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ENHANCING CRITICAL LEARNING THROUGH AN ADAPTIVE WEB APPLICATION: A CASE STUDY OF LOWER SECONDARY SCHOOL STUDENTS STUDYING ARTIFICIAL INTELLIGENCE TECHNOLOGY

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ABSTRACT

This research aims to develop and study the effects of an adaptive web application on critical learning of artificial intelligence technology in students under the Suphan Buri and Nakhon Pathom Secondary Educational Service Area Office. The sample was divided into two groups: 4,264 lower secondary school teachers that were surveyed to create a needs analysis on media use, teaching management and readiness to use technology and a second group of 709 lower secondary school students who volunteered to use the adaptive web application. The research instruments consisted of 1) an opinion and guidelines survey for developing the adaptive web application, 2) an adaptive web application to enhance learning of artificial intelligence, 3) a learning style assessment, 4) a critical learning test on artificial intelligence technology, and 5) a student opinion questionnaire. Data were analysed using content analysis, frequency, percentage, mean, standard deviation, need assessment, one-way ANOVA, and hypothesis tests by paired sample t-test. The results showed that 1) the conditions for media use, teaching management and readiness to use technology were at a high level; 2) there was no significant difference between pre-test and post-test scores at 0.05 significance; 3) there was no significant difference between pre-test and post-test scores among the student learning styles at 0.05 significance; 4) there was no significant difference in the frequency of media use classified by learning style at 0.05 significance; and 5) the students' opinions toward learning activities via an adaptive web application was at the highest level (M = 4.59, SD = 0.49).

Keywords: Web applications; adaptive learning; artificial intelligence technology; critical learning

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1. INTRODUCTION

Rapid advancements in science and technology have led to transformative innovations, such as the Internet of Things, robotics, artificial intelligence, big data analytics, and various other technologies. These are crucial factors that have contributed to the strong development of both the global and Thai economies. The

goals of the National Strategic Plan for 2018–2037 (The National Strategy 2561–2580 B.E., 2021) are to develop the infrastructure for modern technology, and to support and accelerate the use of science, data, artificial intelligence, and robotics to stimulate research and innovation. The aim is to adopt fundamental and advanced technologies, enhance knowledge, and provide diverse information access, benefiting everyone for the best possible societal development.

The challenge is to prepare the Thai youth to be able to cope and keep up with the developments in the era of artificial intelligence, which is a part of the fundamental curriculum of education (Office of the Basic Education Commission, Ministry of Education, 2017). This curriculum requires knowledge of machine learning (ML) content related to the technology for creating machinery with intellectual characteristics and human-like intelligence, whether it's human-like thinking, human-like actions, logical thinking, or logical actions, which together enable artificial intelligence technology to have intellectual and learning capabilities similar to humans. This is the science that allows computers or machinery to learn to understand the relationships between input data and output responses on their own without needing new programming each time the computer or machinery receives new data. It involves applying advanced mathematics and statistics knowledge to data management and programming (Digital Economy Promotion Agency, n.d.).

Currently, artificial intelligence technology has gained significant attention due to its diverse applications in various fields. There is also a growing trend of integrating it with cloud computing and big data technology, enabling rapid data transfer and continuous knowledge development. SAS Institute Inc. (n.d.) has emphasized the importance of artificial intelligence technology, stating that "Artificial intelligence is capable of repetitive automatic learning and can process large volumes of work efficiently. It enhances the intelligence of existing products through intelligent security systems. Artificial intelligence learns progressively through advanced learning algorithms in programming, searching data structures, and maintaining data consistency. Artificial intelligence analyzes data more deeply and accurately using multi-layered neural networks. Artificial intelligence can make the most of available data when algorithms are capable of self-learning. Data becomes intellectual property." Additionally, Nessessence (2018) outlined the study of Artificial Intelligence, Machine Learning, and Deep Learning as key to technological development.

Furthermore, with the advancement of information and communication technology, information and news can generally be accessed anytime and anywhere through smartphones and tablets. Application software serves as an excellent platform for retrieving digital learning resources (Na-songkhla, 2018). Web applications allow a quick response to the technological advancements and dynamic changes among the needs of learners as they can be developed and optimized to display required content through a browser. They can also be used to reduce computing workload when accessed through a smartphone or tablet, thus increasing loading speed. Real-time bug fixes and updates, and platform compatibility allow ease of access and use, regardless of device used. According to Salas-Rueda (2020) who studied quantitative research and recommended designing and developing web-based educational applications to enhance a teaching and learning environment, these applications allow students to access content at any time and from anywhere, while also enabling teachers to create innovative learning experiences through the design and utilization of these applications.

The National Education Plan has set goals for learners with the aim of developing characteristics and learning skills for the 21st century (Office of the Education Council, 2017) including the following 8Cs skills: critical thinking and problem solving; creativity and innovation; cross-cultural understanding; collaboration, teamwork, and leadership; communications, information and media literacy; computing and ICT literacy; career and learning skills; and compassion, discipline, morality and ethics. Learning with critical thinking will help learners have comprehensive reasoning skills, the ability to summarize key points, foresee possibilities, and classify factual data for decision-making. As Watson and Glaser (1981) emphasized, these traits encompass the three characteristics of attitude, knowledge and skills. Attitude refers to the interest in seeking knowledge, the ability to examine problems comprehensively, and a disposition to search for supporting evidence to verify claims. Knowledge pertains to the ability to infer, summarize significance, and generalize from evidence, considering the principles and applying deductive reasoning. Skill refers to the capability to apply both attitude and knowledge to assess and make decisions about problems, situations, or different summaries.

The process of managing learning for learners is essential, and teachers should consider the differences between individuals. Learning styles can be divided into three types using self-assessment tests: visual learners who learn from visual media, diagrams, charts, and symbols; auditory learners who learn from sound media, hearing, and listening; and kinaesthetic learners who learn through touch and action. According to the self-assessment test by the Pennsylvania Higher Education Assistance Agency (PHEAA) (n.d.), to assess differences among individuals, teachers must adapt the learning process to suit the specific learning preferences of each learner, which is known as aptitude-treatment interaction (ATI) (Jung & Ok-Choon, 2007; Klabpadung, 2017). The concept of adaptive learning will enable learners to receive education from adaptive web applications. These applications are characterized by presenting content tailored to the learning style of

each learner. Learners can learn from content delivered through three forms of learning media: infographics, video clips, and webpages. By analyzing the test results or assessing the level of knowledge, adaptive learning helps learners receive the most suitable lessons for themselves and presents the most appropriate content. Moreover, it allows learners to learn using web applications adaptively and take tests. The test results are then used to adapt the type of learning media in the next lesson. Allowing students access to different learning materials is one way of encouraging adaptive learning. In addition, flexibility and convenience is conducive to student led study and adaptive learning but requires systematic monitoring of the learning progress.

National education in Thailand is starting to support the development of artificial intelligence technology and its use, as well as prepare the country's youth to learn about, understand and apply artificial intelligence technology. The artificial intelligence Innovation Development and Promotion Plan is a national agenda that aims to strengthen the Thai economy and increase long term competitiveness. It is part of the Twenty Year National Strategic Plan (2018–2037). The Plan stresses providing a learning program on artificial intelligence, developing capable educational human resources for artificial intelligence and enhancing diversified teaching materials on artificial intelligence. The resources were chosen to encourage students to develop critical learning techniques and knowledge of artificial intelligence.

2. RESEARCH METHODOLOGY

This research and development (R&D) project developed and studied the effects of an adaptive web application to enhance critical learning of artificial intelligence technology. The researchers followed four steps to fulfill the research objectives: study the guidelines for developing an adaptive web application to enhance critical learning of artificial intelligence technology; develop the research instruments; experiment with the use of an adaptive web application to enhance critical learning of artificial intelligence technology among lower secondary school students; and extract lessons from the experiments and develop for completeness.

The study amalgamated theoretical concepts related to artificial intelligence from textbooks and curriculum standards for basic science and technology subjects (computational science) according to the Basic Education Core Curriculum (2018). The content is divided into nine learning units: 1) the origin of artificial intelligence; 2) the types of artificial intelligence; 3) the importance of artificial intelligence; 4) examples of artificial intelligence; 5) big data; 6) deep learning; 7) machine learning; 8) coding; and 9) the misuse of artificial intelligence.

An initial online survey of 4,264 teachers, all teaching lower secondary students and from 61 schools in the target area, was conducted to determine development guidelines, of which 274 responded. An adaptive web application was disseminated by voluntary response. The sampling included 709 lower secondary school students from the Suphan Buri and Nakhon Pathom Secondary Educational Service Area Office.

The data was collected through four methods: analysis of pre-test and post-test scores when learning with an adaptive web application on all three learning styles; comparison of pre-test and post-test scores between subjects' learning styles; frequency of use of the web application based on their learning styles; and the students' opinions towards learning through the adaptive web application.

3. RESEARCH INSTRUMENTS

The researchers developed tools for evaluating the development of an adaptive web application to enhance critical learning of artificial intelligence technology for lower secondary school students, as follows.

The opinion and guidelines survey for developing adaptive web applications served as a needs analysis questionnaire. It was distributed among teachers and comprised three sections. The first section collected basic demographic information from the respondents. The second section investigated the respondents' current situation and expectations regarding teaching materials, instructional management and readiness to use technology. It was designed with a 5-point Likert rating scale covering 30 items, divided into three areas. The results of this section were intended for use as a guideline for the development of the adaptive web application. The third section requested additional recommendations for the guidelines and was an open-ended section that allowed the respondents to broadly and independently express their ideas. The questionnaire was subjected to a reliability test through a pilot test with 30 sets administered to a sample group. This was done to verify whether the questions accurately conveyed the intended meaning and were appropriate. The Cronbach's alpha coefficient (α) was used for reliability testing. The findings indicated that the questionnaire had an overall reliability coefficient of 0.882, which falls within the 'good' range.

The adaptive web application designed to enhance the learning of artificial intelligence is accessible via web-based access, eliminating the need for software installation on the device. Only an internet connected device and a browser are required for access. This is designed to reduce computing power and increase loading speed. The application has two parts, the front-end technology which is the user interface (View) and the back-end technology which is the data processing and management (models and controllers). Both can be viewed directly through any web browser without downloading or installing a full application package on a device. The interface of the web application can be adjusted to the screen dimensions of the output device. The students themselves can select their preferred learning content presentation from the three media formats available. Infographic media presents information visually for easy comprehension and is quick to read. Multimedia video clips feature slides and animations with audio captions for the learners to enjoy. Finally, web pages present information with text and image details and allow links to other websites.

The web application therefore supports visual learners, who develop through images, charts, diagrams and symbols, auditory learners, who respond to sounds and hearing, and kinaesthetic learners, who learn by touch. The design of the adaptive web application allows for customization to align with the learning outcomes at the end of each unit. This enables students to learn content through suitable media. Additionally, assessment results are used to tailor the learning media format for the next learning unit. First, students learn via infographics. If they score 5 or above on the end-of-unit test, they proceed to the next unit. If they do not meet this criterion, students relearn the same unit with video clips and web pages in sequence. Subsequent units start with the latest used media format. A sample of the adaptive web application is shown in Figures 1–4.

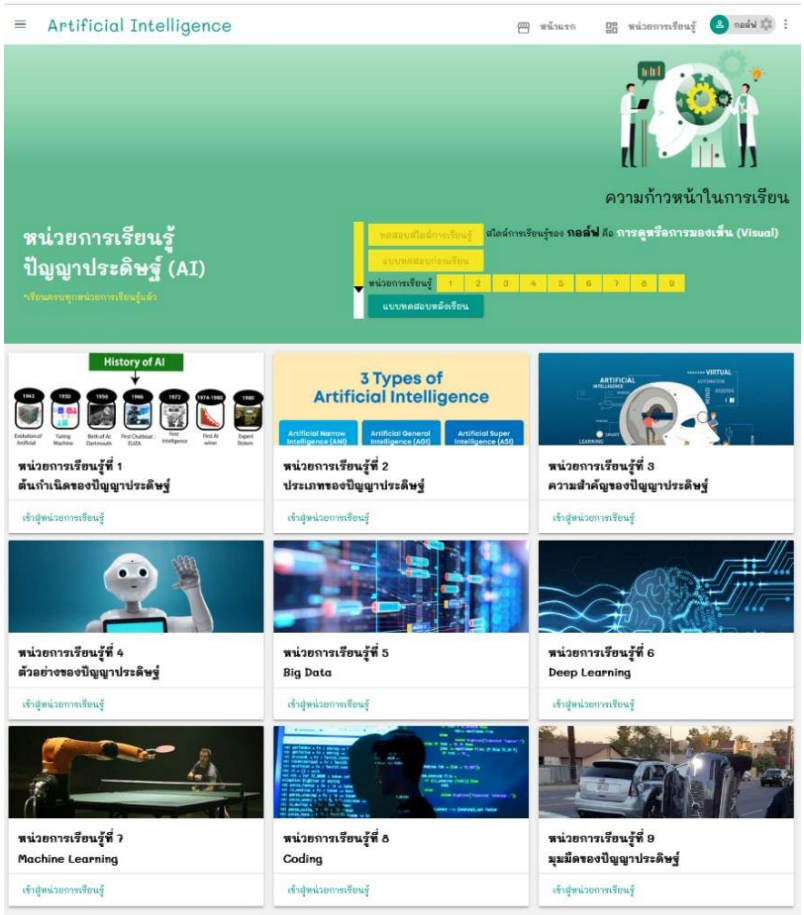

Figure 1: An adaptive web application homepage displays the learner's status and learning progress, which is divided into 9 learning units and assessments

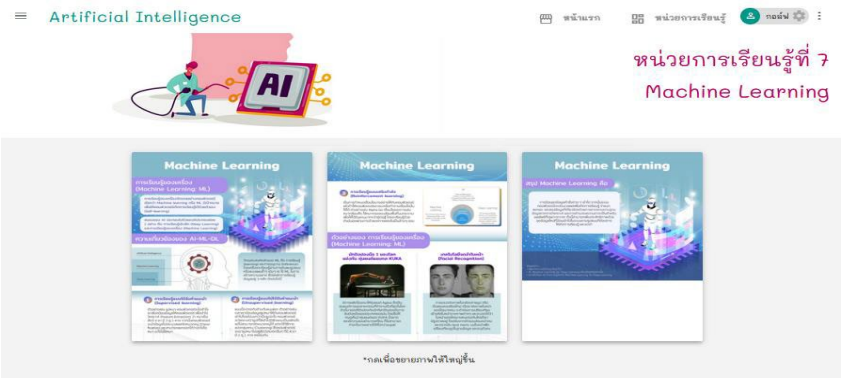

Figure 2: Web application presenting learning content via infographics media, visually focussed for easy comprehension and quick reading

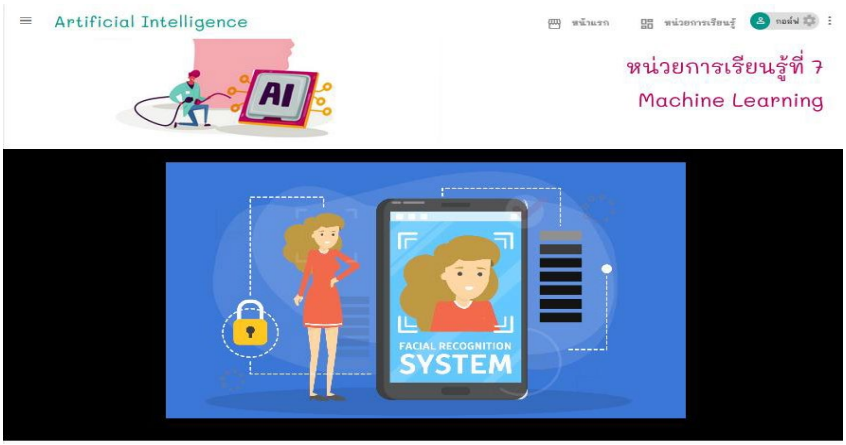

Figure 3: Web application presenting learning content from multimedia video clips, featuring slides and animations with audio captions

Figure 4: Web application presenting learning content from web pages with text and image details and allowing links to other websites

The effectiveness of an adaptive web application was assessed using the judgment of 5 experts, employing a 5-point Likert scale questionnaire. The analysis revealed that it scored a high overall rating (M = 4.86, SD = 0.35). Specifically, the management of learning in the adaptive web application received the highest rating (M = 4.87, SD = 0.34), followed by the usability design of the adaptive web application, which also received a high rating (M = 4.85, SD = 0.36). Additionally, experts recommended minor changes, including rearranging certain sections within the web application, adapting the language used in presenting information to better suit learners, reducing the content volume in some learning units, and reviewing the information presentation to provide instructors with more convenient access to users' learning outcomes.

The learning style assessment began with studying the theoretical concept related to learning styles, which are the ways humans perceive information through three channels: visual perception, auditory perception, and kinaesthetic perception. These learning styles can be divided into three major categories. The learners were asked to take a self-assessment test, adapted from the self-assessments test by the Pennsylvania Higher Education Assistance Agency (PHEAA) (n.d.), to determine their learning styles. Visual learners learn from visual media, such as images, diagrams, charts, and symbols, auditory learners learn from audio media, such as hearing and listening, and kinaesthetic learners learn through touch and action. In this test, learners were given instructions to quickly read each test question and select the most appropriate answer as their initial choice. They were advised not to spend too much time reading or overthinking, as it may lead to incorrect answers. The 20 questions were multiple-choice, with three options. The scores were then calculated separately for each learning style, and a clear learning style group with the highest scores was selected as the sample group for studying the development of the adaptive web application. Groups with equal scores in each learning style were not used in the calculation.

A critical learning test on artificial intelligence technology was given. It aimed to measure a student's analytical thinking abilities, considering various factors, using reasoning, analyzing problems, identifying possibilities, and assessing information reliability. Additionally, it involves classifying factual information and opinions, drawing reasonable conclusions from provided events, and interpreting given information or situations. It serves to assess tool efficiency by examining content validity before actual data collection. This method relies on the opinions of five experts to determine the index of item objective congruence (IOC). The IOC assesses the alignment between questions and content relevant to the study's subject matter. The assessment results revealed that the average congruence index was 0.94 for all items, and every item had a value ≥0.5, indicating that these questions were usable. Some questions were modified to enhance clarity and suitability for the age of the sample group based on expert recommendations. The test was administered to a group of 20 students with similarities to the sample group to determine the difficulty index (p) and the discrimination index (r) of the test. The analysis was conducted using difficulty criteria ranging from 0.20 to 0.80 and the discrimination criteria started from 0.20. From the data analysis, it was found that the difficulty index ranged from 0.31 to 0.79, and the discrimination index ranged from 0.30 to 0.79. Subsequently, the test's reliability was calculated using the KR-20 formula by Kuder and Richardson (1937), resulting in a reliability coefficient of 0.84.

A student opinion questionnaire that allowed students to express their thoughts and feelings regarding the content, learning media, the usability of the web application, the knowledge gained, and its application consisted of a 10-item assessment. These questions were based on a 5-point Likert scale. The opinion questionnaire was assessed for its effectiveness by examining content validity before using it for actual data collection. This assessment relied on the judgment of five experts to determine the IOC to assess alignment between the questions and the content relevant to the study's subject matter. When evaluating the questionnaire items, it was found that the congruence index had a value of 0.97, indicating that these questions could effectively be used to inquire about students' opinions regarding learning through the adaptive web application on the topic of artificial intelligence.

4. RESULTS AND DISCUSSION

4.1 The development of the adaptive web application

The aim of the adaptive web application was to enhance critical learning of artificial intelligence among the students of Suphan Buri and Nakhon Pathom Secondary Educational Service Area Office. Results of the initial survey among teachers showed requirements for teaching materials, instructional management and technological readiness to be moderate, which may be due to the diverse levels of knowledge among the respondents. Moreover, testing student's learning styles to determine differences remained at a low level. Therefore, current web applications are not suitably adapted for the students. The survey showed any teaching

media was expected to have diversified material with an assessment feedback that allows further and consistent differentiation of future teaching materials.

Feedback from teachers on the lesson content division in each learning unit suggested a stronger focus on the appropriate order of difficulty, a more regular evaluation of learning outcomes at the end of each lesson and use of infographics and video clips as the instructional media. The development of the web application was therefore adjusted to test the student's learning style as well as their knowledge before and after learning topics. Students began learning content through different media that was adjusted based on their learning outcomes and the end of each unit. The assessment results were used to adjust the format of the learning media in the next unit.

The needs expressed by the respondents were found to be consistent with other learning management theories, specifically the cognitive theory of multimedia learning (Mayer, 2009; Park, 2022), which reiterate that learning materials should be adjusted based on individual learner interests. This media use helps learners apply previous knowledge to create new knowledge. In addition, according to the 2021 Internet User Behavior Survey Report in Thailand by the Ministry of Digital Economy and Society (2021), both internet use and online learning levels are increasing. With the increase in web applications being used to perform various online activities, a research led design for an adaptive web application is consistent with wider research. As well as basing the web application on student learning styles, the design also consisted of clarified learning objectives. The educational content was presented in different ways depending on the diverse level of knowledge. In addition, at the end of each unit, a unit test was conducted, followed by the evaluation of the results from the student outcomes and also an adjustment of the type of teaching materials. This facilitated the exploration of results and guided future application implementation. An added benefit was that by using an adaptive web platform, study time can be flexible and adjusted based on student needs, as they can study at any time, from any device, using the application.

4.2 Effect of the adaptive application on critical learning of artificial intelligence technology

As shown in Table 1, comparison of pre-test and post-test scores for students' critical learning of artificial intelligence technology when learning through the adaptive web application on all three learning styles was done with t-test dependent analysis. Results showed the post-test scores were higher than before with a significant difference at the 0.05 level for all types of media: infographics, video clips and webpages. All three learning styles had a higher score in the post-test than in the pre-test. This correlation was because all three types of media used digital files allowing them to be used through different devices such as computers, smartphones and tablets. This allowed the students to access them through web pages meaning they were easily accessible and could be viewed both at convenient times and as often as desired. All materials were also graded and organized into an easily recognized design that helped students understand the content of each unit. This result was consistent with Khanhachai (2019) who studied the use of the 5E flipped learning model in conjunction with the infographic design process to enhance science progress skills and visual knowledge for lower secondary school students. It was found that the average scores for science learning skills after using the model were significantly higher than before, at the 0.05 level, and the mean scores of infographics after the study were higher than before at the statistically significant level of 0.05.

Table 1: The analysis of pre-test and post-test scores for students' critical learning of artificial intelligence technology when learning through the adaptive web application through all three learning styles (n = 709 students)

	n	***M***	***SD***	***f***	***df***	***Sig***
Pre-test	709	9.17	2.19	-35	708	< 0.001
Post-test	709	11.68	1.92			

Note: $p < 0.05$

Additionally, Alrwele (2017) examined infographic use and academic performance. Data were collected using achievement tests and questionnaires to assess student perceptions. As a result, it was found that the experimental group had significantly higher learning outcomes than the control group. Ninety percent of the sample in the experimental group reported that the infographics had a positive effect on their intelligence, life skills and emotional development. For this reason, the current study was developed to be in line with these theoretical concepts. The effectiveness of the adaptive web application was considered to be at a high level in several areas. Several factors contributed to this, including adaptive learning management, web application useability design, navigation interface optimisation, and linkage to web application content, appropriateness of language for presenting information, dilapidated videos, clarity of clips and clarity of attached audio. As a result of these, when students learned through the adaptive application, they scored higher than pre-test results.

The comparison of pre-test and post-test scores between subjects' learning styles revealed that there was no significant difference at the 0.05 level (Table 2), when a one-way ANOVA analysis of variance was conducted, students with the same or different learning styles had no difference in scores before or after learning. The reason is that all three learning styles could be satisfied by watching and listening to the learning materials. The developed web application could provide the learning content through a variety of learning materials that students could use as appropriate. The application was also adaptive based on the assessment results at the end of each lesson in each learning unit. As a result, every student's learning style was addressed, which corresponds to the work of Biçer (2014), whose work aimed to find significant differences between levels of critical learning of students with varied learning styles and those with a single learning style. It was found that the most common learning style among the sample was a varied learning style. The distribution of learning style was not differentiated by sex or education level. The level of critical learning of the students was not significantly different at the 0.05 level. Meanwhile Smith et al. (2006) conducted research on the effect of learning style and type of teaching on cognitive performance and mental health of physical therapy students by using one of two teaching strategies: teaching through CDs and live demonstrations. The results showed that there was no difference in the efficiency of cognitive and mental performance after using a multimedia-based teaching style. Additionally, written scores from the practice quizzes improved with both teaching strategies, which shows that there was no significant difference between the strategies. In the current study the learning outcome among different learning styles was also not significantly affected by different media.

Table 2: The analysis of pre-test and post-test scores between three different learning styles (n = 709 students)

	n	***M***	***SD***	***f***	***df***	***Sig***
Pre-test						
Visual	429	9.28	2.13	2.469	211	0.087
Auditory	194	9.16	2.20			
Kinaesthetic	86	8.66	2.41			
Post-test						
Visual	429	11.70	1.85	0.19	209	0.827
Auditory	194	11.69	1.96			
Kinaesthetic	86	11.55	2.15			

Note: $p < 0.05$

A study on the online learning management system, Moodle, by Kolekar et al. (2018), discussed e-learning. It was noted that students preferred online learning to traditional face-to face classes, even though materials were created to suit student's learning styles and learning was shown to have improved. It was suggested that students, on average, did not have time to go through all of the media. In this study, the use of adaptive and organized e-learning material enhanced learning experiences, and improved learning for individuals. Language teaching applications use adaptive technology to help match lessons and content to enhance language learning. Moreover, the online adaptive learning practices have enhanced learning engagement, significantly improved learning outcomes and influenced learning attitudes in other subjects (El-Sabagh, 2021). Therefore, a teacher who knows the learning style of the learners in their class would be successful in preparing and developing materials to adequately impart knowledge to the learner. This was demonstrated in this study where learners reached their potential and a variety of learning materials helped learners of all styles to improve their performance in school.

As shown in Table 3, learners' media usage frequencies categorized by learning style were not statistically significant at the 0.05 level. The learners from all three different learning styles did not differ in their treatment of instructional media in any of the nine learning units. In this regard, most learners made the most of the infographics. Because infographics condense information with illustrations that are easy to understand, they can quickly deliver a point of learning. Reading and listening to video clips can be time consuming, but their use was not affected by different learning styles. Easy-to-understand materials were chosen to arouse the interest of learners. This is consistent with the learning design principles presented by Ertmer and Newby (2013). The design principles are based on behaviorism theory and categorized by design, where content is arranged from easy to hard. Also, consistent ordering of content in each lesson affects the learning of the student, indeed, clear design, content division and assessment nurture engagement in online learning (Dixson, 2010). Czerkawski and Lyman (2016) presented a four-layer framework for instructional design that facilitated student's participation with online learning environments. Beyond this, designing a learning environment requires formative assessment, media selection, and education resources for students. These factors help foster student engagement that influences real learning outcomes (Alemayehu & Chen, 2023).

Table 3: The analysis of the frequency of all 9 learning units classified by learners' learning styles (n = 709 students)

	n	*M*	*SD*	*f*	*df*	*Sig*
Info						
Visual	429	14.13	4.45	0.353	218	0.703
Auditory	194	14.23	4.47			
Kinaesthetic	86	13.74	4.51			
Clip						
Visual	429	6.78	4.24	0.106	220	0.899
Auditory	194	6.64	4.23			
Kinaesthetic	86	6.87	4.19			
Web						
Visual	429	4.82	3.03	1.818	207	0.165
Auditory	194	4.96	3.28			
Kinaesthetic	86	5.62	3.62			

Note: $p < 0.05$

This was consistent with research by Yorganci (2022) who used e-books and video clips to facilitate student learning, motivation and knowledge. E-books and video clips were shown to affect intrinsic motivation related to cognitive load and reduce student's external and internal cognition. Furthermore, a study by Lindner et al. (2021) used images to affect learner's learning and metacognition. This study found that visual use had a positive impact on learning efficiency. Chen and Sun (2012) related educational psychology in general with the use of multimedia in learning. They found that video clip-based multimedia elicited more positive emotions from students than text based interactive multimedia, images, and animations. For this reason, infographic media presents visual information that was easy for learners to digest and took less time to read. Video clips presented slide information, animations with audio narration made learning fun for students, and media websites presented detailed information with text and images. In addition, Bravo et al. (2011) examined the effect of using video clips as an educational tool to increase motivation. Their research revealed that the use of video clips had a positive effect on student perception. Supporting media were so integral to effective learning that it was recommended learning media should be designed in the form of multimedia, combining different types of media such as text, graphics, sound, animation and video.

4.3 Student opinions on adaptive web applications

As seen in Table 4, the highest level of students' opinions on adaptive web applications focused on artificial intelligence technology were 'reasonable' (M = 4.59, SD = 0.49), The highest level was found in the questions, content on artificial intelligence is fascinating (M = 4.89, SD = 0.31); and the knowledge about artificial intelligence can be effectively applied in the present and future world (M = 4.82, SD = 0.38). This suggested that learners felt encouraged to study artificial intelligence through the web application. Aljraiwi (2017) studied the effect of the classroom through a web application on teaching, learning and critical learning that divided the content into six units. The study found that students were more interested in learning and performed better when using the proposed application in the classroom during and after school. In addition, these applications also contributed to obtaining appropriate educational support and effectively assisting teachers and students in managing and directing educational activities both inside and outside the classroom. Ajisoko (2020) surveyed student opinion of their use of the application Duolingo. Of the students, 17.5 percent agreed that the Duolingo application encouraged students in learning vocabulary, and 75 percent learners found that Duolingo was useful, easy to use, and stimulating. In addition, Guerrero-Roldán et al. (2021) studied the use of adaptive learning intelligent systems (LIS). They concluded that learner's perceptions of the topic were more effective and the students were more willing to use their LIS the following semester.

Table 4: Questionnaire and arithmetic means ± standard deviation of student opinions on adaptive web applications. (n = 709)

Questions	*M±SD*
Q1 I gained a better understanding of my own learning style.	4.32±0.47
Q2 Pre- and post-learning assessments helped track progress.	4.57±0.50
Q3 The content on artificial intelligence was fascinating.	4.89±0.31
Q4 The diverse range of learning media was engaging.	4.72±0.45
Q5 Learning media aided in retention and comprehension of the content.	4.68±0.47
Q6 End-of-unit assessments helped review knowledge.	4.35±0.48
Q7 Web applications were user-friendly and accessible on any device.	4.42±0.49
Q8 Learning through web applications was convenient at any time.	4.44±0.50

Table 4: Questionnaire and arithmetic means ± standard deviation of student opinions on adaptive web applications. (n = 709) (Continued)

Questions	*M±SD*
Q9 The acquired knowledge enhanced critical thinking and kept up with the use of artificial intelligence technology.	4.73±0.45
Q10 The knowledge about artificial intelligence could be effectively applied in the present and future world.	4.82±0.38
Overall	**4.59±0.49**

Learners opinions toward the learning media showed a positive trend and that the variety of media was suitable for different learning styles, and the application helped learners increase interest and their likelihood of following up on learning units. The respondents felt they had gained knowledge, improved critical thinking, and had contemporary knowledge on the usage of artificial intelligence technology. This corresponded to Sanjabi and Montazer (2020) who adapted material for online use outside the classroom in an attempt to account for the study styles of learners. Their results showed elevated pride, improved study results and improved study techniques among the learners. The effects confirmed that altering surroundings while using e-learning improved success. Rachen Namwong et al. (2018) designed and developed an internet utility to aid assignment design of a research-based study course and review pride of results among 33 college students and instructors at Det Udom School, Ubon Ratchathani province. The questionnaire consisted of internet design, operation effectiveness and students use of research guided materials. Overall results indicated that the level of pride in results was at the highest level. Research based study became the most preferred form of study. This shows that internet-based applications can be useful in aiding assignment development in research-based study as well as non-research-based work.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Design and development of the adaptive web application

The web application was designed to access several web pages while only displaying the necessary information. It allowed students to access the application without limits on time or location. The material could be displayed through a web browser without installing an application, using relatively low resources. It could also be loaded quickly and was adjusted to work faster than opening a normal application. The display (front-end technology) was easy for students to use. There were menus, instructions, and statuses, and it was designed to be student friendly. The back-end technology meant it had low processor use and the data management helped the instructor authenticate access rights, view, store and save score data that helped to evaluate learners. The application could be presented in a wide variety of formats and adjusted to the size and screen resolution of the display on different devices. The study found that learners commented that the web application was easy to use on any device and they could learn through it at any time that was convenient.

AI content presented in the adaptive web application focussed on enhancing knowledge on artificial intelligence for lower secondary school students studying computer science. The 9 areas of study were 1) the origin of artificial intelligence, 2) the types of artificial intelligence, 3) the importance of artificial intelligence, 4) examples of artificial intelligence, 5) big data, 6) deep learning, 7) machine learning, 8) coding, and 9) the misuse of artificial intelligence. It had an appropriate focus and level of difficulty for students to help understand and develop knowledge and moved from broad to specific content. Each topic required understanding in order to move to the next topic. The content in each unit was designed to enhance thinking abilities, analytical thinking, synthetic thinking, summarizing and seeing the importance and potential uses of artificial intelligence for further benefits. The study found that students found the content to be interesting and they could see how they could apply their knowledge of artificial intelligence in the present and future.

Learning media developed as part of the adaptive web application presented the content through three formats. The infographics media presented visual information that made it easy for learners to digest content and did not take long to read. Media video clips presented slides, animations with audio captions and encouraged students to enjoy learning. Lastly, web pages presented detailed information though text and images, and contained links to other web pages. The adaptive system automatically adjusted itself based on the users' choices. This adaption evaluated the personality and learning aptitude of the learner and the ability of the student to present the most suitable version of the material to the learner. The continuous methods that improved teaching and learning throughout the learning process all focussed on achieving the learning outcomes at each unit, and was not just based on assessment results. As a result, teachers could systematically track the progress of students within each unit. Scores could be viewed from data recorded. The students

commented that the learning materials were diverse and interesting. Appropriateness of learning materials helped students memorize and understand the content more easily.

For the purposes of this study visual learners developed knowledge from media, pictures, chart diagrams and symbols, as well as multimedia such as computer assisted instruction, videos and movies. In addition, the reading of books with rich illustrations could be considered visual learning and help these individuals learn and remember more. Auditory learners learn through audio media by hearing, listening, reading aloud and telling stories or thoughts to others to help them remember stories and information. Tactile, or kinaesthetic, learners were supported in this study by brief reading to get a concept and then reading of details or practice through tasks that required step by step instructions. The study found that all three learning styles had no difference in the use of different types of media. In addition the learners expressed that they understood their own learning styles more.

Learning with critical thinking about artificial intelligence through the adaptive application helped students understand and interpret specific information in different contexts. Students were encouraged and assessed on their ability to consider and summarize the issues and use reasons to justify their ideas. They were also asked to consider future possibilities and judge the credibility of information from various sources. Their ability to appropriately cite sources was measured in pre-test and post-test evaluations and end of learning tests. The test bank contained 180 questions, grouped into the nine learning units and with 20 items per unit. The questions were randomized to help review knowledge, memory, understanding and critical thinking and were designed to encourage reasoning, judgment, summarizing and connection of ideas. Students were encouraged to compare differences and similarities between alternatives and suggest alternatives. The study found that when students learned through the adaptive web application there were differences between the pre-test and post-test scores. Students commented that the tests before and after helped them understand their progress, and the end of unit tests helped them review knowledge and reinforce their knowledge and judgment over artificial intelligence use in the wider society.

5.2 Guidelines for implementing adaptive web applications

Although web applications they are convenient to use, they require teachers to ensure students have access to output devices such as computers, notebooks, mobile phones, and tablets that have a stable internet connection. Provided there is access to such a device, content can be reviewed easily and quickly. Teachers can help learners at any time; therefore, they could be used as supplementary materials outside of class.

Teachers need to study manuals before using adaptive web applications with students. This allows them to understand the components, menus, functions, usage, registration methods, tests, learning styles and assessments, andallows them to more effectively track progress through the units systematically and effectively. Teachers can then effectively support a more positive learning outcomes.

The content of artificial intelligence was presented through nine units. Teachers are encouraged to supplement the materials through additional activities. The web application helped encourage learners to gain more knowledge through activities such as individual reflection and group discussion. The course can be supplemented with case studies related to artificial intelligence from the news and wider world.

Surveying the learning styles of students helps teachers prepare a variety of teaching materials differentiated to their preferences. Teaching materials matched to learning styles motivated learners to study. Preparing different media to present information is therefore important. Teachers need to prepare equipment as well as materials in order to deliver media, clips and audio that appeals to the different learning styles.

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