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Effectiveness of Adaptive Blended Digital Technology Learning to Improve Learning Outcomes of Digital Native Learners in COVID-19 Pandemic Situation

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Abstract

The objectives of this research were (1) to study the students' learning styles to create adaptive blended digital technology learning. (2) To study the effect of adaptive blended digital technology learning to improve learning outcomes of the digital native learners in the COVID-19 pandemic situation and (3) to study the pretest and posttest results with adaptive blended digital technology learning. The sample group consisted of 49 undergraduate students in the Digital Literacy course in the second semester of the 2020 academic year, Suan Dusit University. The research instruments were (1) the perceptual learning style preference questionnaire, (2) learning management plans using adaptive blended digital technology and (3) the questionnaire for learning outcomes with innovative learning. The data obtained were analyzed using frequency, percentage, mean, standard deviation and t-test dependent. The results of the study were as follows: (1) The significant learning style preference of the sample group were Audio Learning Style (ALS), Group Learning Style (GLS) and Kinesthetic Learning Style (KLS), respectively. The sample group use of digital technology for learning was at a high level. (2) The learning outcomes in the learning innovation of the sample group were at the highest level when they were sorted on a descending order to technology utilization, digital media creation and intellectual skills. (3) the learning outcomes of the sample group before and after the study showed significant difference at.05; the learning outcomes after the experiment (M = 4.21, SD = 0.43) were higher than before (M = 3.12, SD = 0.71).

Introduction

Advances in digital technology have been used in teaching and learning, to solve the problem of accessing learning content, facilitating the implementation of online learning activities, such as online lesson websites, smart classrooms, digital classrooms, digital instructional platforms. In addition, students are now called digital natives born into this digital age and able to use various technologies around them to facilitate a wide variety of activities in everyday life and for studying. There are questions regarding how today's children should properly use digital technology. All stakeholders must develop learners in the digital age to be aware of their

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roles, obligations and responsibilities (Said et al., 2014). Other questions focus on the challenges teachers face for digital learners to improve the quality of lifelong learning and skills needed for digital learners. Both in development formats such as traditional media, online lessons development of a digital learning platform, digital lesson production and digital knowledge warehouses for learning.

Educational institutions and teachers need to provide learners with appropriate learning spaces. Provide an environment for action learning and provide new learning resources based on digital technology to exchange knowledge. Conducting activities to develop learners according to learning objectives and a communication channel increases the role of learners from technology users to participants and creators of technology (Punie & Ala-Mutka, 2008). Along with socially responsible citizenship skills, online social service, or service (Said et al., 2014). Coupled with the situation of the COVID- 19 pandemic that caused the lockdown forcing education institutions worldwide to conduct lessons online. Therefore, digital technology must be prepared for online instructional learning.

Blended learning is defined as combining a learning style that offers face-to-face along with electronic tools supporting the teaching. (Anaraki, 2018; Ozadowicz, 2020). Blended learning could be the solution for providing extreme online education in the situation of the COVID-19 pandemic (Bordoloi, Das, & Das, 2021; Busto, Dumbser, & Gaburro, 2021). In Thailand, the COVID-19 lockdown from March to April 2020, caused Suan Dusit University to offer 100% online teaching during the first semester of the academic year 2021 to the second semester of the academic year 2021 (mid-August 2020 to mid-May 2021). According to I Nathaniel et al. (2021), blended learning may be viewed as distance education, entirely online with or without classroom teaching using digital technology, thus providing a virtual face-to-face interaction and then combining the virtual communication with online activities for the learners. Digital technology provides an extreme online learning experience and adaptive learning has been used to provide an individualized of learning activities to learners needs, boundary time and engagement (Clark & Kaw, 2020; I Nathaniel et al., 2021; Tashiro & Hebeler, 2019; Wangwattana & Lertnattee, 2019). Adaptive blended digital technology may improve learning outcomes of digital native learners in the situation of COVID-19, according to the study of I Nathaniel & Black (2021), an adaptive, flexible blended learning approach that combines virtual face-to-face instruction using digital technology. Digital learning platforms such as online meetings like the mobile application Zoom, MS Team, LINE, Google Meet, Cisco WebEx, etc., have provided digital native learners with emergent responses during the COVID-19 crisis (Bordoloi, Das, & Das, 2021). Instructional adaptive blended digital technology supports situational learning activities and combines the mobility of learners into the conception of the content that offers discussion opportunities (Glahn & Gruber, 2018; Suartama, 2019). Adaptive blended digital technology combines digital technology with innovative teaching to create social activities between the learners.

In this study, adaptive learning combined technology to adopt teaching methods according to learning objectives, learning abilities and learning styles. The learners' aptitude to choose the lessons according to the benefits of the learning process, learner's aptitude, reflection and assessed needs of each learner during the course. Learning outcome refers to the results of adaptive blended digital technology in learning innovation consisting of the intellectual skills, creative innovation learning and use of digital technology. This corresponds to the skills needed for learners to improve learning outcomes according to Poovarawan's concept (2017), stating that new learners are born during digital transformation. Therefore, it is necessary to have the skills to create innovation, promote problem-solving, be a creator and use technology in the digital ecosystem.

Objectives

1. To study the students' learning styles to create adaptive blended digital technology learning.
2. To study the effect of adaptive blended digital technology learning to improve learning outcomes of the digital native learners during the COVID-19 pandemic situation.
3. To study the pretest and posttest results with adaptive blended digital technology learning.

Literature review

1. Blended Digital Technology Learning in the COVID-19 pandemic situation

Blended digital technology learning is a blended learning style of virtual face-to-face learning in the online classroom to create an online learning experience using various learning materials and teaching activities. (Singh, 2021). The aim is to enable learners

to achieve their learning goals. The teaching is meaningful to learners and motivates learners whose learning curves must adapt to the advancement of digital technology during the COVID-19 (Okaz, 2015; Singh, 2021). Blended digital technology learning helps to create a good opportunity for interaction between teachers and students using modern technology with flexible time and borderless learning. Digital technology influences teaching and learning, such as broadcasting live teaching online, online chat, social network, blogs, forums, applications and webinars. There are now many digital tools to create digital blended learning opportunities for learners.

Amid the changing world with disruptive technology and the unexpected COVID-19 crisis that has disrupted education, digital technology plays a vital role for learners to access and create knowledge on their own (Shalini et al., 2020). Therefore, the learning environment must be created that supports learning through creating knowledge by interaction between learners and the ability (Learner Content) between teachers and learners and between learners together (Learners Instructor). Despite the challenges, here are five examples of digital technologies to manage blended learning solutions to the challenges; (1) Online lessons through the Learning Management System (LMS). (2) Online classrooms through various programs, teachers can create and operate online classrooms. (e-Classroom) with programs such as Microsoft Teams, Google Classroom and Zoom. (3) Online teaching through the LINE application. (4) Massive Open Online Courses (MOOCs) are taught through online lessons for learning, allowing large groups of students l from all over the world to access classes via the Internet. (5) digital multimedia for teaching and learning.

Blended digital technology learning combines traditional classroom learning with digital technologies such as online lessons, online classrooms, communication applications, MOOCs and digital multimedia as supplementary material for learners to be more interested in learning. Student's receive a new experience from virtual technology media and video clips which is the crucial goal of incorporating digital technology to achieve continuous learning outcomes of learners. Teacher's adapt to different learners through student reflection, they must design a learning method suitable for different learners and make the most of digital technology (Ossiannilsson, 2017).

2. Adaptive learning

Adaptive learning is the presentation of lessons that are suitable for learners' abilities. Each person first selects an address for the production and assesses the learner's abilities, for learners to receive lessons that are most suitable for learners to stimulate the interest to learn more-and adding new communication channels to complement the existing teaching technology by applying modern technology to the maximum benefit (Klabpadung, 2017; The TECH EDVOCATE, 2020). Adaptive learning management has the following three concepts; (1) Macro-Adaptive Instructional Models: There is a relatively fixed framework for learning goals, course content and teaching methods. (2) Aptitude-Treatment Instruction Mode: adapting learning processes and strategies to suit learners. And (3) Micro-Adaptive Instructional Models are methods that combine macro and aptitude concepts.

Based on the adaptive learning approach, the blended digital technology learning environment automatically adapts itself to each learner's personality traits at an individual level. However, the teacher must consider the different principles of teaching that respond to the needs of the learners. Generally, two approaches are used to develop tailored lessons (Klabpadung, 2017; Changkanak, 2017). 1) Personalization: This automatically changes the learning environment to meet the needs of the learners. And 2) Customization: This way, students can change the learning environment according to their own needs.

Blended adapted digital learning is an alternative that can attract the attention of students, a method to interact with learners, to create fun, challenging, new learning experiences that are more diverse. This learning style eliminates time and space constraints with students. It responds to the current situation with the rapid advancement of digital technology and its widespread application.

3. Learning Outcome

The Higher Education Standards 2018 specifies the standards for student outcomes as follows (Ministry of Education, 2020); 1) A person with knowledge and abilities in various fields builds career security and quality of life for one's own family, community and society. 2) A co-creator of innovation which has 21st century skills and the ability to integrate various sciences to develop or solve social problems and entrepreneurial attributes. 3) A strong citizen has the moral courage to adhere to the correctness, know the value and preserve.

The skills needed in the 21st century can be divided into three skill sets (Netwong, 2019); (1) The basic skills that learners must apply in their work consist of general knowledge of literacy, computation, science, technology and communication, finance and being part of society and culture. (2) A skill set of competencies learners needs to use in more complex problem-solving tasks, critical thinking, problem-solving, creativity, communication and collaboration. (3) A skill set that promotes characteristics for adaptation in self-management to social conditions, consisting of curiosity, creativity, persistence to achieve the goals, set the ability to adapt to society and the environmental leadership and awareness of culture and society.

In other words, essential skills are consistent for learning outcomes for both the Higher Education Standards 2018 and 21st century. Adaptive blended digital technology to enhance learning outcomes were defined in three aspects as follows: (1) professional ethics (knowledge and morality), (2) learning innovation about the intellectual skills, the creation and use of digital technology and (3) Digital Active Citizen.

4. Learning Styles

Learning style is how individuals concentrate, absorb and retain new or complex information or skills. It is not the materials or strategies that people use to learn. Those are the resources that complement each person's style. Style comprises a combination of environmental, emotional, sociological, physical and psychological elements that permit individuals to receive, store and use knowledge or abilities (Elizabethtown College, 2021). Each student learns differently using different learning styles at a different rate. Everyone has a learning style. Our style of learning, if accommodated, can result in improved attitudes toward learning and an increase in academic achievement. By identifying your learning style, you will determine how you learn best. Learning styles do not reflect levels of achievement or intellectual ability. No one style is better than the other. The element chart indicates perceptual strengths as six types; (1) VSL-Visual Learning Style (2) ALS- Audio Learning Style (3) TLS- Tactile Learning Style (4) KLS- Kinesthetic Learning Style (5) ILS- Individual Learning Style (6) GLS- Group Learning Style (Elizabethtown College, 2021; Insaard, 2018; Reid, 1987). Each type is divided into three groups: (1) Major Learning Style Preference, (2) Minor Learning Style Preference and (3) Negligible Learning Style Preference (Insaard, 2018; Reid, 1987).

Conceptual framework

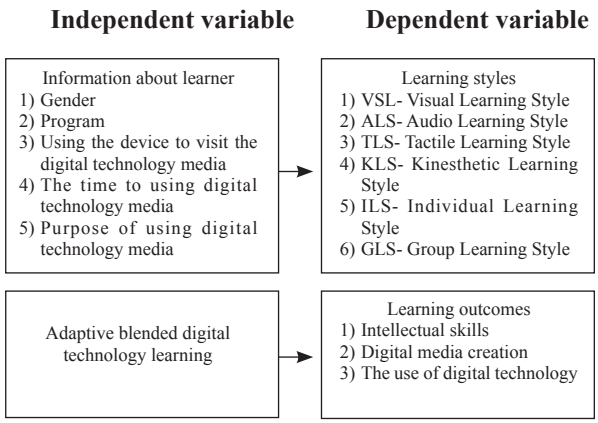

Figure 1 Conceptual framework

Research methodology

This study implemented both quantitative and qualitative research methods to generalize the research finding as follows:

1. To study learners' learning styles to manage adaptive technology blended learning a survey was used to collect data with the target audience.

2. A study of the effects of adapted digital technology blended learning management to enhance learning outcomes of digital native learners.

3. A study of pre-and post-learning outcomes with an adaptive digital technology blend. A one-group pretest-posttest design was used and measured before and after undertaking adaptive blended digital technology learning, including interviews to collect qualitative data from observations. As well as works from reflection through blogs and results from presentations through social networks. Learners were asked to fill out an evaluation form for learning innovations after utilizing adaptive blended digital technology learning.

1. Population and samples

The population were students at Suan Dusit University who were enrolled in the second semester of the academic year 2020. Samples were taken from the students who enrolled in the Digital Literacy Course, semester 2, 2020, consisting of 49 students. Samples were obtained by selective selection, with the research objectives being digital native learners.

2. Research instruments

The research instruments were as follows.

2.1 A questionnaire was used to research learners' learning style (Insaard, 2018; Reid, 1987). The

learning styles were as follows; Organized the learning styles of the sample group according to the concept of Reid (1987) that divided six learning styles as follows: Visual Learning Style (VSL), Audio Learning Style (ALS), Kinesthetic Learning Style (KLS), Tactile Learning Style (TLS), Group Learning Style (GLS) and Individual Learning Style (ILS). Each type is divided into three groups:

1.1) Major Learning Style Preference

1.2) Minor Learning Style Preference

1.3) Negligible Learning Style Preference

2.2 The adaptive digital technology blended learning management plan (Eagleton, 2017; Ennouamani, Akharraz, & Mahani, 2019; Howard, Remenyi, & Pap, 2006; Makarova, 2018). There were three stages: before entering the classroom while conducting activities in the classroom and after learning adapted digital technology blended. This course was conducted for 15 weeks, consisting of 6 steps: (1) Preparing technology for learning (2) Pre-study activities (3) Selecting activities, implementing learning activities (4) Strategies to stimulate learning and feedback in each activity (5) improvement of learning resources information resources (6) Summarize the students' feedback to adjust their learning strategies continually.

2.3 The questionnaire for learning outcomes with innovative learning (Ministry of Education, 2020; Netwong, 2019). It consisted of questions in 3 areas: 7 intellectual skills, 6 digital media creations and 7 digital technology use, totaling 20 items.

The research was conducted as follows.

1. Study information to cover adaptive blended digital technology issues to improve learning outcomes.

2. Create the questionnaire of learning style, adaptive digital technology blended learning management plan and the learning innovation assessment form to cover issues in the instruments section 1) - 3)

3. Send the questionnaire to 3 experts to check content validity IOC (Index of Item Objective Congruence). The average of each item is 0.66 - 1.00 and the correctness was adjusted according to the experts' suggestions.

4. Implement with the experimental group, which was similar to the sample group, i.e., students enrolled in the course Digital Literacy, Suan Dusit University. In the first semester of the academic year 2020, 40 students were determined to find Cronbach's alpha coefficient. The confidence value of the total learning style questionnaire was 0.914 and the confidence value of the student learning innovation assessment form was 0.941.

5. Collect data with the sample group.

3. Data collection

3.1 Collected data regarding learning styles to manage adaptive blended digital technology.

3.2 Assessed students before learning about innovation and then carry out activities according to the adaptive blended digital technology plan.

3.3 Collected data from traces of digital technology usage in terms of frequency of using qualitative information from communication.

3.4 During the teaching and learning process, collected qualitative data from observations and results from reflections through Microsoft Form, results from presentations via social networks and Microsoft Forms, upon completion of teaching activities. Then learners completed an assessment of learning outcomes through Google Form.

4. Data analysis

4.1 Analyze traces of access to adaptive digital technologies such as WBSC, LINE approach, MS-Team and SDU MOOCs.

4.2 Analyze the mean and standard deviation and percentage of learning styles of the samples from the questionnaire.

4.3 Analyze the mean and standard deviation of the learning outcomes of the sample group.

4.4 Analyze the mean, standard deviation and t-test dependent before and after studying and percentage development of learning outcomes in learning innovation.

4.5 Content Analysis: Qualitative data from online communication, reflection and online presentation.

Results

1. Learning styles

The sample group had opinions about the learning style. They agreed with the listening learning style (ALS) with the highest average (M = 3.66, SD = 0.59), followed by the group learning style (GLS) (M = 3.61, SD = 0.63). and the Kinesthetic Learning Style (KLS) (M = 3.48, SD = 0.60), respectively. The Tactile Learning Style (TLS) had the lowest mean (M = 3.16, SD = 0.64).

The results of the learning style analysis were conducted by finding the frequency and percentage of the sample and classified by learning style and use of learning style as presented in Table 1.

Table 1 The percentage of samples classified by learning style and level of use of the model

Learning Style	Major		Minor		Negligible	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
VSL	18	36.70	26	53.10	5	10.20
ALS	24	49.00	23	46.90	2	4.10
KLS	21	42.90	25	51.0	3	6.10
TLS	9	18.40	31	63.30	9	18.40
GLS	23	46.90	25	51.00	1	2.00
ILS	16	32.70	19	38.80	14	28.60

From Table 1, the results show that the sample group has a learning style that is mainly used as Audio Learning Style (ALS) of 24 students, representing 49.00%, Group Learning Style (GLS) of 23 students, representing 46.90%, Kinesthetic Learning Style (KLS) of 21 students accounted for 42.90%, Visual Learning Style (VSL) amounted to 18 students, accounting for 36.70%, Individual Learning Style (ILS) amounted to 16 students, accounted for 32.70% and Tactile Learning Style (TLS) of 9 students, representing 18.40%.

The results of using digital technology for learning showed the sample group had practiced using digital technology for learning at a high level ($M = 3.58$, $SD = 0.69$) with the use of social media applications for communication such as LINE, Facebook, Twitter, etc., at the highest level ($M = 4.22$, $SD = 0.79$), followed by using digital technology at a high level, learning via PowerPoint media in classroom or online classroom (M = 4.00, SD = 0.93) and live teaching with MS-Team or Zoom ($M = 4.14$, $SD = 0.76$). Electronic journal media (e-Journal), the level of practice was at a moderate level ($M = 2.80$, $SD = 1.09$).

2. Learning outcomes

The results found that the learning outcomes of the sample group were the highest level of practice ($M = 4.21$, $SD = 0.43$). The use of digital technology ($M = 4.36$, SD = 0.47), digital media creation ($M = 4.27$, SD = 0.47) and intellectual skills ($M = 4.00$, $SD = 0.52$).

3. The pretest and posttest results with adaptive blended digital technology

Table 2 Comparison of pretest and posttest learning outcomes of the sample group

Experiment	*M*	*SD*	*t*	*df*	*p-value*
pretest	3.12	0.71	11.36	48	0.00
posttest	4.21	0.43			

*p< .05

From Table 2, the learning outcomes before and after learning with adaptive blended digital technology showed a difference. The learning outcomes after the experiment ($M = 4.21$) were higher than before ($M = 3.12$).

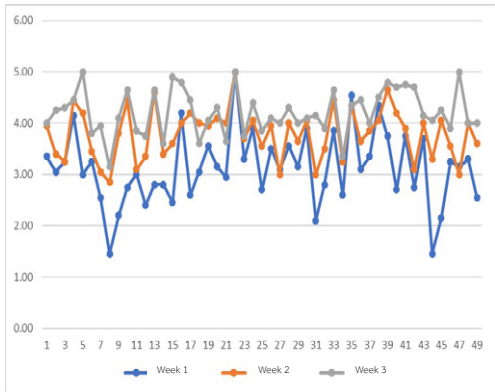

Figure 2 A graph showing the learning outcomes

From Figure 2, it was found that the learning outcomes measured at week 7 averaged 4.21, which were higher compared to the learning outcomes at week 4, that averaged 3.79 and were higher than before week 1. The overall average was 3.13, the improvement accounted for 21.69% with results showing samples had higher learning outcome scores.

Qualitative data collection of opinions of the sample from adapted blended digital technology learning are as follows:

1. What I learned:

"Getting more knowledge about the use of digital media, such as media literacy or the benefits of digital media in various forms."

"Understanding and types of digital media applications and features of users in the 21st century."

"Reviewed knowledge and learned about the understanding of digital media that a person who understands digital media must consist of comprehension, media literacy, information literacy and keeping up with the media."

2. Feeling of what has been learned:

"I felt that I was learning, teachers made it easy to understand and I enjoy participating in the activities in the class."

"Feeling friendly, it is easy to access because, in this era, digital is the main use."

"I feel more understanding of the content because the ppt media that teachers used make it quite easy to understand the content taught and it is not too

heavy. And I like the student activities to participate. I was not bored."

"I feel normal because it is something I should know today."

3. The benefits of learning:

"After learning, we knew more about the media, understand how to use media analysis and use the media more cost-effectively and usefully."

"It can be applied to every day and the digital media learned today can also be applied to work in more ways."

"I got to share my opinions with my classmates and got to know the elements and tools that are important to the digital age."

4. Implementation/Planning to apply what has been learned:

"Daily use, whether Facebook, Line or various programs used for learning, use it more correctly."

"Can be used to generate income through online media or writing novels through e-Book. I have a plan to use media to generate income by writing novels in various applications and to buy media movies online and I will also earn income from writing novels."

Discussion

1. The learning styles of the sample group consisted of listening learning style (ALS), followed by group learning style (GLS) and kinesthetic learning style (KLS). Preparing learning resources for this group of learners must provide tools for large-scale communication between learners and teachers. And learners with learners such as Instant interactive whiteboard applications for teamwork. By integrating various learning sources that affect the way students learn. The learning content is suitable for use in daily life, meaningful to learners and valuable for learning materials support activities organized in digital classrooms—media to promote learning that learners jointly operate. There is a media base to help group learners and mobile learning, which focuses on learners accessing digital classrooms anytime, anywhere, with unrestricted access to any device (Avvisati et al., n.d.). The fundamental elements in organizing a digital classroom are a personal computer in order to retrieve the information and communication technology infrastructure. It can link data to Internet and intranet formats, visualizers and projectors. There are digital learning resources, especially Open Educational Resources (OERs) and MOOCs, that can reach a diverse range of learners and teachers. According to Dublin (2012), the available online lessons, known as the Digital Learning Space (DLS), will meet the needs of today's individuals. With the use of web technology in social networks that offers online collaborative learning, self-learning design, or self-teaching design that can all be done online. As can be seen, the overall sample group has practiced using digital technology for learning at a high level. The use of social media applications for communication, such as LINE, Facebook, Twitter, etc., was at the highest level.

2. Implementation of an adaptive blended digital technology learning management plan had 3 phases: before entering the classroom and at the same time, conducting activities in the classroom and after learning adapted blended digital technology. The instructional was worked for 7 weeks (Eagleton, 2017; Ennouamani, Akharraz, & Mahani, 2019; Howard, Remenyi, & Pap, 2006; Makarova, 2018). When separated by aspects in descending order, the level of practice was the use of technology, digital media creation and cognitive skills, which are the knowledge and abilities required for learners to enhance learning outcomes. 21st century learners must have the following skills (JISC, 2010; Poovarawan, 2017), Media Literacy, Information Literacy, Communication and Collaboration, Digital Scholarship, Career & Identity Management, Learning Skills and ICT Literacy. Poovarawan (2017) stated that the new generation of learners were born during the digital transformation. Therefore, skills are required for innovation, promoting problem-solving, being creative and using digital technology in the digital ecosystem. According to Chatwattana & Piriyasurawong (2017), education management for the 21st century face challenges , such as self-learning creation and create new knowledge and the benefit to apply knowledge and can produce innovations in response to society's needs.

In regards to the use of digital technology it was found that students use the internet and social networks for project activities. Students are aware of digital technology's appropriate, safe and ethical use in digital communication. Students use digital technology to create networks for communication and project implementation or learning activities. This is consistent with Netwong (2019; 2021), based on a study of the use of exploratory and creative learning that affects digital literacy among students enrolled in library and information science courses, it was found that students' use of digital technology can avoid being tempted cybersecurity using digital technology. Awareness of

appropriate, safe and ethical use of digital technology, including the internet and social networks for learning.

Digital media creation found that students effectively create and select images to meet the stated digital media presentation objectives. Students can choose an appropriate program to develop digital media to distribute digital content suitable for their audience. And students can learn digital media, plan, write scripts and research information for digital media creation. Therefore, it can be said that teaching and learning management must have the characteristics of creative learners without boundaries, without barriers between them. There is unlimited space for students to participate in research, have creative activities, promote diversity in receiving various knowledge processes for both average learners and students with special needs. To develop digital literacy, a survival skill in the digital era (Netwong, 2019; 2021). Hanjai et al. (2019) studied organizing design, proactive learning support services for smart classrooms. The development process reflects the transformation strategy and service design process to evolve into a high-performance digital organization.

3. The results before and after learning with adaptive blended digital technology found that Learning outcomes after learning were higher than before. All learners showed a higher trend in learning outcomes. The results are consistent with the study results of Changkanak (2017) who developed adaptive web-based lessons, for an Information Technology course and found that learners with adaptive web-based lessons have higher academic achievement after learning than before. It was statistically significant at the .05 level and the students had a group of satisfaction with learning with adaptive web lessons on computer systems; overall, it's at a high level. Therefore, it can be said that adaptive learning management with the combination of technology can develop learners in a real learning outcome on issues of using digital technology, digital media creation and intellectual skills that affect different aspects of thinking, interpreting and summarizing texts to cover essential characteristics and properties of information. The ability to describe information details by describing the attributes of images, events and feelings is consistent with the notion that cognitive skills are positively correlated with critical thinking. Intellectual skills require sub-skills: observation, narrative, comparison, classification, definition, prediction and proposing alternatives (Nanta et al., 2014). Furthermore, Insaard's (2018) concept states that the learning process should be related to the learner's learning style. KLS-Kinesthetic, GLS learning style ALS-audio group learning style can increase academic achievement. Media production development should be coordinated to learners' learning styles for effective learning

Suggestion

1. Suggestions for applying the result

1.1 Based on the findings, digital native learners have a high use of the Listening Learning Style (ALS), Group Learning Style (GLS) and the Kinesthetic Learning Style (KLS). Ultimately, in teaching and learning management, media development and digital technology to adapt to learners, it must be coordinated with learning styles to carry out activities that are consistent with the learning style.

1.2 Digital native learners use the internet and social networks for their activities as much as possible. Therefore, the digital ecosystem for teaching and learning should emphasize the effective interaction of learners with the teaching and learning system to enhance learning outcomes effectively.

2. Future research

2.1 This study is intended to enhance learning outcomes in learning innovation only. Therefore, future research should study professional ethics (knowledge and morality) and proactive digital citizens to raise learning outcomes.

2.2 Digital ecosystem should be studied to promote the learning of digital native learners and digital leadership to enhance learning outcomes.

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