39
Moderate	I-OERs	4.46	0.16	17
	N-I-OERs	4.23	0.27	19
	Total	4.34	0.25	36
High	I-OERs	4.57	0.14	24
	N-I-OERs	4.47	0.28	18
	Total	4.52	0.21	42
Total	I-OERs	4.49	0.16	62
	N-I-OERs	4.25	0.31	55
	Total	4.38	0.27	117

Research Objective 1

RO1 aims to determine the main effect of Interactive OERs (I-OERs) and Non-Interactive OERs (N-I-OERs) on pre-service teachers' perceived motivation. The results reveal that the

main effect of the types of OER (i.e., I-OERs and N-I-OERs) significantly affected pre-service teachers' perceived motivation, $F(1,111) = 34.232$, $p < .05$, partial eta squared = .236 (considered a large effect size). The results in Table 2 indicate that perceived motivation of the students who used Interactive OERs (M= 4.49, SD= 0.16) was significantly greater than those who used Non-Interactive OERs (M= 4.25, SD= 0.31). The interactive features, such as feedback, navigation, and control, appeared to make students more involved and encouraged them to continue learning.

Research Objective 2

RO2 aims to determine the main effect of self-regulated learning (SRL) levels on pre-service teachers' perceived motivation. The findings in Table 1 show that main effect of SRL levels significantly influenced pre-service teachers' perceived motivation, $F(2,111) = 15.517$, $p < .05$, partial eta squared = .218 (considered a large effect size). The results in Table 2 indicate that learners with high levels of self-regulation (M= 4.52, SD= 0.21) reported higher motivation than those with moderate (M=4.34, SD=0.25) and low (M=4.27, SD=0.28) levels. This suggests that students who are more capable of setting goals, managing time, and monitoring their learning are also more likely to feel motivated when using OERs.

Research Objective 3

RO3 aims to examine the interaction effect between I-OERs and N-I-OERs on perceived motivation among pre-service teachers with different SRL levels. The results demonstrate that there was a statistically significant interaction effect between OER types and SRL levels on students' perceived motivation, $F(2,111) = 3.650$, $p < .05$, partial eta squared = .062 (considered a medium effect size). This interaction effect found infers the impact of OER types on motivation which depended on learners' self-regulation levels. In other words, the increase in motivation gained from interactive materials was more evident among higher self-regulated learners.

5. DISCUSSION

The findings of this study underscore the significance of Open Educational Resources design and learner characteristics in shaping pre-service teachers' perceived motivation in open online learning environments. The large main effect of OER design indicates that interactivity plays a crucial role in engaging learners' attention, curiosity, and motivational persistence. I-OERs designed based on the CATLM emphasize learner control, immediate feedback, and reflective engagement, which closely correspond to the attention and confidence components of Keller's ARCS model [2]. As learners become more actively involved in the learning process, they are more likely to experience satisfaction, thereby sustaining their motivation. This finding is consistent with prior studies reporting that interactive digital learning environments enhance motivation through increased autonomy and engagement [42], [48].

From a comparative perspective, the effectiveness of interactivity is influenced by learners' SRL capacities. The significant main effect of SRL levels suggests that motivation is closely related to learners' abilities to plan, monitor, and evaluate their own learning processes. Learners with higher levels of self-regulation tended to perceive learning materials as more meaningful and were more responsive to feedback, resulting in higher perceived motivation. Although SRL was not examined as a dependent variable in this study, it provides an important perspective for understanding variations in learners' motivational responses to the same instructional design. This finding aligns with the view that motivation and self-regulation operate as reciprocal determinants, whereby motivated learners are more likely to employ self-regulatory strategies that further enhance their motivation [49], [50].

The interaction effect between OER design types and SRL levels offers particularly interesting insights that extend existing literature. While all learners benefited from I-OERs, the motivational gains were most pronounced among learners with higher self-regulation skills. These learners appeared better able to utilize interactive features such as pacing control, feedback, and reflective activities to support their learning needs. In contrast, learners with lower levels of self-regulation may have encountered difficulties in managing the cognitive and motivational demands imposed by high levels of interactivity, indicating a need for additional instructional scaffolding. This result is consistent with the CATLM, which posits that meaningful learning emerges from the interaction between cognitive processing and affective engagement rather than from instructional features in isolation [41], [42].

A further comparative analysis between I-OERs and N-I-OERs clarifies their distinct motivational affordances. N-I-OERs, typically developed under the CTML, prioritize the reduction of cognitive load through structured presentation and signaling principles [40]. While this approach supports comprehension and content clarity, it offers limited opportunities for active engagement, learner control, or feedback. Consequently, learners using N-I-OERs may experience lower levels of attention and satisfaction, reflecting more passive learning experiences [42]. In contrast, I-OERs promote exploration, learner control, and individualized pacing, which are widely recognized as key factors supporting motivation in digital learning environments [51].

The integration of H5P as an authoring tool further strengthens the motivational design of Interactive OERs examined in this study. H5P enables educators to develop interactive videos, embedded questions, branching activities, and immediate feedback without requiring advanced technical skills. These features directly support motivational design by capturing learners' attention, enhancing relevance to future professional practice, building confidence through feedback, and fostering satisfaction through visible learning progress [2], [52], [53], [54]. Consistent with previous research, learners engaging with H5P based activities reported higher levels of enjoyment, persistence, and perceived success, which are central indicators of perceived motivation [44], [55]. Similar findings have been reported in recent studies examining the use of interactive authoring tools in online learning contexts [56].

When contrasted with N-I-OERs developed under the CTML, H5P based interactive resources demonstrated higher motivational affordance values [55]. The CTML primarily emphasizes the reduction of cognitive load through multimedia design principles such as segmenting and signaling [11]. While this approach is effective in supporting comprehension and content clarity, it does not explicitly promote active learner engagement, learner control, or formative feedback. As observed in this study, pre-service teachers who utilized N-I-OERs were largely confined to passive observation rather than active participation, which may have limited their attention and satisfaction during the learning process [57], [58].

In contrast, I-OERs provided opportunities for learner control, exploration, and student paced individualization, which are widely recognized as motivationally supportive features in digital learning environments [46], [59]. These interactive elements enabled learners to regulate the sequence and pace of learning activities and to receive immediate feedback, thereby fostering greater engagement and motivational persistence. This comparative evidence suggests that while N-I-OERs may be suitable for reducing cognitive complexity, Interactive OERs offer stronger motivational support by actively involving learners in the learning process.

Another important aspect in the results of this study is that the motivational impact of H5P based interactivity varied according to learners' levels of SRL and the types of OERs used. Learners with higher levels of SRL demonstrated the greatest motivational gains when engaging with Interactive OERs, as they were better able to direct their learning tasks autonomously, manage higher cognitive demands, and apply feedback effectively [49], [60]. For these learners, control over the sequence and pace of interactive materials enhanced their sense of autonomy and mastery, which are central components of sustained motivation.

However, learners with lower levels of SRL appeared to benefit less from highly interactive designs. These learners tended to find N-I-OERs less challenging due to their structured and predictable format, which helped minimize cognitive load and reduce potential confusion [61]. This finding highlights the importance of aligning interactivity with learners' self-regulatory capacities. Appropriately designed interactivity should provide sufficient challenge to stimulate motivation while avoiding excessive cognitive demands that may overwhelm learners with lower self-regulation skills. Accordingly, instructional designers should consider integrating scaffolding mechanisms within interactive OERs to support diverse learners and ensure equitable motivational outcomes.

Overall, the findings demonstrate that the motivational effectiveness of OERs is not determined solely by openness or multimedia presentation, but by the interaction between instructional design and learners' SRL capacities. While I-OERs offer clear motivational advantages, their implementation should be accompanied by appropriate guidance and scaffolding to ensure that learners with lower self-regulation skills are not disadvantaged. This nuanced understanding advances research on multimedia learning and motivation by highlighting the importance of

aligning interactivity with learner characteristics, particularly in the context of pre-service teacher education and open online learning environments.

6. CONCLUSION

This study provides empirical evidence on the role of OERs design and learner characteristics in shaping pre-service teachers' perceived motivation in open online learning environments. The findings demonstrate that I-OERs significantly enhance learners' perceived motivation compared with N-I-OERs, reinforcing the importance of interactivity, learner control, and feedback in sustaining attention, confidence, and satisfaction as conceptualized in Keller's ARCS model [2]. In this study, all the null hypotheses were rejected. These results support previous research indicating that learner centred and interactive digital learning environments contribute positively to motivational outcomes [13], [51].

In addition, learners' levels of SRL were found to significantly influence motivational outcomes, confirming that motivation is closely associated with learners' ability to plan, monitor, and regulate their own learning processes [42], [50]. Learners with higher SRL skills consistently reported greater perceived motivation, suggesting that self-regulation enables learners to engage more effectively with instructional affordances provided by Open Educational Resources.

A central contribution of this study lies in its examination of the interaction effect between OER design types and SRL levels on perceived motivation. While I-OERs benefited learners across all SRL levels, the motivational gains were more pronounced among learners with higher SRL skills. This finding extends existing multimedia learning research by demonstrating that the effectiveness of interactivity depends not only on instructional design, but also on learner characteristics, in line with the CATLM which emphasizes the joint influence of cognitive and affective processes on learning outcomes [12], [42].

From a practical perspective, these findings provide a strong rationale for integrating interactive and motivationally informed OERs into teacher education programs. I-OERs developed under theory driven frameworks such as the CATLM and supported by authoring tools like H5P can create more engaging and motivating learning experiences for pre-service teachers [13], [56]. However, the results also suggest that instructional designers and teacher educators should consider learners' SRL levels when implementing interactive designs, as additional scaffolding may be required to support learners with lower SRL skills and to prevent excessive cognitive demands [12].

In the current context of increasing reliance on online and open learning in higher education, this study offers timely insights into how instructional design decisions influence learner motivation and engagement. By highlighting the combined effects of OER interactivity and learner self-regulation, the findings provide a clear foundation for the implications discussed in the following section, particularly in relation to the preparation of pre-service teachers, the design of motivating digital learning resources, and directions for future research in open and online learning environments.

7. IMPLICATIONS FOR TEACHER EDUCATION AND FUTURE RESEARCH

The findings of this study provide several important implications for teacher education, especially in preparing pre-service teachers to design and use interactive and open learning materials effectively. The significant difference in perceived motivation between students who used interactive open educational resources and those who used non-interactive ones shows that interactive digital design, particularly when created with H5P, can transform learning from a passive process into an active and engaging experience [13], [48], [62].

Implications for Teacher Education

First, the idea that teacher training programs may provide opportunities for novice teachers to learn in the teaching space as learners is plausible. They experience feelings that these interactions are guided by care, confidence, and satisfaction, elements of Keller's motivation model (ARCS model) [2]. When they use H5P lessons, which may include interactive videos embedded in the task content for reflection, this transferable, hands-on experience will enable them to create unique lessons that will engage and work with their future students.

Second, given H5P and open educational resources are open and shareable, this integrated approach encourages collaboration, as well as lifelong learning. Teacher educators need to advise pre-service teachers on developing, adapting and

sharing learning resources with a creative commons license. This approach not only enhances their digital literacies skills but also enables them to grasp the potential for domains such as openness and creativity to enhance levels of motivation and engagement in real classroom situations.

Thirdly, due to the variable SRL levels of students, educators should support as well as guidance in H5P activities to ensure that every learner gets an equal gain out of them. For example, providing prompting questions or brief hints and feedback justifying why an answer is correct or incorrect. Such design strategies can offer scaffolding for students with lower self-regulation, without limiting freedom and autonomy from those with higher self-regulation [43], [63], thereby helping pre-service teachers learn to strike a balance between structure and freedom in designing motivated digital lessons.

Implications for Future Research

Further studies must continue examining how various types of interactive H5P elements (e.g., branching scenarios, gamified contents and real-time feedback) influence different aspects of motivation like curiosity, persistence and self-assurance. Combining data on both quantitative measures and qualitative reflections can give a comprehensive understanding of students' cognitive, affective, and action processes in their interactions with interactive learning systems [55].

Future research should also explore how pre-service teachers apply motivational design principles after having been trained with H5P materials. Such longitudinal data might tell us if their exposure to interactive open materials will result in more engaging classroom practices and greater student motivation when they become teachers.

Lastly, with an evolving technology landscape, future research can explore how new technologies like artificial intelligence, when integrated with H5P, could provide adaptive feedback and personalized learning pathways. Such integration could potentially also increase learner motivation and engage participants to an even larger extent, resulting in exciting models of open digital education [48], [62].

REFERENCES:

[1] E. L. Deci and R. M. Ryan, "Self-determination theory: A macrotheory of human motivation, development, and health", *Canadian Psychology*, Vol. 49, No. 3, 2008, pp. 182–185. doi:10.1037/ a0012801.

[2] J. M. Keller, "The ARCS model of motivational design", in *Motivational Design for Learning and Performance*, Springer, 2010.

[3] J. Crossan, "Thai teachers' self-efficacy towards educational technology integration", *AU-eJournal of Interdisciplinary Research*, Vol. 5, No. 1, 2020, pp. 107–123.

[4] P. Nuangchalerm, "TPACK in ASEAN perspectives: Case study on Thai pre-service teacher", *International Journal of Evaluation and Research in Education*, Vol. 9, No. 4, 2020, pp. 993–999.

[5] M. Rajas-Fernández, M. Gértrudix-Barrio, and M. Baños-González, "Knowledge in images and sounds: Informative, narrative and aesthetic analysis of the video for MOOC", *Publications*, Vol. 9, No. 3, 2021, p. 32. doi:10.3390/publications 9030032.

[6] A. M. Sukowati, A. Mustadi, A. A. Y. Putro, and G. I. Pradewi, "Self-regulation of primary education pre-service teachers", *Journal of Education and Learning*, Vol. 14, No. 2, 2020, pp. 263–271.

[7] Y. Sun and F. Gao, "An investigation of the influence of intrinsic motivation on students' intention to use mobile devices in language learning", *Educational Technology Research and Development*, Vol. 68, No. 3, 2020, pp. 1181–1198.

[8] Y. A. Zaid and A. O. Alabi, "Sustaining Open Educational Resources (OER) initiatives in Nigerian Universities", *Open Learning*, 2020. doi:10.1080/02680513.2020.1713738.

[9] M. Baas, W. F. Admiraal, and E. van den Berg, "Teachers' adoption of Open Educational Resources in higher education", *Journal of Interactive Media in Education*, Vol. 2019, No. 1, 2019, pp.1–11.

[10] R. Vrana, "Open educational resources as means of promotion of open education", in *44th International Convention on Information, Communication and Electronic Technology*, IEEE, 2021, pp. 576–581. doi:10.23919/MIPRO52101. 2021.9596873.

[11] R. E. Mayer, "Cognitive theory of multimedia learning", in *The Cambridge Handbook of*

Multimedia Learning, Cambridge University Press, 2005, pp. 31–48.

[12] R. Moreno, "Does the modality principle hold for different media? A test of the method affects learning hypothesis", *Journal of Computer Assisted Learning*, Vol. 22, No. 3, 2006, pp. 149–158. doi:10.1111/j.13652729.2006.00170. x.

[13] H. Tohidi and M. M. Jabbari, "The effects of motivation in education", *Procedia – Social and Behavioral Sciences*, Vol. 31, 2012, pp. 820–824.

[14] T. Jacob and S. Centofanti, "Effectiveness of H5P in improving student learning outcomes in an online tertiary education setting", *Journal of Computing in Higher Education*, 2023. doi:10.1007/s12528-023-09361-6.

[15] J. M. Keller, "Motivational systems", in *Handbook of Human Performance Technology*, Jossey-Bass/Pfeiffer, 2000, pp. 374–391.

[16] M. Rajas-Fernández, M. Gértrudix-Barrio, and M. Baños-González, "Knowledge in images and sounds: Informative, narrative and aesthetic analysis of the video for MOOC," *Publications*, vol. 9, no. 3, article 32, 2021, doi:10.3390/publications9030032.

[17] P. Suwanwong, N. Jamiat, and E. Phairot, "Undergraduates' self-regulated learning and motivation during the COVID-19 situation," in *Proceedings of the International and National Teacher Education Conference (INTEC 2022)*, Thailand, 2022.

[18] S. Namsomboon, "A study on media information and digital literacy of pre-service teachers," *Veridian E-Journal, Silpakorn University*, vol. 12, no. 3, pp. 978–997, 2019.

[19] J. Castellví, M.-C. Díez-Bedmar, and A. Santisteban, "Pre-service teachers' critical digital literacy skills and attitudes to address social problems," *Social Sciences*, vol. 9, no. 8, article 134, 2020, doi:10.3390/socsci9080134.

[20] S. Oakkharamahasenawong, S. Ouppinjai, P. Rattanachuwong, and P. Vechcha, "Guidelines on management for development of teachers' digital competency in small primary schools," *Journal of Modern Learning Development*, vol. 7, no. 2, pp. 1–18, 2022.

[21] M. Henderikx, K. Kreijns, and M. Kalz, "A classification of barriers that influence intention achievement in MOOCs," in *Proceedings of the European Conference on Technology Enhanced Learning (EC-TEL 2018)*, Lecture Notes in Computer Science, vol. 11082, V. Pammer-Schindler et al., Eds., Springer, Cham, 2018, pp. 3–15, doi:10.1007/978-3-319-98572-5_1.

[22] A. M. Sukowati, A. Mustadi, A. A. Y. Putro, and G. I. Pradewi, "Self-regulation of primary education pre-service teachers," *Journal of Education and Learning (EduLearn)*, vol. 14, no. 2, pp. 263–271, 2020.

[23] B. Moy, I. Renshaw, and K. Davids, "The impact of nonlinear pedagogy on physical education teacher education students' intrinsic motivation", *Physical Education and Sport Pedagogy*, Vol. 21, No. 5, 2016, pp. 517–538.

[24] Z. W. Goldman, A. K. Goodboy, and K. Weber, "College students' psychological needs and intrinsic motivation to learn", *Communication Quarterly*, Vol. 65, No. 2, 2017, pp. 167–191.

[25] D. H. Schunk and M. K. DiBenedetto, "Motivation and social cognitive theory", *Contemporary Educational Psychology*, Vol. 60, 2020, Article 101832. doi:10.1016/j.cedpsych.2019.101832.

[26] S. Siddiqui, M. Thomas, and N. N. Soomro, "Technology integration in education: Source of intrinsic motivation, self-efficacy and performance", *Journal of e-Learning and Knowledge Society*, Vol. 16, No. 1, 2020, pp. 11–22.

[27] H. Alamri, V. Lowell, W. Watson, and S. L. Watson, "Using personalized learning as an instructional approach to motivate learners in online higher education", *Journal of Research on Technology in Education*, Vol. 52, No. 3, 2020, pp. 322–352.

[28] O. A. Sogunro, "Motivating factors for adult learners in higher education", *International Journal of Higher Education*, Vol. 4, No. 1, 2015, pp. 22–37.

[29] D. Wiley, "Connections, Counterfactuals, and the 5Rs", 2021, Available at: https://opencontent.org/blog/archives/6773.

[30] D. Olcott, "New pathways to learning Leveraging the use of OERs to support non-formal education", International Journal of Educational Technology in Higher Education, Vol. 10, No. 1, 2013, pp. 327–344.

[31]. N. Butcher, *A basic guide to open educational resources (OER)*, Commonwealth of Learning & UNESCO, 2011.

[32]. N. Huttner, L. Green, and R. Cowher, "Seeking a sustainable OER ecosystem", Redstone, 2018.

[33] A. Tlili, F. Nascimbeni, D. Burgos, X. Zhang, R. Huang, and T. W. Chang, "The evolution of sustainability models for Open Educational

Resources: Insights from the literature and experts", *Interactive Learning Environments*, Vol. 31, No. 3, 2023, pp. 1421–1436.

[34] E. Ossiannilsson, "OER and OEP for access, equity, equality, quality, inclusiveness, and empowering lifelong learning", *International Journal of Open Educational Resources*, Vol. 1, No. 2, 2019, pp. 131–154. doi:10.18278/ijoer.1.2.8.

[35] L. M. Campbell, "The benefits of open education and OER", 2017, Available at: https://lornamcampbell.org/higher-education/the-benefits-of-open-education-and-oer/.

[36] M. Berti, "Open educational resources in higher education", *Issues and Trends in Educational Technology*, Vol. 6, No. 1, 2018, pp. 4–15. doi:10.2458/azu_itet_v6i1_berti.

[37] M. King, M. Pegrum, and M. Forsey, "MOOCs and OER in the Global South: Problems and potential", *International Review of Research in Open and Distributed Learning*, Vol. 19, No. 5, 2018, pp. 1–20. doi:10.19173/irrodl.v19i5.3742.

[38] N. Manowaluilou, "Development of open educational resources for supporting academic English in higher education", *Kasetsart Journal of Social Sciences*, Vol. 41, 2020, pp. 238–243. doi:10.34044/j.kjss.2020.41.2.02.

[39] P. Amornrit, J. Na-Songkhla, and P. Wannapiroon, "A study of use and supporting factors to effective use of Open Educational Resources towards active learning in the context of higher education in Thailand", *Suranaree Journal of Social Science*, Vol. 12, No. 1, 2018, pp. 17–36.

[40] R. E. Mayer, "Applying the science of learning to multimedia instruction", in J. P. Mestre and B. H. Ross (eds.), *Psychology of Learning and Motivation*, Vol. 55, Academic Press, 2011, pp. 77–108. doi:10.1016/B978-0-12-387691-1.000 03-X.

[41] R. E. Mayer, "Principles based on social cues in multimedia learning: Personalization, voice, image, and embodiment principles", in R. E. Mayer (ed.), *The Cambridge Handbook of Multimedia Learning*, 2nd ed., Cambridge University Press, 2014, pp. 345–368. doi:10.1017/CBO9781139547369.017.

[42] R. Moreno, "Optimising learning from animations by minimising cognitive load: Cognitive and affective consequences of signaling and segmentation methods", *Applied Cognitive Psychology*, Vol. 21, No. 6, 2007, pp. 765–781. doi:10.1002/acp.1348.

[43] S. Domagk, R. N. Schwartz, and J. L. Plass, "Interactivity in multimedia learning: An integrated model", *Computers in Human Behavior*, Vol. 26, No. 5, 2010, pp. 1024–1033. doi:10.1016/j.chb.2010.03.003.

[44] I. M. Rajendra and I. M. Sudana, "The influence of interactive multimedia technology to enhance achievement students on practice skills in mechanical technology", *Journal of Physics: Conference Series*, Vol. 953, 2018, Article 012104. doi:10.1088/1742-6596/953/1/012104.

[45] F. V. O'Callaghan, D. L. Neumann, L. Jones, and P. A. Creed, "The use of lecture recordings in higher education: A review of institutional, student, and lecturer issues", *Education and Information Technologies*, Vol. 22, No. 1, 2017, pp. 399–415.

[46] M. Noetel, S. Griffith, O. Delaney, T. Sanders, P. Parker, B. del Pozo Cruz, and C. Lonsdale, "Video improves learning in higher education: A systematic review", *Review of Educational Research*, Vol. 91, No. 2, 2021, pp. 204–236. doi:10.3102/0034654321990713.

[47] N. I. Scagnoli, J. Choo, and J. Tian, "Students' insights on the use of video lectures in online classes", *British Journal of Educational Technology*, Vol. 50, No. 1, 2019, pp. 399–414.

[48] U. Rahmi, B. R. Fajri, and A. Azrul, "Effectiveness of interactive content with H5P for Moodle-learning management system in blended learning", *Journal of Learning for Development*, Vol. 11, No. 1, 2024, pp. 66–81. doi:10.56059/jl4d.v11i1.1135.

[49] B. J. Zimmerman, "Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects", *American Educational Research Journal*, Vol. 45, No. 1, 2008, pp. 166–183.

[50] E. Panadero, "A review of self-regulated learning: Six models and four directions for research", *Frontiers in Psychology*, vol. ***8***, article 422**,** 2017**,** doi**:**10.3389/fpsyg.2017.00422.

[51] M. Khalil and M. Ebner, "Clustering patterns of engagement in Massive Open Online Courses (MOOCs): The use of learning analytics to reveal student categories," *Journal of Computing in Higher Education*, vol. 29, no. 1, pp. 114–132, 2017, doi:10.1007/s12528-016-9126-9.

[52] J. Guaña-Moya, Y. Arteaga-Alcívar, S. Criollo-C, and D. Cajamarca-Carrazco, "Use of interactive technologies to increase motivation in university online courses", *Education Sciences*, Vol. 14, No. 12, 2024, Article 1406. doi:10.3390/educsci14121406.

[53] A. Bandura, "Self-efficacy: The exercise of control", FrancoAngeli, 1997.

[54] M. Muflihah, U. Hanifah, M. Thoha, and H. R. Haji Abdullah, "Management of developing interactive multimedia-based Arabic teaching materials: Enhancing learning for diverse students at Indonesian Islamic universities", *Munaddhomah: Jurnal Manajemen Pendidikan Islam*, Vol. 6, No. 1, 2025, pp. 82–98. doi:10.31538/munadd homah.v6i1.1469.

[55] M. Hartnett, "The importance of motivation in online learning", in *Motivation in Online Education*, Springer Singapore, 2016, pp. 5–32. doi:10.1007/978-981-10-0700-2_2.

[56] I. A. Mohammed, T. G. Olatunde-Aiyedun, and A. Bello, "Distance learning lecturers' awareness and readiness towards open educational resources," *Computers and Children*, vol. 3, no. 1, article em006, 2024, doi:10.29333/cac/15209.

[57] L. P. Rieber, "Animation, incidental learning, and continuing motivation", *Journal of Educational Psychology*, Vol. 83, No. 3, 1991, pp. 318–328. doi:10.1037/00220663.83.3.318.

[58] S. Schwan and R. Riempp, "The cognitive benefits of interactive videos: Learning to tie nautical knots", *Learning and Instruction*, Vol. 14, No. 3, 2004, pp. 293–305. doi:10.1016/j.learninstruc.2004.06.005.

[59] J. W. Lin and C. W. Tsai, "The impact of an online project-based learning environment with group awareness support on students with different self-regulation levels: An extended-period experiment", *Computers & Education*, Vol. 99, 2016, pp. 28–38. doi:10.1016/j.compedu.2016.04.005.

[60] Y. L. Chen and C. C. Hsu, "Enhancing English learning experience with an innovative interpretation training mobile app: A self-determination theory perspective on autonomous motivation", in *INTED2024 Proceedings*, IATED, 2024, pp. 2170–2174.

[61] J. Sweller, "Cognitive load theory and educational technology", *Educational Technology Research and Development*, Vol. 68, 2020, pp. 1–16. doi:10.1007/s11423-019-09701-3.

[62] R. E. Mayer, *Multimedia learning*, 3rd ed., Cambridge University Press, 2021. doi:10.1017/9781316941355.

[63] B. J. Zimmerman and D. H. Schunk, "Self-regulated learning and performance: An introduction and an overview", in *Handbook of Self-Regulation of Learning and Performance*, Routledge, 2011, pp. 15–26.