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Research Article

Designing the video-based learning environments using workflow and scaffolding to enhance self-instructional video production ability of pre-service teacher

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ABSTRACT

This study aims to design a video-based learning environment using workflow and scaffolding to enhance self-instructional video production ability of pre-service teacher and to explore the impacts of the use of the designed video-based learning environment on learning. The methodology was divided into two main phases. In the first phase, a video-based learning environment was designed using workflow and scaffolding. In the second phase, the impacts of the use of the developed video-based learning environment on learning were investigated. The samples were 47 undergraduate students at the School of Education, University of Phayao. The results were, as follows: (a) The design draft of the developed video-based learning environment was appropriate, and the revision was made according to six criteria: (1) instructional media, (2) content, (3) learning activities, (4) communication devices, (5) learning management systems, and (6) screen design. The analysis of related studies and documents, the instructional video production process consisted of three steps: (1) design, (2) development, and (3) video delivery. (b) The comparison of scores on the instructional video production knowledge test revealed that the pre-service teachers' average post-test score was higher than the average pre-test score with a statistically significant difference at the .05 level. The assessment of instructional videos, it was found that the pre-service teachers in the field of humanities obtained a higher score than those in the field of science. Male pre-service teachers received a higher score than female pre-service teachers. The average suit-ability score indicated the overall appropriateness of the developed video-based learning environment.

Keywords: video-based learning environment, workflow, scaffolding, instructional videos, self-instructional video production ability

INTRODUCTION

A learning environment refers to all the surroundings, which encourage learners to learn. It influences learning achievement, attitude, and the relationship between learners and teachers. An appropriate learning environment allows the management of teaching and learning to operate more effectively and achieve the pre-established learning objectives (Closs et al., 2021). It also encourages learners to develop various skills at higher levels (The School in Rose Valley, 2019). Video-based learning environment refers to videos that are used to create learners' engagement and interaction. All activities completed by learners are collected and stored in a database. It also includes sample videos or demonstration videos that provide learners with guidance and assistance and encourage them to practice by following the guideline (Gorucu-Coskuner et al., 2020; Madariaga et al., 2021). A video-based learning has long practically been used in the education environment to help students enhance their level of understanding (Othman et al., 2022).

The COVID-19 pandemic has forced all educational institutions across the world to promptly migrate to online teaching and learning (Adnan & Anwar, 2020; Dhawan, 2020). For online learning, instructional videos

are often used as a form of instructional media. Pre-service teachers have to independently design and create instructional videos based on their needs and learners' characteristics. From the survey, it was found that pre-service teachers experienced three problems in the production of instructional videos, including

(1) content design,

(2) video production, and

(3) video editing (Nonthamand, n. d.-a).

This is in line with the survey on problems encountered in instruction-al video production conducted with undergraduate students in the school of education at University of Phayao, which revealed that their instructional video production ability was low (Nonthamand, n. d.-b).

In previous studies related to the use of videos in teaching and learning, it was clear that videos helped improve learners' laboratory skills and engagement (Donkin et al., 2019) . In addition, compared to lecture videos, demonstration videos helped learners better understand content related to laboratory skills and engagement (Sugathapala & Chandrika, 2021). while micro-teaching videos could enhance teaching skills and could be used as teaching materials for pre-service teachers (Sofyan et al., 2019).

Moreover, the workflow can effectively create knowledge and understanding as it illustrates the steps in a work process to support the work and create interactions between people working on the project (Hyysalo et al., 2017; Wang et al., 2020). Workflow is also helpful in analyzing and designing work processes, organizing work tasks, and making quick and effective decisions (Microtool, 2020). In addition, it helps learners to understand the whole process as well as individual tasks in each step from the beginning until the end and to systematically complete the tasks that are all related to one another (Eisner, 2021).

Vygotsky's (1986) scaffolding concept is a path to systematically develop learners' ability by assisting and facilitating the learning of learners using demonstration or concrete examples, guided questions, feedback, additional resources with teachers as facilitators, and peer support. As a result, learners can eventually complete assigned tasks on their own as the assistance is gradually adjusted or decreased. Learners' ability then gradually improves as they complete the tasks on their own (Doo et al., 2020; Ghassemi et al., 2018; Korhonen et al., 2019).

Video-based learning, workflow, and scaffolding in designing the learning environment have been used to help pre-service teachers create learning and engagement (Taskin et al., 2019), and incorporating video games into the design of learning activities has positive impacts on the levels of learners' motivation and engagement (Barreto et al., 2017). In addition, the use of videos helps improve the level of learners' analytical skills and learning efficiency (Carmichael et al., 2018).

The purposes of this study are to create a video-based learning environment by incorporating workflow and scaffolding to enhance self-instructional video production ability of pre-service teacher and to examine the impacts of the use of the de-signed video-based learning environment on learning.

Research Objectives

1. To design a video-based learning environment using workflow and scaffolding to enhance teachers' and students' ability to create instructional videos.
2. To explore the impacts of the use of the designed video-based learning environment on learning.

METHODOLOGY

This research and development study was conducted in two phases.

Phase 1. Designing Video-Based Learning Environment Using Workflow and Scaffolding to Enhance Self-Instructional Video Production Ability of Pre-Service Teacher

A review of related literature and research on learning environment design is presented.

Research samples

1. Documents and research papers related to video-based learning, workflow, and scaffolding published between 2010 and 2020.

2. Three experts in instructional design, educational technology, and assessment and evaluation with at least five-year experience.

Research instruments

1. A research and document analysis form in a table format

2. A suitability assessment form for the design draft of the developed learning environment using a 3 point rating scale: inappropriate, uncertain, and appropriate

Data collection

The researcher collected and analyzed related documents and studies. The results were used to draft the learning environment using theory-based design. The suitability of the draft was later evaluated by three experts in related fields.

Data analysis

The analysis and synthesis of the selected documents and research were conducted in a table format. Descriptive statistics used in this study were means and standard deviations.

Phase 2. Exploring Impacts of the Use of Designed Video-Based Learning Environment on Learning to Enhance Self-Instructional Video Production Ability of Pre-Service Teacher

Research population and samples

The research populations were third and fourth-year undergraduate students at the University of Phayao in the academic year 2021.

Research samples

Research samples were 47 third-year undergraduate students studying in the academic year 2020 in the school of education at University of Phayao. G*power (Cohen, 2013) was used to determine the sample size while the one-sample t-test was used to confirm the number of samples. The effect size was .50, the α err prob was .50, and the statistical power obtained (1-β err prob) was .95. The samples were select-ed using purposive selection based on the following characteristics:

(1) being well equipped with basic educational technology infrastructures, such as the Internet and a computer, and

(2) having enrolled in any subject related to educational technology and communication, instructional video production, or instructional multimedia development.

Research instruments

1. The knowledge test on instructional video production contained 38 four multiple-choice questions. There were 17 questions about design, 14 questions about development, and seven questions about video delivery.

   In terms of content validity, three experts validated the content of 44 items on the test. The item-objective congruence (IOC) was between .76 and 1.00. Of all the questions, IOC values of the three questions were .50 and lower, which meant these questions were irrelevant to the operational definitions and test objectives. The researcher then revised the wording of these questions accordingly.

   Regarding the test's reliability, the test was tried out on 30 undergraduate pre-service teachers whose characteristics were similar to the samples. In the first trial, the test was distributed online using Google Form. The index of difficulty ranged from .100 to .900 while the average difficulty was .489. In addition, the discrimination values were between -.330 and .780 and the average discrimination index of all items was .272 and the reliability coefficient (KR20) was .715. From the first trial, it was found that some

questions and choices did not meet the criteria. The research, therefore, revised the questions and choices and took out some questions. The revised test contained 38 questions that addressed all the indicators. In the second trial, the test was created using Google Form and distributed to another group of 30 undergraduate pre-service teachers whose characteristics were similar to the samples. The difficulty index of the test was between .167 and .933, and the average difficulty value was .478. Additionally, the discrimination index of the revised test ranged from .100 to .800, and the average discrimination value was .396 while the KR20 was .838.

2. The instructional video production aptitude test consisted of 39 five-point rating scale questions. In terms of content validity, three experts validated the test items and, as a result, IOC was found between .667 and 1.000 while the average value of all items was .933. Regarding the face validity of the test, the test was tried out with five pre-service teachers whose characteristics were similar to the samples. It was found that the test's face validity values ranged from .600 to 1.000 and the average face validity value was .958. To validate the test's reliability, the test was tried out with 30 undergraduate pre-service teachers. The value of the total Cronbach's alpha coefficient of the test was .947.
3. The scoring rubric for instructional videos consisted of two parts: design and production. The full score was three. Assessment objectives were determined, and all elements and indicators were included in the scoring rubric for instructional videos created by the pre-service teachers. The test's content validity was validated by three experts using IOC. As a result, the average index of IOC was found at 1.000.

Data collection

This study adopted a one-group pretest-posttest design, which is a type of quasi-experiment. The emphasis of designing the learning environment management in this study was on allowing students to create instructional videos presenting the contents related to their fields of study. The instructions included the use of on-demand videos, video conferences, online examinations, discussion boards, online chatting, social media, educational technological devices for online learning, and tools for video production. The students had to self-study the contents of instructional videos in the learning system before attending an online classroom. They summarized the contents, asked questions, and submit the assigned task. The researcher divided the contents into small sections and assessed the students' knowledge using a knowledge test and video production skills using a scoring rubric for instructional videos, as shown in **Table 1**.

Table 1. Learning environment draft

Week	Objective	Topic	Learning environment	Instructional media	Assessment
1	To enable learners to identify objectives in production of their videos	Objective identification in video production	Images, website graphics, fonts, font sizes, font colors, workflow, work submission systems, anonymous virtual discussion boards (e.g., Mentimeter & Padlet), & student-teacher communication channels or chat rooms	PowerPoint, teaching materials, illustrations, instructional videos, & infographics	Worksheets on objective identification in video production
	To enable learners to generate ideas in their video production	Main idea identification in video production	Images, website graphics, fonts, font sizes, font colors, workflow, sample images, sample videos, work submission systems, anonymous virtual discussion boards (e.g., Mentimeter & Padlet), & student-teacher communication channels or chat rooms	PowerPoint, teaching materials, illustrations, instructional videos, & infographics	Worksheets on main idea identification in video production
2	To enable learners to apply design principles in their video production	Design principles	Images, website graphics, fonts, font sizes, font colors, workflow, sample images, sample videos, additional learning resources, discussion forums, & student-teacher communication channels or chat rooms	PowerPoint, teaching materials, illustrations, instructional videos, & infographics	
	To enable learners to create storyboards in their video production	Storytelling with storyboards	Images, website graphics, fonts, font sizes, font colors, workflow, sample images, sample videos, work submission systems, anonymous virtual discussion boards (e.g., Mentimeter & Padlet), & student- teacher communication channels or chat rooms	PowerPoint, teaching materials, illustrations, instructional videos, & infographics	

Table 1 (Continued). Learning environment draft

Week	Objective	Topic	Learning environment	Instructional media	Assessment
	To enable learners to arrange steps in their video production	Arrangement of steps in video production	Images, website graphics, fonts, font sizes, font colors, workflow, video demonstration, work submission systems, discussion forums, & student-teacher communication channels or chat rooms	PowerPoint, teaching materials, illustrations, instructional videos, infographics, video conferences, & video presentations	
3-4	To enable learners to shoot their videos	Video shooting process	Images, website graphics, fonts, font sizes, font colors, workflow, sample images, sample videos, work submission systems, discussion forums, & student-teacher communication channels or chat rooms	PowerPoint, teaching materials, illustrations, instructional videos, & infographics	Worksheets on photos & video shooting
	To enable learners to give a presentation in front of a camera	Presentation in front of a camera	Images, website graphics, fonts, font sizes, font colors, workflow, sample images, sample videos, reading practices, additional learning resources, work submission systems, discussion forums, & student-teacher communication channels or chat rooms	PowerPoint, teaching materials, illustrations, instructional videos, & infographics	Worksheets on video shooting
5-6	To enable learners to edit their videos	Video editing	Images, website graphics, fonts, font sizes, font colors, workflow, sample images, sample videos, additional learning resources, anonymous virtual discussion boards (e.g., Mentimeter & Padlet), opinion-sharing activities, work submission systems, discussion forums, & student-teacher communication channels or chat rooms	PowerPoint, teaching materials, illustrations, instructional videos, & infographics	Worksheets on instructional videos
7	To enable learners to use videos in their instructions	Synchronous & asynchronous video delivery	Images, website graphics, fonts, font sizes, font colors, workflow, sample images, sample videos, work submission systems, discussion forums, & student-teacher communication channels or chat rooms	PowerPoint, teaching materials, illustrations, instructional videos, & infographics	Worksheets on video delivery
8	To encourage learners to exchange ideas about video production	Video production process	Anonymous virtual discussion boards (e.g., Mentimeter & Padlet)	Video conferences & video presentations	Instructional videos

Data analysis

General information was analyzed using descriptive statistics, namely means (M) and standard deviation (SD), and the comparison of the average scores on the knowledge test and aptitude test was performed using inferential statistics, namely t-test.

RESULTS

Phase 1. Designing Video-Based Learning Environment Using Workflow and Scaffolding to Enhance Self-Instructional Video Production Ability of Pre-Service Teacher

Part 1. Analysis results of related documents and research

From the analysis of related documents and research, it was found that there were three steps in producing instructional videos, including

(1) design,

(2) development, and

(3) video delivery.

The researcher placed the main emphasis on design as the literature showed that teachers should pay attention to audience analysis, content design, storyline design, and instructional video production planning. Therefore, pre-service teachers should

(1) analyze the audience in terms of their learning behaviors and characteristics,

(2) design content based on principles, concepts, theories, and practices by dividing content into small units with specific objectives for video production and explaining the benefits of each video,

(3) design storylines using digital video storytelling with images, texts, videos, narration by pre-service teachers, and music, in the form of storyboards, which reveal camera angles, image sizes, and design principles of a six-minute instructional video, and

(4) plan the video production by listing tools and devices, shooting dates and times, locations, setups, and props, duration of shooting, editing, and delivery phases, budgets as well as schedules of actors and actresses or pre-service teachers with dress code, as shown in **Table 2**.

Table 2. Sample research results

Author	Objective	Research methodology	Sample characteristics	Research results
Classroom environment				
Friend and Militello (2015)	To analyze video production process in education	A video content analysis	23 video examples with guidelines for readers to practice video production within each category	The video production process included: 1) choosing content and pedagogical methods for the video, 2) designing and creating video digital storytelling using images, texts, videos and the instructor's narration, 3) using the video in the classroom, and 4) evaluating the video by collecting data, analyzing the collected data, and publishing the analysis results.
Norton and Hathaway (2010)	To examine teacher-learners' reflections about use of video production	A qualitative study of teacher-learners' reflections about use of video production	138 teacher-learners from 2007 through 2009	Teacher-learners had a better understanding of video production & learned strategies to boost learners' engagement. They also learned roles & responsibilities required in video production & developed their creativity from this experience. Challenges found in their video production experience were limitation & availability of equipment, inefficient production planning, & video delivery channels for learners.
Petr et al. (2015)	To propose videography as a method for academics' development	An experimental study on content design, photography, & videography	Researchers who wished to create videos in their research mixing art & science	Video production process included (1) analyzing target audience, (2) analyzing content, (3) creating videos, & (4) publishing video. Researcher designed video storytelling by giving importance to selection of images, texts, graphics, & music to suit the target audience as it could increase number of viewers.
Snelson (2018)	To learn about video design & production to train pre-service teachers to create videos for their own class	A literature review of research articles from 2006 to 2017	61 studies published from 2006 through 2017	Video production process for pre-service teachers included (1) researching background of topic, (2) creating a story and outlining video presentation, (3) storyboarding, (4) recording video & narrating, (5) editing video & audio, (6) using video in classroom, (7) evaluating quality of video production process & video. Pre-service teachers were expected to use their creativity & complete video production process independently.
Watt (2019)	The examine how video production can be integrated into teacher education programs to promote critical digital literacy	A qualitative inquiry study using a focus group, questionnaires, observations, and content analysis of teacher candidate	40 pre-service elementary teachers at a large Canadian university	Video making process included (1) choosing a topic, (2) planning, (3) shooting, & (4) publishing a 30 second one-shot video, to be screened during last 20 minutes of class. All videos were shot & edited on mobile phones. Pre-service teachers shared their experiences completing video & multimodal instructional plan, as well as about their understandings of literacy in one of focus group sessions. Challenges confronted during video production were (1) a lack of technical knowledge & skills, (2) privacy & safety issues with

Table 2 (Continued). Sample research results

Author	Objective	Research methodology	Sample characteristics	Research results
		videos & instructional plans		kids filming one another & sharing online, (3) inefficient time consumption due to a lack of expertise, (4) a lack of assistance when experiencing problems in video production, (5) a lack of video production tools, such as microphones, & (6) students' unwillingness to appear in video and a lack of parental consent.
Winslett (2014)	To examine how videos are used in higher education teaching and learning	A landscape literature review of studies published from 1997 through 2011	703 articles on video usage in higher education teaching and learning	Type of video production that was most supported in higher education was providing exemplars of best practice as it was created with specific objectives, well-developed composition, unique styles of presentation, clear production roles & responsibilities, & various easy-to-access channels. Some challenges in video production was designing video presentation that was appropriate to content, a lack of tools, high cost of video production, readiness of instructors & supporting staff, & adequate financial support.
Wood and Olivier (2011)	To explore the use of video production as a tool for assisting teachers to explore their perceptions about parental involvement in education	A participatory research	Nine teachers who participated in this study by designing & producing short videos about issues that they perceived to impact negatively on their teaching & learning, & critically reflecting on these videos	The video production process included (1) preparing the participants, (2) brainstorming on the design and presentation, 3) shooting, (4) compiling sub-titles, and (5) publishing the videos. The video production helped the teachers to understand the production process and the videos were used to engage with parents in a participative way.
Online learning environment				
Gaston and Havard (2019)	To determine how collaborative video production (CVP) influences students' perceived learning	A mixed methods study using survey and interview	242 students (117 girls & 108 boys) & 13 teachers representing grades 2 through 5	CVP was a group task that required group members to (1) choose a topic, (2) write a storyboard, (3) write a script, (4) shoot a video, (5) edit video, & (6) deliver video. Emphasis was on students' opportunity to design content and present it together & exchanges throughout the video production process using online tools.
Guo et al. (2014)	To reveal how video production decisions affect student engagement in MOOC	A empirical study	6.9 million video watching sessions across four courses on the edX MOOC platform	A video promoted learner engagement when (1) it was shorter than six minutes, (2) it was filmed in an informal setting, (3) recording of instructor's head & topics were inserted into presentation video at appropriate times, (4) instructor add emphasis by sketching on PowerPoint slides, (5) instructor used upbeat pace & natural enthusiasm, (6) instructor put an emphasis on overall picture of content in video & encouraged students to re-watch it, & (7) video for MOOC was designed as it led to more engagement compared to a recorded classroom video.
Rasi and Poikela (2016)	To discuss how use of video triggers & video production in PBL can bridge education & authentic work	A literature review	Literature on uses & effects of video triggers & video production within PBL	Video production in PBL settings created more authentic ways to simulate work-life, for example, panoramic videos with 360-degree images, realistic videos, multimedia case scenarios, which enhanced learning and critical thinking.

Table 2 (Continued). Sample research results

Author	Objective	Research methodology	Sample characteristics	Research results
			contexts & related higher education & continuing education contexts that feature authentic problems	
Shelton et al. (2017)	To evaluate online learning & teaching management via video storytelling among pre-service teachers	A mixed methods study	31 pre-service elementary teachers	Designing digital storytelling required in-depth understanding of the contents and technology expertise in video shooting and editing. Digital storytelling production experiences could be a salient demonstration of engaging with interdisciplinary topics via relevant technological mediums.
Teo and Chai (2009)	To promote the engagement of novice learners in collaborative critiquing in the context of producing an educational video project	A research and development study of a critique model and activities implemented in an online system	42 pre-service teachers at the National Institute of Education	Four-step critique procedure consisted of (1) identifying project purpose, audience & expertise, (2) evaluating strengths of design & suggesting improvements, (3) evaluating weaknesses of design & suggesting improvements, & (4) summarizing important points for transfer to own project. Emphasis was on pre-service teachers' critiques of each video project by filling in blanks in critique forums following guidelines provided by instructor, allowing exchanges between peers & building connections between them.
Wang et al. (2020)	To examine learners' learning and perceptions towards the use of videos from eye-tracking data	An empirical study in which 60 college students who watched two videos on statistics, one on an easy topic & other one on a difficult topic were observed & inquired	60 public college students in America	Learners' perceptions of the videos increased in the following situations: (1) instructor presence in videos improved transfer performance for the difficult topic, (2) appropriate questions were selected and asked at the right time, (3) suitable non-verbal behaviors, such as manners, tones of voice, facial expressions, and postures, were used, (4) instructors repeated contents in a discussion board and a forum, and (5) instructors used images, graphics, and on-screen writing to explain complex contents.
Yan (2021)	To study the MOOC-based micro-class combined with the MOOC video production method for improving the video production effect	An experimental study in which students created instructional videos for the MOOC-based micro-class	80 high school students	Process of video development for MOOC-based micro-class consisted of (1) topic selection, (2) pre-designing stages-learner analysis, video structure analysis, manuscript design, & video target analysis, (3) preparation stage of shooting–determining shooting plan, image design, shooting environment layout, & preparing props for shooting, (4) recording phase, (5) post-production stage, & (6) publishing videos online. Videos should be short, and the two popular types of videos were situational videos & demonstration/experimental videos.

Part 2. Suitability assessment results of the drafted video-based learning environment using workflow and scaffolding to enhance self-instructional video production ability of pre-service teacher

According to suitability assessment of learning environment draft, experts found that the overall learning environment was suitable (M=2.98, SD=.174).

Part 3. Assessment results of the revised learning environment draft

The experts' opinions and suggestions obtained from the open-ended questions were used in the revision of the learning environment draft. The following six main points were addressed.

1. **Instructional media:** The experts suggested that learning resources on social media platforms should be added to the designed learning environment. The researcher, therefore, selected and added learning resources in the form of text links directing to social media platforms. Text graphics were used as labels for learning resources, such as YouTube channels. For example, iLoveToGoDotCOM is a YouTube channel that shares a variety of techniques in photography and videography and introduces photography and videography tools with product demonstration videos, and 2how is also a YouTube channel about photography and videography. In addition, Asayhi Channel is a YouTube channel that reviews cameras and tools for photography, videography, and live streaming.
2. **Contents:** The experts commented that some parts of the contents, such as main idea identification, presentation in front of a camera, and video editing, were so brief that additional explanation was inevitably demanded. The researcher then added more content to the instructional videos and supplements on several topics, including presentation in front of a camera, personality, dress code, makeup, and hairstyles. Oral reading exercises for presenters were also included.
3. **Learning activities:** The experts recommended that there should be examples of expected outputs or templates for pre-service teachers. The researcher later created fill-in-the-blank worksheets on several topics, such as objective identification, storyboard writing, and flowcharts. The researcher also provided examples of final products from previous years for pre-service teachers to see what was expected of them.
4. **Communication tools:** The experts suggested that there should be both synchronous and asynchronous tools to increase learning engagement and interaction. The researcher designed activities in which pre-service teachers would have the opportunities to exchange opinions using both synchronous and asynchronous tools. The researcher also made appointments with pre-service teachers for synchronous activities, such as presenting their instructional videos, and exchanging their experience of video production, including problems, obstacles, and solutions.
5. **Learning management systems:** The experts pointed out that some parts of the assignment submission system need to be improved, and pre-service teachers should be able to review their works and check whether the submission was complete by displaying the dates and times of submission. Also, pre-service teachers should receive feedback while doing activities or after submitting their final works. The researcher, therefore, used Google Form as a platform for work submission and Share Sheet to list the submission details, such as names, student identification numbers, sections, and submission links, allowing pre-service teachers to review their submissions.
6. **Video graphic design:** The experts have found that some parts of the videos contained hyperlinks that direct to other videos from other resources. They suggested that those videos should be embedded in every lesson video, otherwise pre-service teachers would skip them without realizing that they are missing out on some related content. The researcher then removed all hyperlinks and embedded those videos in all lessons instead.

Phase 2. Exploring Impacts of the Use of Designed Video-Based Learning Environment on Learning to Enhance Self-Instructional Video Production Ability of Pre-Service Teacher

Part 1. Comparison of average scores on instructional video production knowledge of pre-service teachers before and after the lesson

The comparison results of the average scores on instructional video production knowledge of the pre-service teachers before and after completing the lesson revealed that the mean score on the pre-test (M=17.94, SD=3.90) and the mean score on the post-test (M=32.64, SD=4.24), which were statistically significantly different at the .05 level, as shown in **Table 3**.

The comparison results of the average scores on the ability to produce instructional videos of pre-service teachers before and after the lesson showed the overall ability of the pre-service teachers before attending

Table 3. Comparison of average scores on instructional video production knowledge of pre-service teachers before and after the lesson (n=47)

Instructional video production knowledge	Score	Pre-test		Post-test		t	p
		M	SD	M	SD		
Total	38	17.94	3.900	32.64	4.240	-19.079	.000
Element 1. Design ability	17	8.12	1.800	14.04	1.933	-19.079	.000
Element 2. Development ability	14	5.15	1.850	11.43	2.030	-17.847	.000
Element *3.* Video delivery ability	7	4.66	1.540	7.17	.963	-10.171	.000

Table 4. Comparison of average scores on self-instructional video production knowledge of pre-service teachers before and after the lesson (n=47)

Instructional video production knowledge	Score	Pre-test		Post-test		t	p
		M	SD	M	SD		
Total	195	141.04	25.880	171.70	17.550	-6.780	.000
Element 1. Design ability	100	72.47	12.520	88.51	8.850	-9.279	.000
Element 2. Development ability	60	42.17	8.440	17.62	2.080	21.223	.000
Element *3.* Video delivery ability	35	25.11	4.720	17.74	2.180	11.243	.000

Table 5. Evaluation results of instructional videos created by pre-service teachers categorized by majors of study and sex (n=44)

Score	Major		Sex	
	Humanities (14 students)	Science (33 students)	Male (15 students)	Female (32 students)
Instructional video evaluation (total score*:* 30)	27.14	26.97	27.33	26.78
Design (total score=12)	11.07	11.21	11.47	11.00
Development (total score=18)	16.07	15.76	15.87	15.78

the lesson (M=141.04, SD=25.88) and the mean score of their ability after completing the lesson (M=171.70, SD=17.55), which were statistically significantly different at the .05 level, as shown in **Table 4**.

Evaluation results of instructional videos created by pre-service teachers categorized by majors of study and sex.

The evaluation results of the pre-service teachers' instructional videos revealed that the mean score of the instructional videos created by the pre-service teachers majoring in humanities (27.14) was higher than the mean score obtained by the pre-service teachers majoring in science (26.97), and it was also found that the male pre-service teachers (27.33) received higher scores than female pre-service teachers (26.78), as shown in **Table 5**.

Part 2. Evaluation results of video-based learning environment using workflow and scaffolding to enhance self-instructional video production ability of pre-service teacher

This evaluation was carried out on the learning environment that was revised in phase 2 and trialed with pre-service teachers. It was found that the revised learning environment was overall appropriate (M=5.00, SD=.00).

Part 3. Final video-based learning environment using workflow and scaffolding revised based on experts' opinions

The researcher adopted the experts' opinions and suggestions collected from the open-ended questions in improving the learning environment. The details are, as follows:

In terms of content, the experts suggested that there should be content about a variety of video production tools and other tools that could be adapted and applied to create videos. The researcher then added the content on video production tools and DIY tools, such as blogs on Shutterstock and Fotofaga, and websites about DIY tools. The examples were

(1) 10 best introductions to lighting using DIY tools,

(2) five shooting techniques using DIY tools in one minute, and several other videos about DIY tools.

In addition, introduction and review videos about video production tools were added while some websites and Facebook groups, where opinions on the use of video production tools were exchanged as well as online marketplaces were also introduced. Some examples were, as follows:

(1) http://www.thaidfilm.com, a website that contained content about video production and a discussion board,

(2) http://www.thaidphoto.com, a website about photography and tools, and

(3) http://www.thaidvshop.com/, an online market, where tools and suggestions were provided.

DISCUSSION

The discussion is divided according to the objective of this study.

Results of Designing a Video-Based Learning Environment Using Workflow and Scaffolding to Enhance Self-Instructional Video Production Ability of Pre-Service Teacher

Aspect 1. In the developed learning environment, pre-service teachers are expected to learn from videos, and instructions in the videos were used as models for pre-service teachers to follow. According to the social learning theory (Bandura, 1986), learners learn from models or examples by observing and imitating the behaviors of others. In the learning environment in this study, videos were used as models from which pre-service teachers learned and observed. These videos were instructional materials that illustrate instructional video production steps using texts, images, graphics, audio, video, and camera angles. The content included explanations and illustrations about composition principles, camera angles, image sizes, videography tools, and video editing tools. These videos encouraged and enabled pre-service teachers to self-study the content anywhere anytime, and they could rewatch the videos afterward. In the videos, there were situations in which pre-service teachers had the opportunities to solve problems in various situations, such as 360-degree videos, actual video production, and case studies, leading to the development of analytical thinking of learners (Rasi & Poikela, 2016). Demonstration videos were also provided in order for learners to learn to self-regulate their learning and to learn by doing (Trabelsi et al., 2021).

Aspect 2. This learning environment places an emphasis on the use of workflow to reveal the overall picture of the instructional video production process and help pre-service teachers organize ideas and the production process. Since workflow illustrates connections and steps in the instructional video pro-duction process, instructors should create a workflow to clarify the contents and steps using graphics and visuals for pre-service teachers to learn, integrate and engage (Wang et al., 2021).

Aspect 3. This learning environment emphasizes on scaffolding using directing, suggesting, questioning, explaining, demonstrating, and facilitating learners in problem-solving and individual work. This is based on the zone of proximal development (ZPD) theory (Vygotsky, 1978), which addresses the distance between what a learner can do on his/her own and what he/she can do with assistance and guidance. It is also referred to as an area of learning in which instructors provide learners with suggestions, directions, and feedback, and act as facilitators who closely and consistently help learners to complete each task. With scaffolding in this learning environment, pre-service teachers will understand how to work, how to solve problems, and how to be in control in complicated situations. However, it is important to note that pre-service teachers should not rely too much on assistance in order for them to achieve the learning outcomes and engage more deeply in learning (Doo et al., 2020).

Results of Using a Video-Based Learning Environment Using Workflow and Scaffolding to Enhance Self-Instructional Video Production Ability of Pre-Service Teacher

Aspect 1. The average post-test score on the knowledge about instructional video production was higher than that of the pre-test, which indicated that the pre-service teachers learned the content about principles, concepts, and theory about instructional video production in this learning environment in an appropriate order. The content was presented in the form of instructional videos, demonstration videos, and composition videos along with the use of workflows or flowcharts there have been summarized for the pre-service teachers.

Aspect 2. The average post-test score on the ability to create instructional videos was higher than that of the pre-test, which meant that the pre-service teachers could produce their own instructional videos. At each step in the process, there were practices and instructions with samples for pre-service teachers to use as guidelines for completing the assigned tasks. Additionally, there were feedback, assistance, and additional resources that could help pre-service teachers in their instructional video production.

Aspect 3. Regarding the assessment results of the instructional videos, it was found that the instructional videos created by both male and female pre-service teachers majoring in science as well as humanities and social sciences were rated at a high level. This was likely because the learning environment provided sample instructional videos with the production workflows, which the pre-service teachers could follow. One activity was connected to the other, leading to the finished products. In addition, the instructor also gave suggestions for further improvement, which helped enable the pre-service teachers to create instructional videos on their own in the future.

Examples of video-based learning environment using workflow and scaffolding to enhance self-instructional video production ability of pre-service teacher

The following are examples of the developed video-based learning environment with explanations about how this environment can be implemented. This learning environment consists of three main elements, including

(1) lecture videos, sample videos, and demonstration videos,

(2) flowcharts, which include graphics that illustrate all steps in the process with details and summaries, and

(3) scaffolding, which include guidance, samples, and feedback.

The details are, as follows:

1. Videos presented in this video-based learning environment are lecture videos, sample videos, and demonstration videos.
2. Workflows or flowcharts in this learning environment include

   (a) diagrams that illustrate the steps in the process or order of content, and

   (b) diagrams with details and summaries.

   Visual graphics are designed to show the steps and how they are connected. Summaries of content make it easier for pre-service teachers to learn and follow as they create their own instructional videos. Pre-service teachers can also evaluate their knowledge and ability as they learn each topic. As shown in **Figure 1**, the text blinks to show where pre-service are learning in the lesson.

Figure 1. Steps in the process or order of content (https://sites.google.com/view/instruction-video-production/*การพัฒนาวิดีโอ*)

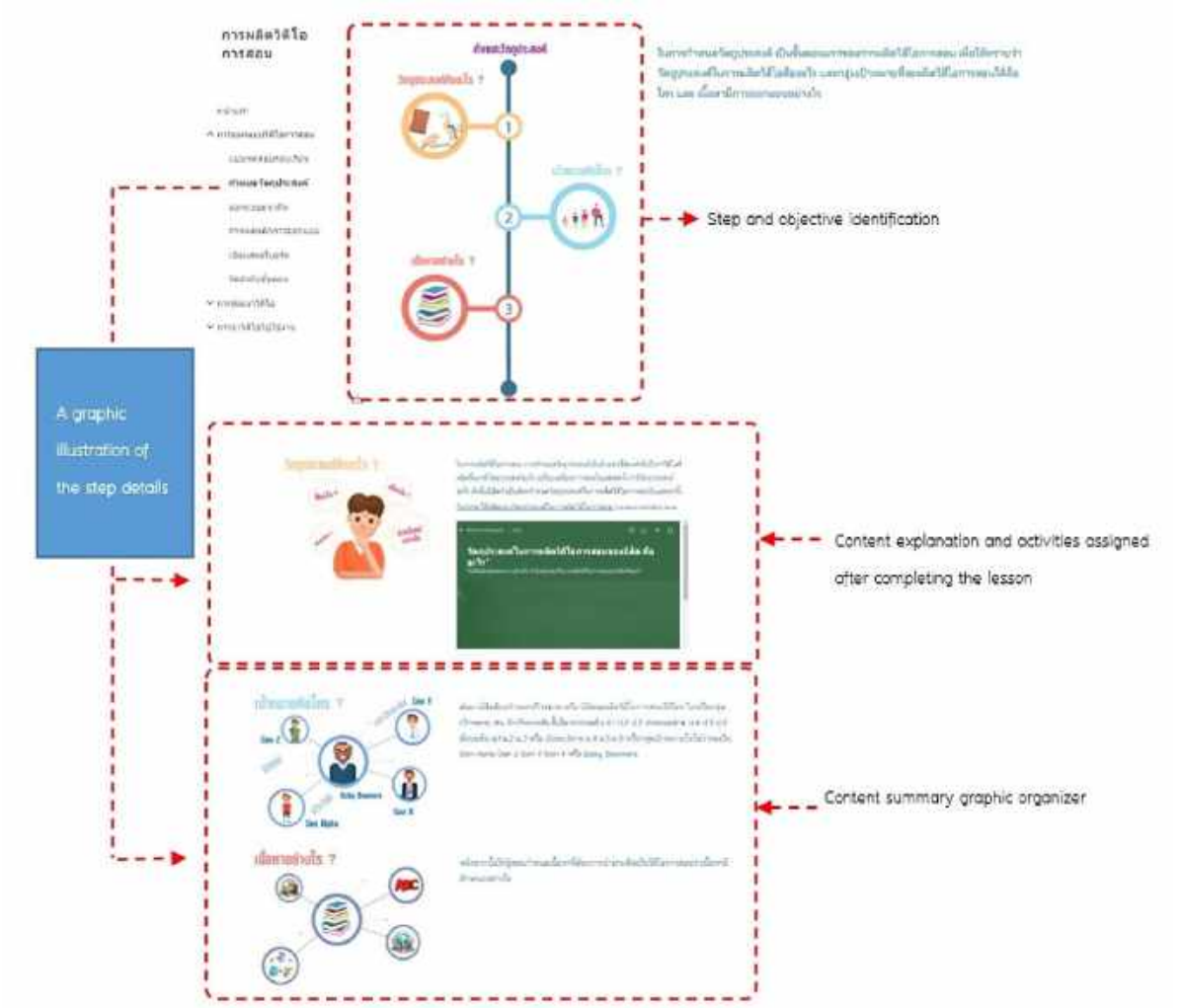

Figure 2. Detailed content (https://sites.google.com/view/instruction-video-production/*การออกแบบวดโอการสอน/ กำหนดวตถประสงค*)

Descriptive diagrams illustrate the detailed content, explaining the overall picture and all the elements in video production. The graphics inform pre-service teachers of the tasks that have been completed and those that are in the queue until the goals are accomplished. This helps encourage pre-service teachers to take the next step. With detailed explanations, pre-service teachers are able to complete the tasks for each topic, as shown in **Figure 2**.

3. Scaffolding in this learning environment requires

   (a) guidance,

   (b) examples,

   (c) feedback, and

   (d) facilitation.

   In this environment, examples are provided in the form of worksheets and explanations for self-study. At every step, there is a worksheet for pre-service teachers to complete after learning the contents of each video. Once pre-service teachers submit their work, they can check the submission and feedback from the teacher. Some examples of the worksheets available in this environment are

   (a) a worksheet on objective identification in video production,

   (b) a worksheet on main idea identification in video production,

   (c) a worksheet on storyboard writing,

   (d) a worksheet on flowcharts,

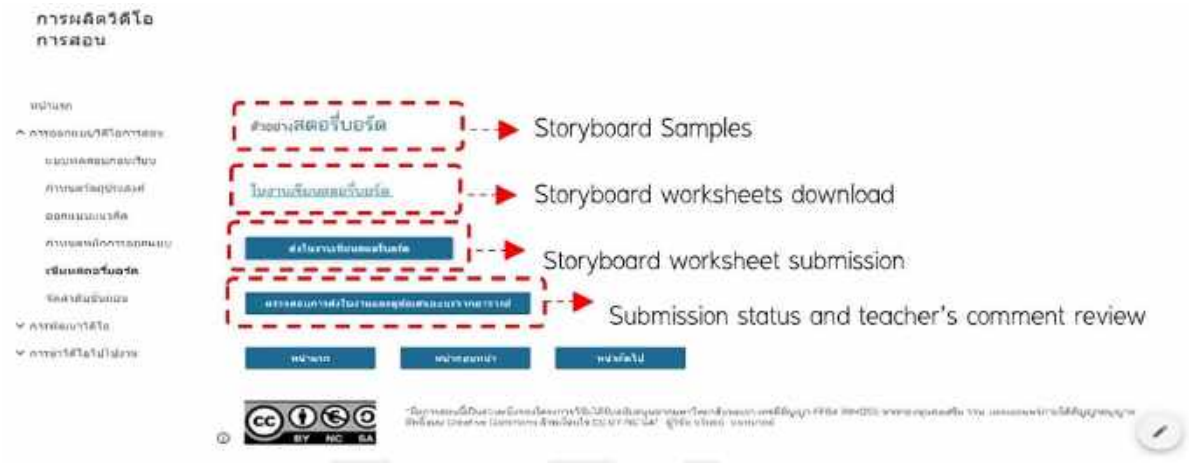

Figure 3. An example of the learning environment (https://sites.google.com/view/instruction-video-production/*การออกแบบวิดีโอการสอน/ เขียนสตอรีบอรด*)

(e) a worksheet on photos and shooting,

(f) a worksheet on video shooting,

(g) a worksheet on instructional videos, and

(h) a worksheet on video delivery.

The details are shown in **Figure 3**.

Recommendations

Recommendations for future research

1. A pre-test to determine pre-service teachers' ability to produce videos should be conducted as the results can be used to design learning activities appropriate to their skill levels to improve their video production skills. In addition, general information collected from the participants can be used in the design of workflow and scaffolding for pre-service teachers to reach the expected skill levels.
2. User tracking systems should be developed to monitor the scaffolding process. The collected data can be used to study scaffolding behaviors and types of scaffolding tools, such as manuals, flowcharts, texts, and motion graphic videos. The tools preferred by pre-service teachers can be used in the scaffolding design to suit pre-service teachers.
3. Learning management systems should be developed with the emphasis on revealing the steps of each task taken by pre-service teachers. There should be notifications for student work and updates while a student database should be created to compile information that can be used in MOOC management.
4. It would be interesting to explore various characteristics of pre-service teachers and design a learning environment by adjusting workflow and scaffolding structures according to different characteristics of pre-service teachers. As a result, designed learning environment can be used with all of them.

Recommendations for implementation

1. Group activities should be conducted to allow pre-service teachers to collaboratively design instructional videos, which leads to knowledge sharing between group members and others. Pre-service teachers will have the opportunities to learn different concepts of instructional video designs from other groups and come up with unique design concepts for their instructional videos.
2. Various types of instructional videos related to students' fields of study should be available for pre-service teachers. There should also be demonstration videos on video production tools, video editing, and new techniques used in video production, which enable students to use their tools or devices, such as smartphones, tablets, laptops, and computers, to create instructional videos.

3. Teachers and teacher assistants should be experienced in video production so that they can offer suggestions and guide pre-service teachers through the video production process.
4. The video-based learning environment using workflow and scaffolding should be implemented with a control group or compared with different interventions, other types of learning environments, or learners with different characteristics.

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