

# Research Article

# A Digital Painting Learning Model Using Mixed-Reality Technology to Develop Practical Skills in Character Design for Animation

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This research aims to (1) synthesize the digital painting learning process by using mixed-reality technology to develop practical skills in character design for animation and (2) develop and evaluate digital painting learning models using mixed-reality technology to develop practical skills in character design for animation. This research was conducted by studying documentation and related research and designing digital painting learning models using mixed-reality technology to develop practical skills in character design for animation. Using a questionnaire, a total of 9 experts evaluated the model's suitability. The statistics used in the research were the mean and standard deviation. The study found that a component of the digital painting learning process involves using mixed-reality technology to develop practical skills in character design for animation. It consists of the following four components: (1) input data, (2) the digital painting learning process, (3) output assessment, and (4) feedback. The expert's evaluation of the model's suitability found that the digital painting learning model using mixed-reality technology to develop practical skills in character design for animation was at the highest level (mean  $\pm$  SD = 4.38  $\pm$  0.21). This research is beneficial to faculty who teach character design and development for animation. The results of the study can be applied to teaching and learning.

# 1. Introduction

Information and communication technologies have become increasingly important in everyday life in the industrial, economic, social, and educational spheres. Education needs to adapt to the industry by increasing modern learning experiences, adding technical knowledge, building practical skills, and encouraging lifelong learning [1, 2]. Thailand focuses on the development and implementation of information and communication technologies to support the country's development, particularly high-speed Internet, and supports the use of computers and other technological equipment in education, which is an international professional practice in the field of science, technology, and innovation to support human capital-focused development in developing countries in order to create stability, abundance, and flexibility. According to the objectives of the future national strategy, graduates in the field of mass communication technology with Thai higher education qualifications require professional and practical skills, consisting of the following four components: practice, theory application, application of academic and professional knowledge, and product creation. Students are required to undergo a training process comprising the following three stages: (1) the cognitive phase, where students must have a preliminary knowledge of what they need to be trained on, can be described as the initial stages; (2) the associative phase, where teachers must demonstrate to the students so that they can observe and follow the pattern and then provide the students with the practical skills [3]; and (3) the autonomous phase, during which the students are trained repeatedly until the mechanism has been practiced smoothly and accurately. The technology supports the creation of a combination of the real world and the virtual world, including virtual reality (VR), augmented reality (AR), and mixed reality (MR) [4]. The integrated-reality technology uses optional display headsets. It combines computergenerated images and objects in a real environment. It integrates virtual and real-world objects. The feeling remains in the world of reality, but there are elements and virtual objects that are intertwined. There is finger-to-touch exposure and interaction. It is used at the middle level of training.

Character design is also a key component of the animation industry, and research suggests that character design trends include the following four elements: (1) character creation, (2) expression of character, (3) art composition and design principles, and (4) the character design phase, in which digital painting skills can be applied to help character design [5]. The study found that digital painting is the creation of paintings on electronic instruments that are stored as files, resulting from the combination of color from pixels (pixels), with features such as brightness, clarity, weight, linear geometry, and color dimensions [6]. Character design is crucial in animation, as it drives the story and establishes relationships with the audience. Good characters should have a clear personality, be realistic, and be creative. Digital painting tools can help create animated characters quickly and efficiently, allowing for highly detailed designs and a wide range of styles, such as cartoons, reality, or fantasy.

With such a source and importance, researchers were interested in studying digital paintings and learning patterns using combined-reality technologies to develop practical skills in character design for animation. This research aims to (1) synthesize the digital painting learning process by using mixed-reality technology to develop practical skills in character design for animation and (2) develop and evaluate digital painting learning models using mixed-reality technology to develop practical skills in character design for animation.

#### 2. Literature Review

2.1. Digital Painting. Digital painting has its origins in computer graphics, which emerged in the 1960s and 1970s. Early computer graphics were used for scientific and technical purposes, but artists began to experiment with digital tools in the 1980s. The development of software programs such as Mac Paint by Apple in 1984 allowed for the creation of digital paintings [7]. Digital painting techniques vary depending on the software and hardware used, but many of the basic principles are similar to those of

traditional painting. Artists can use brushes, colors, textures, and layers to create complex compositions. Some artists use digital tools to mimic traditional media, such as oil or watercolor paintings [8]. Digital painting has many benefits, such as giving the artist the ability to work quickly and efficiently, eliminating the need for expensive materials and equipment, and allowing artists to work in a more environmentally friendly way. It also allows artists to easily share and distribute digital paintings online, reaching a wider audience than traditional paintings. In addition, digital tools make it possible to create highly detailed and complex images that would be difficult or impossible to achieve with traditional techniques [9]. While digital painting presents many benefits, it also presents challenges. One of the main challenges is the need for technical knowledge and skills, including proficiency with digital tools and software. This can be daunting for artists who are not familiar with digital technologies and require a significant investment of time and resources to learn [10]. Digital painting lacks the physicality of traditional painting, which can be a disadvantage for artists who enjoy the tactile experience of traditional painting [11].

The future of digital painting is likely to continue to evolve with the development of new software programs and hardware technologies. Artificial intelligence is an area of growing interest, and virtual and augmented-reality technologies may provide new opportunities for digital painting, allowing artists to create immersive, interactive works of art [12]. Digital painting is a form of artistic expression that has emerged in recent years due to advances in technology and software development. It offers many benefits, such as giving the artist the ability to work quickly and efficiently, create highly detailed images, and easily share and distribute artwork online. However, it also presents challenges, such as the need for technical knowledge and skills and the lack of physicality in the creative process. The future of digital painting is likely to continue to evolve with the development of new technologies and applications [13].

2.2. Mixed Reality (MR). Mixed reality is the blending of physical and digital environments to create an immersive experience, including AR, VR, and other hybrid realities [14]. MR can be used for a variety of purposes, including entertainment, education, training, and healthcare [15]. Mixed reality is used in entertainment, education, and training to create immersive experiences in video games, theme parks, and movies. It is also used to simulate realworld scenarios and provide hands-on learning experiences [16]. It is used in healthcare for medical training, pain management, and rehabilitation [17]. Mixed reality is used to help architects and builders visualize and test building designs in a simulated environment [18]. Mixed reality offers immersive and engaging experiences, the ability to simulate real-world scenarios in a safe environment, and the potential to improve learning outcomes and retention [19]. Mixed reality is likely to continue to evolve with new technologies and applications, such as MR in remote collaboration and communication, allowing people to interact in a shared Advances in Human-Computer Interaction

digital environment regardless of their physical location [4]. Haptic technology, which simulates touch and other sensations, can further enhance the immersive experience of mixed reality [20]. Mixed reality is a rapidly developing field that offers immersive experiences and practical applications in entertainment, education, training, healthcare, and other industries. It presents challenges but offers many benefits and has the potential to evolve with new technology [21, 22]. Mixed reality (MR) can enhance character design skills by making character overviews clearer, improving drawing and 3D modeling practice, and enhancing teamwork. MR can be used in character sketches, 3D modeling, and character motion experiments, allowing designers to evaluate the realism and harmony of characters in real environments. It also enhances teamwork by allowing designers to share work and feedback in real time. MR is still a developing technology, but its potential to enhance practical character design skills in animation events makes it a key tool in the future. MR can be used in character sketches, 3D modeling, and motion experiments, making it a valuable tool in the animation industry.

2.3. Practical Skills. Practical skills are the abilities and techniques that individuals develop through repeated and intentional practice. They are essential for success in many areas, such as sports, music, art, and business [23]. Deliberate practice is a key factor in developing practical skills. It involves setting goals, receiving feedback, and engaging in focused and repetitive practice. Studies have shown that deliberate practice is a critical factor in the development of expertise and that the amount and quality of practice are stronger predictors of success than innate talent [24]. Feedback is an important factor in the development of practical skills. It can come from a variety of sources, such as coaches, mentors, peers, and self-reflection. It can help individuals identify areas for improvement, refine technique, and build confidence. Studies have shown that high-quality feedback can significantly improve performance [25]. Personal goals, social support, and intrinsic and extrinsic rewards can all have an impact on motivation, which is the drive or desire to engage in an activity [26]. People who are motivated to improve their performance are more likely to engage in deliberate practice and achieve greater success [25]. Practical skills are essential for success in many areas of life and are developed through deliberate practice, feedback, and motivation. By engaging in purposeful and structured practice, seeking feedback, and maintaining high levels of motivation, individuals can improve their performance and achieve greater success [24, 25, 27].

2.4. Character Design in Animation. Character design is essential for animation, as it is the primary way to convey the story to the audience. Effective character design involves creating a visually compelling and memorable character that is appropriate for the story and audience [28]. Character design is essential for successful animation, and this literature review will discuss the factors that contribute to effective character design [28, 29]. Character design is essential for animation, as it can affect the audience's emotional investment in the story [5]. A well-designed character can enhance the audience's understanding of the story, convey its personality and emotions, and provide continuity throughout the film or series. Memorable characters can become iconic and have a lasting impact on popular culture [30, 31].

#### 2.5. Research Questions

2.5.1. RQ1. What does learning digital painting using mixed-reality technology to develop practical skills in character design for animation involve?

*2.5.2. RQ2.* What is the process of learning digital painting using mixed-reality technology to develop practical skills in character design for animation?

#### 2.6. Objective

2.6.1. To synthesize the process of learning digital painting using mixed-reality technology to develop practical skills in character design for animation;

2.6.2. To design and develop digital painting learning models using mixed-reality technologies to develop practical skills in character design for animation; and

2.6.3. To assess the suitability of digital painting learning patterns using mixed-reality technology to develop practical skills in character design for animation.

### 3. Materials and Methods

3.1. Analyze a Digital Painting Learning Model Using Mixed-Reality Technology to Develop Practical Skills in Character Design for Animation. In analyzing digital painting learning patterns to develop practical character design skills for animation using mixed-reality technology, document research methods were used through content analysis of digital painting learning to develop practical character design skills in animation with mixed-reality technology. The Scopus database was analyzed step by step. There were 90 document results: (TITLE-ABS-KEY (character AND design)) AND (((digital AND painting)) AND (mixed-reality)) AND (practical AND skills).

This study analyzed a digital painting learning model using mixed-reality technology to develop practical skills in character design for animation using three-field plot analysis and word cloud analysis, as shown in Figures 1 and 2.

In developing a digital painting learning model using mixed-reality technology to develop practical character design skills in animation, the researchers divided the research into the following three phases according to the research objectives.



FIGURE 1: A digital painting learning model using mixed-reality technology to develop practical skills in character design for animation using three-field plot analysis.



FIGURE 2: A digital painting learning model using mixed-reality technology to develop practical skills in character design for animation using word cloud analysis.

Phase 1: study relevant documentation and research and synthesize digital painting learning patterns using mixed-reality technologies to develop practical skills in character design for animation.

Phase 2: develop digital painting learning patterns using mixed-reality technologies. Develop practical character design skills for animation.

Phase 3: evaluate digital painting learning patterns using mixed-reality technologies to develop practical skills in character design for animation.

*3.2. Research Framework.* A digital painting learning model using mixed-reality technology to develop practical skills in character design for animation.

The research framework concepts describe digital painting, which uses mixed-reality technology to develop character design skills for practical use in animation. Figure 3, by DMC, refers to a digital painting learning model using mixed-reality technologies. To develop operational character design skills in animation, a combination of the following three main elements is required: (1) digital paints, (2) mixed-reality technology, and (3) practical skills in character design for animation.

# 4. Results

Researchers conducted the research for several purposes, including the synthesis of learning patterns, learning pattern development, and learning model evaluation.

4.1. Synthesis Results. A digital painting learning model using mixed-reality technology to develop practical skills in character design for animation.

The researchers conducted documentary studies and research related to digital painting learning processes to develop practical character design skills for animation using mixed-reality technology to combine and synthesize processes. This is shown in Table 1.

From Table 1, it can be seen that the synthesis of documents and research related to digital painting learning found that digital painting was done using the following steps: digital painting is the process of learning digital painting. It is a technique that uses the Autodesk SketchBook application on a tablet to create shapes, which are digital image files that express the conceptual content. It consists of four steps, which are as follows:

Stage 1: to use the user interface, the instructor must use the user interface or the part used to connect with the user. That is, the part that allows the user to interact with the product application, which focuses on the aspect and design, for example, screen, platform, menu, forms, image placement, font size, button, keyboard, and sound.

Stage 2: a sketch or outline is a thin drawing that uses the shape of the pattern or object to be drawn. In addition, the drawing is also used as a drawing before the character design and assembly. The lines must be lightweight and easy to remove or modify.

Stage 3: the use of brushes and colors, the choice of colors, and the proper matching of colors will make it possible to respond to the feelings and emotions of the painter.

Stage 4: in adding color and details, pairs and colors are used in relation to the area and size to lower the desired color, while smoothing and sliding, as well as highlighting lines and shadows, are considered the final steps.

From Table 2, it can be seen that the synthesis of documents and research related to mixed-reality technology (MR) found that a computer-built environment combined augmented-reality (AR) and virtual-reality (VR)



FIGURE 3: The primary and follow-up variables of the research conceptual framework are clearly shown: a digital painting learning model using mixed-reality technology to develop practical skills in character design for animation.

TABLE 1: Processes of digital painting.

Digital paintings	[9]	[10]	[11]	[12]	[32]	Researchers
(1) User interface						
(2) Sketch and outline		$\checkmark$	$\checkmark$			$\checkmark$
(3) Brushes and colors	$\checkmark$				$\checkmark$	$\checkmark$
(4) Add color and details	$\checkmark$		$\checkmark$	$\checkmark$	$\checkmark$	

Mixed-reality technology	[4]	[15]	[16]	[17]	[18]	[20]	[21]	[33]	Researchers
(1) Real environment									
(2) Augmented reality: AR	v								
(3) Virtual reality: VR									
(4) Virtual environment									
(5) Software									
(6) Marker									
(7) HoloLens display									
(8) Camera									
(9) Processing									

TABLE 2: Components of mixed-reality technology.

technologies and worked together in real time. By combining the physical and digital worlds, digital objects are displayed in a real environment through digital glasses. It has the following elements: (1) real environment (real environment); (2) augmented-reality technology (augmented reality: AR); (3) virtual-reality technology (virtual reality: VR); (4) virtual real environment (virtual environment); (5) software (software), which is an application developed; (6) a marker, which is a symbol that communicates with applications and is used with augmented-reality technology (augmented reality: AR); (7) digital glasses (HoloLens display), which are used when the data processing is completed and have a display in the form of virtual-reality (VR) technology, which is displayed through digital glasses such as the VR Box, Samsung Gear, and Oculus, etc.; (8) the camera, which is the part of the application that uses augmented-reality (AR) technology to read markers (marker); and (9) processing, which is when the camera detects a marker and is performed to search for digital objects in the database (database).

Mixed reality is a real-world technology that creates something linked to the real world with a visible object or environment and with dimensions. It does not only overlap on top of augmented reality (AR) but can also respond and interact with the user as it does in the world of reality. Through an intermediate, it is a technology that uses the Microsoft HoloLens application.

Table 3 shows the synthesis of documentation and research related to the composition of character design in animation (character design for animation). The character profile data were as follows: (1) appearance, age, sex, height, skin color, hair, and eyes and important observations such as wearing glasses at all times or having small wings, etc.; (2) definitions of personality characteristics, such as being in a good mood at all times or accumulated depression; (3) the role determines what the character's main role is in this story, such as a child from the countryside who wants to pursue legendary weapons in order to defend the world or get revenge on his father; (4) the background of the character tells what the character has ever done. Why did this come about? For example, as a child, when the children started to learn the art, there was proper discipline, and as a result, they came to help people; (5) special capacity (power), determination, or special capability; and (6) other associations, such as determination and other character relationships.

Figure 4 shows the relationships between learning digital painting using mixed-reality technology and practical character design skills in animation; it was found that the learning process, the digital painting, and the components of mixed-reality technology were all combined. This is related to the development of character design practical skills in animation through (1) perception, (2) guided response, and (3) improvement and adaptation, which are highly interrelated.

4.2. Design Results: A Digital Painting Learning Model Using Mixed-Reality Technology to Develop Practical Skills in Character Design for Animation. From the data in Tables 1–3, it can be seen that learning digital painting, character design for animation, and application processes have been synthesized. Mixed-reality technology has been developed as a form of digital painting learning, using mixed-reality technology to develop practical character design skills in animation (see Figure 5).

From Figure 5, it can be seen that the learning model was a digital painting learning model developed using mixedreality technology. To develop practical character design skills in animation, the work was divided into three main parts, which were as follows:

Part 1: input data consisting of teacher, student, Scontent, learning objectives and plan, character profile data, and mixed-reality technology were used to develop practical character design skills in animation.

Part 2: a digital painting model using mixed-reality technology.

Part 3: the result was practical skills in character design for animation using a combination of learning patterns, digital painting, and mixed-reality technology.

TABLE 3: Components of character design for animation.

Character design for animation	[34]	[35]	[36]	[37]	[38]	Researchers
(1) Appearance						
(2) Characteristics						
(3) Role						$\checkmark$
(4) Background						$\checkmark$
(5) Power						$\checkmark$
(6) Associations						$\checkmark$

4.2.1. Process Display System: A Digital Painting Learning Model Using Mixed-Reality Technology to Develop Practical Skills in Character Design for Animation

(1) Input. The input data consisting of teacher, student, content, learning objectives and plan, character profile data, mixed-reality technology, and character profile data were used to develop practical character design skills in animation.

- (1) Appearance, age, sex, height, skin color, hair, and eyes and important observations such as wearing glasses at all times or having small wings, etc.
- (2) Definitions of personality characteristics, such as being in a good mood at all times or accumulating depression
- (3) The role determines what the character's main role is in this story, such as a child from the countryside who wants to pursue legendary weapons in order to defend the world or get revenge on his father.
- (4) The background of the character tells what the character has ever done. Why did this come about? For example, as a child, when the children started to learn the art, there was proper discipline, and as a result, they came to help people.
- (5) Special capacity (power) determination or special capability
- (6) Other associations, such as determination and other character relationships

(2) *Process*. The researchers chose the digital painting learning process using mixed-reality technology to develop practical character design skills in animation. It has the following components:

- (i) Digital painting is the process of learning digital painting. It is a technique that uses the Autodesk SketchBook application on a tablet to create shapes, which are digital image files that express the conceptual content. It consists of four steps, which are as follows:
  - To use the user interface, the instructor must use the user interface or the part used to connect with the user. That is, the part that allows the user

			Prac	ctical Sl	kills in C	Characte	er Desigr	n for Anima	tion	
	Digital Pair Mixed-reality ar Practical Skills in for Ani	nting y Tec nd Cha imati	Using hnology racter Design on	Perception	Readiness	Guided Response	Mechanism	Complex Overt Response	Adaptation	Origination
			<ul> <li>Objectives and plan</li> <li>User interface</li> </ul>	<b>√</b>	$\checkmark$	<b>√</b>	$\checkmark$	<b>√</b>	4	$\checkmark$
Digital Painting in Character Design for Animation and Mixed-reality Technology		rocess	• Experiment With Brushes and Colors	* ~		✓ ✓	$\checkmark$	✓ ✓	<b>↓</b>	$\checkmark$
	Digital Painting	Η	<ul><li>Sketch Outline</li><li>Add Color and details</li></ul>	$\checkmark$	$\checkmark$	$\checkmark$	✓ ✓	✓ ✓	✓ ✓	$\checkmark$
		Component	<ul> <li>Real environment</li> <li>Augmented Reality : AR</li> <li>Virtual Reality : VR</li> <li>Virtual environment</li> <li>Software</li> <li>Marker</li> <li>HoloLens Display</li> </ul>		<ul> <li></li> &lt;</ul>		✓ ✓	<ul> <li>✓</li> <li>✓&lt;</li></ul>	< <	✓ ✓ ✓
	Mixed-reality Technology		<ul><li>Camera</li><li>Processing</li></ul>	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$

FIGURE 4: Relationships of a digital painting learning model using mixed-reality technology to develop practical skills in character design for animation.



FIGURE 5: A digital painting learning model using mixed-reality technology to develop practical skills in character design for animation.

to interact with the product application, which will focus on the subjects of appearance and design, for example, screen, platform, menu, forms, image placement, size, font, button, keyboard, and sound.

- (2) A sketch or outline is a thin drawing that uses the shape of the pattern or object to be drawn. Furthermore, the drawing is also used as a drawing before the character design and assembly. The lines must be lightweight and easy to remove or modify.
- (3) The use of brushes and colors, the selection of colors, and the proper matching of the colors will enable the artist to respond to his or her feelings and emotions.
- (4) Coloring and adding detail are done to make the character design more complete.
- (ii) Mixed-reality technology, or MR, is a modern technology that can be applied to teaching based on interaction between students and teachers. Building awareness for students in virtual environments includes the use of augmented-reality (AR) and virtual-reality technologies (virtual reality: VR).

(3) Output. The result is practical skills in character design for animation. These practical skills can be developed through practice, which, if the user is well-trained, results in accuracy, flexibility, expertise, and perseverance. The effects of behavior or action can be observed through speed, precision, strength, or smoothness in management. The practical skills obtained have seven components. The components are as follows.

- Perception is the process by which the student becomes aware of what is to be done by deliberately allowing him or her to observe what is to be done.
- (2) Readiness is the process of adapting to a function or behavior, both physically, mentally, and emotionally, by adapting oneself to perform or demonstrate the movement and having a good mental and emotional state to do or display the skill.
- (3) Guided response is a step that gives students the opportunity to respond to what they perceive, which may be used as a method of teaching them how to act or demonstrate that skill through a trial-and-error method until they can respond correctly.
- (4) The practical ability to act can become a mechanism that can be performed by itself (a mechanism) and is a step that enables students to succeed in practice and build confidence in doing so.
- (5) A complex overt response is a step that allows students to practice those actions until they can do them fluently. The skills become automatic, and students become confident.
- (6) Adaptation is a step that enables students to improve their skills or practices and apply the developed skills in different situations.

(7) Origination is when a student is able to practice or act out something skillfully and apply it to a variety of situations. A practitioner begins to generate new ideas for action or adjust the action to suit their needs.

(4) Feedback. This section discusses the system's functional response. According to the first step in the process of the research system, this study aims to synthesize the digital painting learning pattern process using mixed-reality technology to develop practical character design skills in animation [28].

4.3. Evaluation of the Model's Suitability. This study assessed the suitability of models using a total of nine experts. The suitability assessment of a digital painting learning model using mixed-reality technology to develop practical skills in character design for animation considers all the following five aspects: input, digital painting, mixed-reality technology, output, and feedback. The average score of all five was  $4.38 \pm 0.21$ , and each side has a score as shown in Table 4.

# 5. Discussion

Learning models, digital painting learning models, and mixed-reality technologies were used to develop practical character design skills in animation, and the work was divided into three main sections. In each section, there were the following details: (1) learning digital painting, (2) mixedreality technology, and (3) practical skills in character design for animation. Appropriate patterns could be applied to strengthen learning skills and develop thinking skills for high school students, institutions, or organizations that want to adopt models developed to develop mixed-reality systems to develop character design practices in animation. Digital painting learning pattern synthesis results were produced using mixed-reality technologies. There were four stages as follows: (1) data import (input), (2) process, (3) output, and (4) feedback. The design and development of digital painting learning patterns using mixed-reality technologies to develop practical skills in character design for animation consisted of the following seven components: (1) perception, (2) readiness, (3) guided response, (4) mechanism, (5) complex overt responses, (6) adaptation, and (7) origination.

The expert's evaluation of the model's suitability found that the digital painting learning model using mixed-reality technology to develop practical skills in character design for animation was at the highest level (mean  $\pm$  SD = 4.38  $\pm$  0.21). The best rating system component was the input (mean  $\pm$  SD = 4.6  $\pm$  0.00). The lowest rating system component was mixed-reality technology (mean  $\pm$  SD = 4.11  $\pm$  0.23). The reason this model received such a high score is because mixed-reality technology can actually increase students' practical skills, which is in line with research by Uhl et al. [39].

Limitations of using mixed-reality technology are mixed-reality experiences require expensive hardware and software, including technical expertise, and there may be health concerns such as eye strain and motion sickness [29].

TABLE 4: The results of an evaluation of the suitability of a digital painting learning model using mixed-reality technology to develop practical skills in character design for animation by experts.

Factors	Mean ± SD
(1) Input	$4.60\pm0.00$
(2) Digital painting	$4.50\pm0.12$
(3) Mixed-reality technology	$4.11 \pm 0.23$
(4) Output	$4.50\pm0.14$
(5) Feedback	$4.20\pm0.00$
Total	$4.38\pm0.21$

This model should be developed and implemented in animation character design teaching so that students with character design skills can create creative animation works.

Examples of organizations that can use the system to develop teaching and learning include universities, character design institutes, and animation production companies. Organizations that adopt models designed to be used in the development of systems and provide benefits in creative works, character design, or other aspects of design are the standard for elevating design to the next international level.

# 6. Conclusion

Digital painting learning pattern synthesis results were produced using mixed-reality technologies. There were four stages as follows: (1) data import (input), (2) process, (3) output, and (4) feedback. The design and development of digital painting learning patterns using mixed-reality technologies to develop practical skills in character design for animation consisted of the following seven components: (1) perception, (2) readiness, (3) guided response, (4) mechanism, (5) complex overt responses, (6) adaptation, and (7) origination. This model should be developed and implemented in animation character design teaching so that students with character design skills can create creative animation works.

#### **Data Availability**

The data used to support the findings of this study are available from the corresponding author upon request.

## **Conflicts of Interest**

The authors declare that they have no conflicts of interest.

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