ASEAN Journal of Open and Distance Learning (AJODL)
https://ajodl.oum.edu.my/
Vol. 16, No. 2, 2024, pp. 15 – 29

The Development of Assessment as a Learning Model by Applying Digital Technology for Undergraduate Students in Distance Education at Sukhothai Thammathirat Open University, Thailand

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Article Info:
Received: **10 Aug 2024**; Revised: **25 Sept 2024**; Accepted: **26 Nov 2024**; Available Online: : **13 Dec 2024**

DOI: https://doi.org/10.64233/GSSQ3780

Abstract

This study aimed to develop a model to address the challenges associated with the learning and assessment of students in distance education. The objective was to develop and experiment with an Assessment as a Learning model by applying digital technology to undergraduate students. The research followed a two-phase methodology. Phase 1 focused on developing the Assessment as a Learning model through a needs assessment survey involving 400 students, which yielded high needs index values. The model's quality was assessed by a focus group comprising 16 experts, who reached a consensus on its validity. Values for the item content validity index ranged from 0.88 to 1.00, and the value for the scale content validity index was 0.98. The final Assessment as Learning model, consisting of eight steps and four components, demonstrated strong validity and suitability for implementation in the subsequent phase. Phase 2 entailed an experimental study involving 168 students to test the Assessment as a Learning model. The findings significantly enhanced students' self-assessment skills and metacognitive strategies. Moreover, differences in learning styles and age groups led to statistically significant differences in these skills, reflecting the age-related characteristics inherent in distance learning. The effectiveness of the Assessment as a Learning model underscored the necessity for students to understand learning goals, assessment criteria, and opportunities for reflection, as well as to have clearly defined pathways for future actions. This research recommended that educational researchers design applications and artificial intelligence technologies that facilitate student journey mapping within distance learning systems, thereby enhancing educational outcomes.

Keywords: assessment as learning, distance education system, digital technology, goal-setting, metacognitive strategies, self-assessment, self-reflection

1. Introduction

In the context of 21st-century education, the evolution of student assessment has led to the identification of three approaches: Assessment as Learning (AaL), Assessment for Learning (AfL), and Assessment of Learning (AoL). AaL emphasises the learner's role in evaluating their learning progress, with the central aim of fostering self-awareness and metacognition regarding one's cognitive processes. This self-assessment enables learners to make informed decisions about their educational development in line with established learning goals. Through self-assessment techniques such as questioning, goal setting, and critical reflection, students actively seek strategies and methodologies to improve their learning

experience. AaL is inherently linked to Assessment as Learning, which focuses on empowering students to evaluate and direct their learning actively (Earl, 2013). While AaL and AfL are increasingly recognised in contemporary assessment literature, empirical evidence suggests that AoL continues to dominate educational environments. Consistent with findings by Black and Wiliam (2018), AaL is integral to helping students develop the skills necessary for self-regulation, metacognition, and personal responsibility. By encouraging students to reflect on their learning progress actively, AaL supports the development of critical thinking and problem-solving abilities, which are crucial for lifelong learning. The limited implementation of AaL and AfL can largely be attributed to educators' need to provide detailed reports of student learning outcomes, which serve as crucial evidence for stakeholders and reflect institutional accountability (Khammanee, 2015).

At Sukhothai Thammathirat Open University (STOU), students customarily engage in self-directed learning through course materials and e-learning platforms. They study course objectives, set personal learning goals, and conduct self-assessments aligned with the principles of Assessment as Learning (AaL). However, with each course containing up to 15 chapters (equivalent to six credits), students may find it difficult to fully comprehend all the material independently. Many students have expressed the need for direct instructional support from teachers, though practical limitations made such support challenging to provide. Moreover, students' goal-setting and learning-planning processes are often unclear, and tracking of their learning progress is inadequate. The application of learning strategies and self-reflection of individual strengths and weaknesses can be limited, which hinders learning. Students frequently postpone study preparation until shortly before their exams, leaving insufficient time to cover all course topics thoroughly.

These issues present significant gaps and challenges that require integrating AaL to help STOU students improve their goal-setting, learning planning, metacognitive skills, self-assessment, and self-reflection. Furthermore, incorporating digital technologies could support learning in distance education, fostering better self-regulation and deeper engagement with the learning materials, ultimately leading to enhanced academic achievement.

This research study aimed to develop and experiment with the AaL model by applying digital technology to bachelor's degree students engaged in distance education at STOU. The study aligns with students' needs and integrates 21st-century assessment concepts, specifically AaL, with digital technology, harmoniously integrating assessment and instruction. This approach is beneficial for enhancing student learning development and achievement.

2. Literature Review

2.1. The 21st-Century Assessment and AaL

The concept of 21st-century assessment emphasises the measurement of skills and competencies that are essential for success in modern, knowledge-based societies. Unlike traditional assessment, it uses digital tools and real-world tasks to reflect the demands of the modern workforce (Care et al., 2018). The emphasis on formative assessment practices, student-centred learning, and the development of self-regulation is central to 21st-century assessment. As such, these assessments are inherently linked to AaL, which focuses on empowering students to actively evaluate and direct their own learning (Earl, 2013). AaL is distinguishable from other assessment approaches (i.e., AfL and AoL) by encouraging learners to be responsible for their own learning journey. AaL promotes ongoing reflection, goal-setting, and adjustment to strategies, helping students to develop critical skills like problem-solving and adaptability, which are essential in the 21st century (Panadero, 2017; Andrade & Brookhart, 2020).

AaL is underpinned by constructivist learning theories, particularly the works of Piaget (1970) and Vygotsky (1978), who emphasise the active role of learners in constructing knowledge. Earl (2013) presents AaL as a formative assessment strategy that places students at the centre of the learning process, emphasising the importance of self-regulation and reflection. AaL encourages students to actively assess their learning progress and foster metacognitive awareness: students reflect on what they know, what they

need to know, and how they can improve. This process allows students to take ownership of their learning by understanding learning objectives and measuring their progress against them. In this framework, students engage with learning objectives by continuously assessing their own progress and reflecting on their learning strategies. Panadero (2017) notes that this metacognitive process encourages students to take ownership of their learning by developing skills for self-regulation. In AaL, assessment becomes a tool for learning, not merely a measure of what has been learnt (Andrade, 2019). This student-centred approach helps learners internalise the criteria for success, fostering both critical thinking and personal responsibility for learning outcomes. AaL is also an internal motivator that significantly influences student learning more than academic achievements (Black & Wiliam, 2018).

AaL emphasises self-assessment, using various techniques such as questioning to check students' learning and using assessment results to set goals and plan their learning. Teachers stimulate students' thinking for learning checks and goal-setting and help them explore strategies and methods for their own learning development (Earl, 2013; Khammanee, 2015; Chanchusakun, 2017).

Table 1. A Summary of the Principles and Characteristics of AaL

Principles/characteristics	AaL
Objective	Self-monitoring, self-correction, adjustment.
Comparable criteria	Personal goals and external standards.
Main assessor	Learner.
Assessment feature	Assessment of learning progress.
	Focusing on students following their own learning.
	Assessment between teaching and learning units.
	Encourage learners to know the criteria for assessing their own learning.
	Students choose learning methods that are suitable for themselves.

Note. Earl (2013)

Research by Panadero et al. (2019) suggests that AaL helps prepare students for lifelong learning demands by fostering self-regulation and goal-setting abilities. These are also key competencies in 21st-century assessments that emphasise learning how to learn rather than simply mastering content. When students are given the tools to assess and reflect on their learning, they become more adaptable and resilient. They can better prepare for future education and work environment uncertainties (Care et al., 2018).

This research integrates relevant concepts and theories regarding the components of AaL to establish a foundational framework for developing and experimenting an AaL model at STOU. The model comprises four key components: (1) learning goal-setting and success criteria, (2) developing metacognitive strategies, (3) developing self-assessment skills, and (4) self-reflection and individual goal-setting.

2.2. Digital Technology Supports in Learning and Assessment

Digital technology plays a crucial role in both 21st-century assessment and AaL. Technological advancements have facilitated the implementation of AaL by providing students with tools to self-assess in real time. Digital platforms, such as learning management systems and e-portfolios, allow students to track their progress, set learning goals, and reflect on their achievements (Pellegrino, 2014, Panadero et al., 2019). These platforms also enable teachers to provide personalised feedback and monitor students' development over time, thus enhancing the formative nature of AaL.

Panadero (2017) highlights that technology-driven self-assessment tools are particularly effective in promoting student autonomy and engagement. For instance, digital portfolios allow students to compile and reflect on their work, fostering a sense of ownership and responsibility for their learning. Moreover, digital platforms can facilitate peer assessment, allowing students to learn from one another in

collaborative settings (Andrade & Brookhart, 2020). However, Nicol (2021) cautions that the effectiveness of these tools depends on their thoughtful integration into classroom practices. Teachers must ensure that technology enhances, rather than detracts from, the metacognitive processes central to AaL (Boud & Molloy, 2013). Nicol (2021) emphasises that integrating technology in AaL not only enhances self-regulation but also aligns with the broader goals of 21st-century assessment, which seeks to create more adaptive and flexible learning environments.

Digital technology plays a crucial role in supporting learning and assessment in ways that were impossible with traditional paper-and-pencil methods. As teaching and learning adapt to future technological advancements, teachers and students must keep pace with these changes, including classroom technologies. EduBright (2020) and Lam (2016) identified three key components of utilising digital technology: (1) digital technology helps set goals and plan learning through such tools as Planner Pro, Calendar, Goodnotes, Canva, and Coggle, (2) digital technology enhances learning strategies and self-assessment through such tools as Canva and Coggle, and software for making mind maps, and (3) digital technology reflects and accumulates individual learning outcomes through such tools as e-portfolios and learning logs.

This research integrates relevant concepts and theories from AaL, which comprises four key components, and the application of digital technology to support learning, which includes three essential components. Together, they form the foundational framework for developing and experimenting with a comprehensive model to enhance student engagement and learning outcomes. This model is promotes metacognitive skills, self-assessment, and reflection while leveraging digital tools to facilitate accessibility, collaboration, and personalised learning strategies.

3. Research Method

This research employed a research-and-development methodology to develop an AaL model by applying digital technology for undergraduate students engaged in distance education at STOU. The research procedures were divided into the following two phases.

3.1. Phase 1: Developing the AaL model by applying digital technology for undergraduate students at STOU

Data collection in this phase was divided into the following two types of study:

3.1.1. Determining the survey needs of the AaL model

Population and sample group: The total undergraduate student population of STOU, enrolled in all fields of study in the 2017-2022 academic years, was 71,125 students. For this study, the sample size was determined using the Taro Yamane formula and calculated to be 398 students. This study collected data from 400 students, selected using the stratified random sampling method, and categorised according to 12 academic fields.

Research tool: The questionnaire was designed to study the variables for AaL and applying digital technology. AaL variables include learning goal-setting and success criteria, metacognitive strategies, self-assessment, and self-reflection. Digital technology variables include digital technology for learning planning, metacognitive strategies and self-assessment, and reflection and accumulation of learning outcomes. The validity and reliability of the research tool were assessed through content validity and reliability.

Data analysis: The research used descriptive statistical analysis to describe the general characteristics of the sample group, including frequency, percentage, mean, standard deviation, and needs assessment index (NI), which was calculated using the following formula:

$$NI = 100 \times \frac{(\text{Expected value} - \text{Current value})}{(\text{Expected value} - \text{Possible value})} \quad \text{.....(1)}$$

In interpreting NI values, the following applies (Kanjanawasee, 2013):

- NI = 0-25 signifies a very low level of need;
- NI = 25-50 signifies a low level of need;
- NI = 51-75 signifies a high level of need; and
- NI = 76-100 signifies a very high level of need.

3.1.2. Analysing and developing an AaL model

This step called for establishing a focus group to discuss specific issues related to AaL by applying digital technology. The focus group involved a total of 16 qualified participants, who were experts from 12 academic fields, as well as STOU's Registration and Evaluation Office and Educational Technology Office. Data analysis was performed using content analysis.

3.1.3. Evaluating the quality of the AaL model

This research confirmed and evaluated the quality of the AaL model by engaging 16 qualified participants in the focus group discussion. The group assessed the model using an evaluation form designed to examine its validity and appropriateness. The model was then adjusted to ensure suitability for experimentation and implementation in the subsequent phase.

3.2. Phase 2: Experimenting the AaL model by applying digital technology on undergraduate students at STOU

3.2.1. Experimenting the AaL model

This research experimented with the developed model using an experimental methodology and administered pre- and post-tests with a control group design. Random sampling consisted of three steps: random sampling from the population, random selection into two groups, and random assignment to the two sample groups. The experimental and control groups were divided by learning models, conducted with a sample group comprising 168 students, who were then distributed equally into an experimental group of 84 students and a control group of 84 students.

The research tools for the experimental process included the following:

i. An initial assessment of knowledge and abilities through the application of a digital technology literacy skills assessment;
ii. Self-directed learning activities; and
iii. Self-assessment before and after the learning process through two assessments: student's self-assessment skills and metacognitive strategies in learning.

Data analysis involved the following:

i. Descriptive statistics, such as maximum, minimum, mean, and standard deviation; and
ii. Inferential statistics for hypothesis testing such as independent t-tests, paired sample t-tests, ANOVA, and two-way MANOVA using Jamovi and the SPSS programme.

3.2.2. Evaluating the AaL model

This research evaluated the experimental implementation of the AaL model through a satisfaction questionnaire administered to participants who took part in the experimentation of the model as described above. Data analysis was carried out by using values for mean and standard deviation.

4. Findings

The research findings are illustrated in two sections based on the following research objectives.

4.1. Section 1: Developing an AaL model by applying digital technology for undergraduate students at STOU

4.1.1. Surveying the need of the AaL model

4.1.1.1. Demographic characteristics of the research sample

A survey conducted on a sample of 400 undergraduate students at STOU revealed that the majority (65.50%) are female. Those aged between 20 and 39 years accounted for 64.75% of the student population, followed by those between 40 and 59 years (31.50%).

The highest percentage of students (20.50%) began their studies in the 2019 academic year, followed by 18.75% who started in the 2022 academic year. The most popular field of study was education (23.75%), followed by management science (19.25%), and law (15.50%).

Regarding examination performance, 42.25% of the sample failed between one and three subjects, while 14.25% failed four or more subjects. The top three digital technologies used to aid learning were YouTube (76.07%), Line (75.82%), and Facebook (73.30%).

4.1.1.2. Needs assessment index

A needs assessment is a systematic process for determining and addressing needs or 'gaps' between current conditions and desired conditions or 'wants'. The results of the needs assessment index contain important information that can help students improve their learning or inform policy or programme decisions.
The NI values in this research were calculated using the formula provided in Section 3 above, yielding the following findings.

The essential needs for using AaL to support self-directed learning, ranked by NI scores from highest to lowest, are as follows:

- Rank 1: Metacognitive reading strategies (NI = 72.06) indicated a high level of need, and included three sub-components: global reading strategies, problem-solving strategies, and support strategies.
- Rank 2: Development of self-assessment skills (NI = 71.91) indicated a high level of need.
- Rank 3: Reflection on learning and setting personal goals (NI = 71.77) also indicated a high level of need, and included three sub-components: reflection on learning issues, reflection on feelings, and reflection on application in learning or work.
- Rank 4: Learning goal-setting and success criteria (NI = 68.26) indicated a high level of need.

Meanwhile, the essential needs for using digital technology to support self-directed learning in order to achieve learning outcomes, ranked by NI scores from highest to lowest, are as follows:

- Rank 1: Digital technology for metacognitive strategies and self-assessment (NI = 79.75) indicated a very high level of need.
- Rank 2: Digital technology for reflection and accumulation of learning outcomes (NI = 78.31) indicated a very high level of need.
- Rank 3: Digital technology for learning planning (NI = 76.31) also indicated a very high level of need.

4.1.1.3. Analysis and development of the AaL model

The researchers examined relevant documents and previous studies to inform the drafting of the AaL model utilising digital technology. We conducted focus group discussions to gather feedback on these previous models tothe aim of enhancing learning for undergraduate students. A total of 16 qualified participants formed the group, and ultimately, all of them supported the use of an AaL model by applying digital technology within distance education systems for undergraduate students. Additionally, the group offered valuable suggestions for improving the model. The researchers summarised the findings regarding the models deemed suitable for adaptation and utilisation in the next phase of this study.

4.1.1.4. Evaluating the quality of the AaL model

The quality of the AaL model by applying digital technology was measured using the Content Validity Index (CVI). The item-level content validity index (I-CVI) values ranged from 0.88 to 1.00, and the scale-level content validity index (S-CVI) was 0.98. These results indicate that the AaL model applying digital technology has a high content validity and is suitable for further use.

In summary, the development of the AaL model in this research was established based on the concept of assessment as learning, which consists of four components: (1) learning goal setting and success criteria, (2) developing metacognitive strategies, (3) developing self-assessment skills, and (4) self-reflection and individual goal setting.

The concept of digital technology for learning consists of three components: (1) digital technology for learning plans, (2) digital technology for metacognitive strategies and self-assessment, and (3) digital technology for self-reflection.

The research was conducted systematically following the Plan, Act, Observe, Reflect (PAOR) model, which includes four key principles. The activity process was divided into the following eight steps (Earl, 2013; Khammanee, 2015; Kemmis, 2009; Healey et al., 2011) as shown in Figure 1:

i. Plan: Survey and random assignment to experimental and control groups;
ii. Act 1: Initial knowledge and skill assessment;
iii. Act 2: Pre-experimental assessment;
iv. Act 3: Meeting for activity introduction and training;
v. Act 4: Self-learning and doing activities;
vi. Act 5: Post-experimental assessment;
vii. Observe: Observation and monitoring of learning development; and
viii. Reflect: Reflection on learning outcomes.

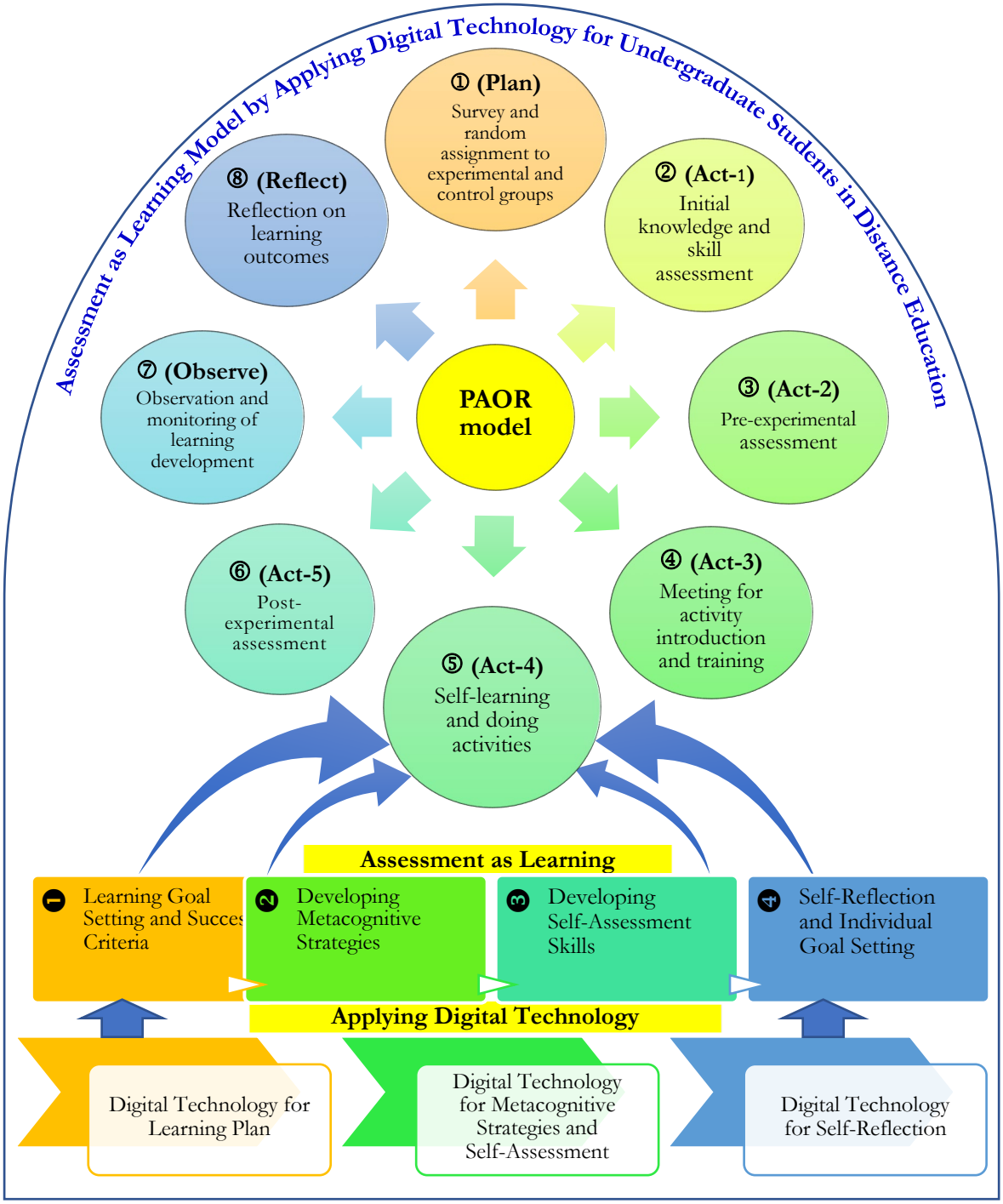

Figure 1. The AaL model by applying digital technology for undergraduate students in distance education at STOU

4.2. Section 2: Experimenting with the AaL model by applying digital technology to undergraduate students in distance education at STOU

4.2.1. Demographic characteristics

The sample of bachelor's degree students in the experiment comprised 168 students who voluntarily participated in the trial of the model; they were further categorised into one experimental group (84 students) and another control group (84 students). The majority (69.94%) were females, their ages ranging from 20 to 39 years old (58.33%), and 40 to 59 years old (36.31%). Most were studying in the field of education (27.38%), followed by management science and liberal arts (16.67%), and law (13.10%).

4.2.2. Results of experimenting with the AaL model

i. Comparison of scores in self-assessment skills between the experimental and control groups are as follows:

- **Before the experiment:** The experimental group had an average self-assessment skill score of 11.54 (M = 11.54, SD = 3.27), while the control group had an average score of 10.76 (M = 10.76, SD = 2.13). The comparison showed no statistically significant difference with $t(166) = 1.81$, $p = .07$.
- **After the experiment:** The experimental group had an average self-assessment skill score of 13.86 (M = 13.86, SD = 1.57), while the control group had an average score of 13.00 (M = 13.00, SD = 2.58). The comparison showed a statistically significant difference at the .05 level with $t(166) = 2.61$, $p = .01$.

ii. Comparison of scores in metacognitive strategy in learning between the experimental and control groups are as follows:

- **Before the experiment:** The experimental group had an average score of 4.01 (M = 4.01, SD = 0.64) for using metacognitive strategies in learning, while the control group had an average score of 4.04 (M = 4.04, SD = 0.62). The comparison showed no statistically significant difference with $t(166) = -0.26$, $p = .78$.
- **After the experiment:** The experimental group had an average score of 4.26 (M = 4.26, SD = 0.45) for using metacognitive strategies in learning, while the control group had an average score of 4.08 (M = 4.08, SD = 0.57). The comparison showed a statistically significant difference at the .05 level with $t(166) = 2.28$, $p = .02$.

Table 2. The comparison of scores in self-assessment skill and metacognitive strategy in learning between the experimental and control groups

Comparison groups		n	M	SD	MD	t	df	p
Self-assessment skill								
Before	Experimental group	84	11.54	3.27	-0.77	-1.81	166	.07
	Control group	84	10.76	2.13				
After	Experimental group	84	13.86	1.57	0.80	2.61*	166	.01
	Control group	84	13.00	2.58				
Metacognitive strategy in learning								
Before	Experimental group	84	4.01	0.60	0.03	-0.28	166	.78
	Control group	84	4.04	0.62				
After	Experimental group	84	4.26	0.45	0.18	2.28*	166	.02
	Control group	84	4.08	0.57				

Note: * $\alpha = 0.05$

iii. Comparison of scores in self-assessment skills for students in the experimental group before and after the experiment are as follows:

- **Before the experiment:** The experimental group's average self-assessment skill score was 11.54 (M = 11.54, SD = 3.27).
- **After the experiment:** The average score was 13.86 (M = 13.86, SD = 1.57). The comparison showed a statistically significant difference at the .05 level with $t(83) = 5.98$, $p = .00$.

iv. Comparison of scores metacognitive strategy use in learning for the experimental group before and after the experiment are as follows:

- **Before the experiment:**, The experimental group's average score for using metacognitive strategies in learning was 4.01 (M = 4.01, SD = 0.60).
- **After the experiment:** The average score was 4.26 (M = 4.26, SD = 0.45). The comparison showed a statistically significant difference at the .05 level with $t(83) = 3.15$, $p = .00$.

Table 3. The comparison of scores in self-assessment skill and metacognitive strategy in learning for students in the experimental group

Comparison groups		n	M	SD	MD	t	df	p
Self-assessment skill	Before	84	11.54	3.27	2.32	5.98*	83	.00
	After	84	13.86	1.57				
Metacognitive strategy in learning	Before	84	4.01	.60	0.25	3.15*	83	.00
	After	84	4.26	.45				

Note: * α = 0.05

v. Comparison of post-experimental multivariate variable scores for self-assessment skill and metacognitive strategy in learning among students with different learning models and ages

Analysis was performed using a multivariate approach with Wilks' Lambda to determine statistical significance. The findings revealed significant differences in scores for self-assessment skills and metacognitive strategy in learning after the experiment among students with varying learning models and ages at the .05 level of statistical significance. The test statistics were $F(6, 318) = 2.09$, $p = .05$, with an effect size (η^2) of .04.

Table 4. The comparison of scores in self-assessment skills and metacognitive strategies in learning based on ages and learning models

Source of variance	Wilks' Lambda	F	Hypothesis df	Error df	p	η_p^2
Intercept	0.07	1134.92	2	159	.00	.93
Learning models	0.99	0.43	2	159	.65	.01
Ages	0.98	0.67	6	318	.67	.01
Learning models x Ages	0.93	2.09*	6	318	.05	.04

Note: * α = 0.05

Figure 2 shows how the interaction plot illustrates the self-assessment skill scores of the experimental and control groups based on age. Students in the experimental group who were under 20 had lower self-assessment skill scores than the control group. However, students in the experimental group aged between 20 and 39, 40 and 59, and over 60 had higher self-assessment skill scores than those in the control group.

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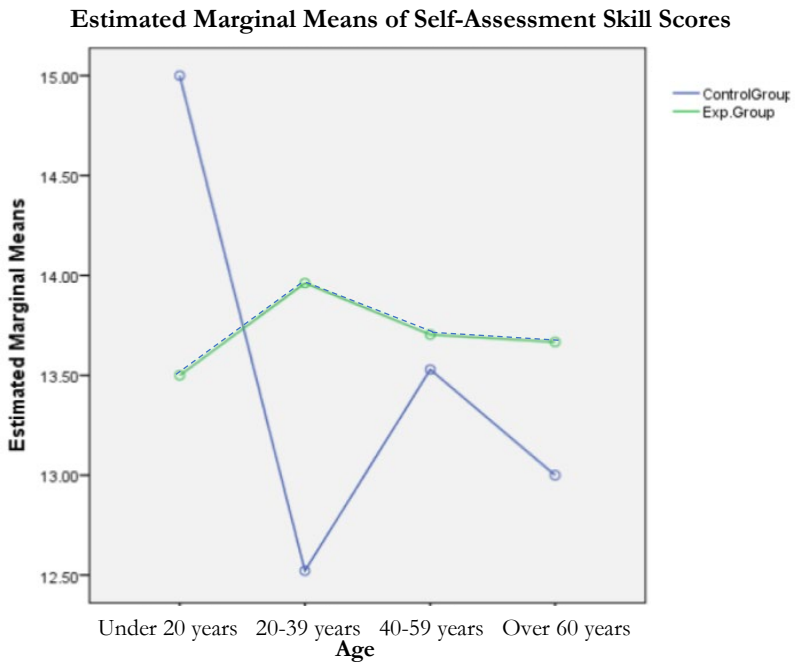

Figure 2. The interaction effect plot of self-assessment skill scores and ages

In Figure 3, the interaction plot illustrates levels for the metacognitive strategy in learning for the experimental and control groups across different ages. Students in the experimental group under 20 years had lower metacognitive strategy levels than the control group. However, students in the experimental group aged between 20 and 39 years and those over 60 years had higher levels than those in the control group. Students in the experimental group aged 40-59 bracket had metacognitive strategy levels similar to those in the control group.

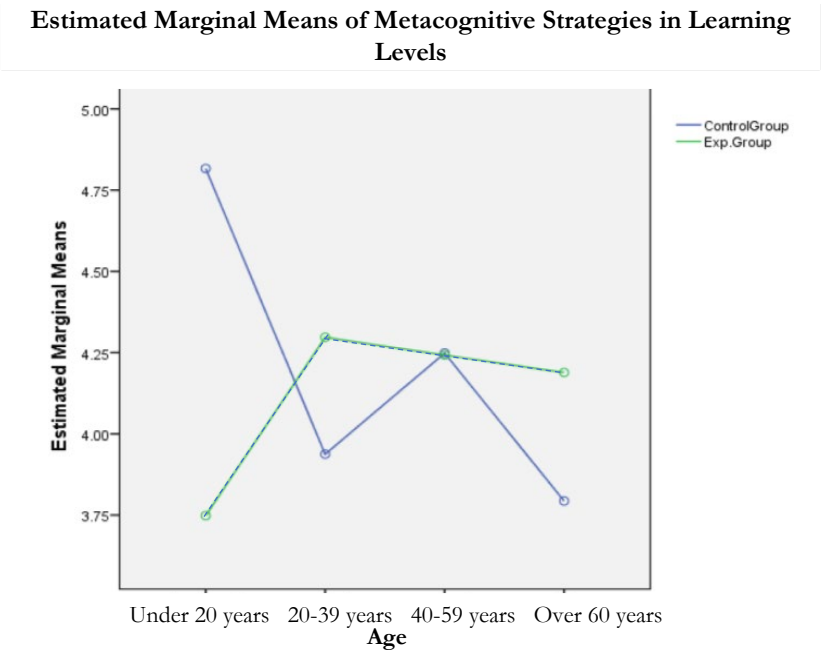

Figure 3. The interaction effect plot of metacognitive strategies in learning levels and ages

4.3. Overall satisfaction levels of the AaL model

With a sample of 168 participants, the researchers found that the overall satisfaction with the AaL model by applying digital technology was at the highest level (M = 4.60, SD = 0.41). Considering each aspect, the results were as follows: (1) the benefits received from AaL had the highest level of satisfaction (M = 4.71, SD = 0.44), (2) the documents and learning materials had the highest level of satisfaction (M = 4.66, SD = 0.49), (3) the format of learning activities had the highest level of satisfaction (M = 4.54, SD = 0.48), and (4) the experimental implementation also had the highest level of satisfaction (M = 4.52, SD = 0.50).

Table 5. Satisfaction Levels of the Experimental Group Toward the AaL Model

Assessment issues	Levels of satisfaction (n =168)		
	M	*SD*	Level
1. Learning activities	4.54	0.48	Very satisfied
2. Documents and learning media	4.66	0.49	Very satisfied
3. Experimental operator	4.52	0.50	Very satisfied
4. Benefits from AaL	4.71	0.44	Very satisfied
Total Satisfaction Level	4.60	0.41	Very satisfied

5. Discussion

The AaL model by applying digital technology for undergraduate students in distance education at STOU in this research was developed based on the concept of assessment as learning, which consists of four components, and the concept of digital technology for learning, which consists of three components: (1) digital technology for learning plan, (2) digital technology for metacognitive strategies and self-assessment, and (3) digital technology for self-reflection and learning portfolio.

Consistent with assertions by Earl (2013), Khammanee (2015), and Chanchusakun (2017), AaL helps learners become aware of their learning process, enabling them to plan, guide, diagnose, assess, reflect on, and improve their learning. This approach encourages learners to design their own learning plans and reflect on their learning and learning strategies, thus fostering continuous development. By relying on learners' metacognition, the approach emphasises the importance of self-assessment using various techniques, requiring learners to use reasoning to evaluate their progress. Khammanee (2016) also discussed the importance of self-monitoring and following a plan to develop one's learning until the desired goals are achieved. Assessment as a learning mechanism is a method that can elevate learners from the role of students to that of evaluators, emphasising the assessment of thinking processes and learning processes as key elements. Moreover, research by Panadero et al. (2019) suggests that AaL helps prepare students for lifelong learning demands by fostering self-regulation and goal-setting abilities.

Technological advancements have facilitated the implementation of AaL by providing students with tools to self-assess in real-time, thus allowing them to track their progress, set learning goals, and reflect on their achievements, which would be effective in promoting student autonomy and engagement (Pellegrino, 2014; Panadero, 2017; Panadero et al., 2019; Andrade & Brookhart, 2020; Nicol, 2021). Additionally, the application of digital technology, as referenced in the TESOL Technology Standards, emphasises three key competencies to enhance learners' development effectively (Healey et al., 2011). Teachers must ensure that technology enhances, rather than detracts from, the metacognitive processes central to AaL (Boud & Molloy, 2013; Nicol, 2021).

Experimenting the AaL model by applying digital technology on undergraduate students in distance education at STOU found that: (1) students' self-assessment skills in the experimental group was higher than the control group with a statistical significance at 0.05, (2) students' metacognitive strategies in the experimental group was higher than the control group with a statistical significance at 0.05, and (3) using the multivariate analysis approach to compare the learning model and age range that affect students' self-assessment skills and metacognitive strategies found differences with a statistical significance at 0.05.

Following findings by Earl (2013), this study found that the student plays a role as the critical connector between assessment and their own learning. Students act as active critical thinkers, make sense of information, relate new information to prior knowledge, and use it to construct new learning. This is the regulatory process in metacognition. Consistent with findings by Black and Wiliam (2018), awareness of one's own study progress through AaL is an internal motivation that significantly influences a person's learning, more so than academic achievement. As Kaewkohsaba and Jumnaksarn (2023) asserted, using digital tools such as mind maps can enhance learners' ability to summarise and retain content, establish connections, and improve understanding of key concepts. This technique also supports the development of critical thinking skills. Meanwhile, Hattie (2009) discussed how students need to become adaptive experts who can use many effective strategies for learning and assessment and must also have high levels of flexibility that allow them to innovate, ascertain when to know where to go next and adapt resources and strategies to meet worthwhile learning goals. AaL emphasises self-assessment using various techniques such as questioning students to check their learning and using assessment results to set goals and plan their learning. Teachers can stimulate students' thinking for learning goal-setting, as well as help them explore learning strategies and reflect methods for their learning development to better prepare for future education (Earl, 2013; Khammanee, 2015; Chanchusakun, 2017; Care et al., 2018).

This study identified limitations in the application of digital technology, noting that participants were required to use multiple applications for learning activities, which hindered their overall comfort and efficiency. Consequently, it is recommended that researchers consider designing and implementing applications or artificial intelligence (AI) technologies to support student journey mapping with a single application, utilising the concept of AaL. Such an integrated approach could enhance the learning experience and facilitate more effective educational outcomes.

6. Conclusion

This study developed an AaL model by applying digital technology, which is grounded on four key principles: learning goal-setting, metacognitive strategies, self-assessment, and self-reflection, along with three principles for applying digital technology. The research employed a Participatory Action Research approach, encompassing planning, acting, observing, and reflecting. The results indicated that this model significantly enhanced students' self-assessment skills and metacognitive strategies. Additionally, the results indicated that differences in learning styles and age groups resulted in statistically significant differences in these skills. These findings reflect the characteristics of distance learning concerning age-related differences. The model effectively supported learners in designing personalised learning plans, training them to find strategies and methods to develop their learning, fostering critical thinking, and emphasising self-assessment. Techniques utilised included questioning to evaluate understanding, monitoring progress, diagnosing challenges, and reflecting on learning processes. This approach facilitated ongoing development, enabling students to achieve their educational goals, essential for cultivating 21st-century competencies that enhance learning outcomes. Based on these findings, this study recommends that educational researchers consider designing and implementing applications or AI technologies that support student journey mapping using the concept of AaL. These tools would enable students to monitor their progress, set learning goals, and reflect on their achievements. By enhancing students' cognitive skills, such applications could facilitate the attainment of learning outcomes within a cohesive framework tailored to the context of distance education.

Funding: This research received a distance education research grant from STOU.

Acknowledgement: The author would like to acknowledge the research grant from STOU, the executives of the Office of Registration, Records and Evaluation, and the research participants.

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