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Utilizing Augmented Reality (AR) to Enhance Learning and Preservation of Local Wisdom: A Case Study on Champada in Lan Saka District

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Abstract: This research explores the application of Augmented Reality (AR) technology for learning local wisdom among youth in Lan Saka District, Nakhon Si Thammarat Province, Thailand. The study aimed to develop AR learning media focused on Champada to enhance educational engagement and knowledge retention. The development followed the ADDIE model. In the Analysis phase, comprehensive data was collected from local philosophers, agriculturists, and agricultural officials to ensure alignment with research objectives. The Design phase involved creating content and storyboards incorporating AR to enhance book content. During Development, Blippar was used for AR creation. Implementation involved practical application with a sample of 30 students from Lan Saka District, followed by an Evaluation phase to assess satisfaction and effectiveness. Results indicated the AR learning media achieved a high-quality rating ($\bar{x}$=4.90, S.D.=0.13) and high user satisfaction ($\bar{x}$=4.13, S.D.=0.53). The media was praised for its user-friendliness, engagement, and effectiveness in improving content comprehension. These findings align with existing research on AR's positive impact on learning outcomes and student attitudes. The study concludes that AR technology significantly enhances learning efficiency and satisfaction, promoting a deeper understanding of local wisdom and Champada, and underscores the potential of AR to transform educational practices and foster cultural preservation.

Keywords: *Perceived Organizational Support, Affective Commitment, Individual-Organization Fit, Work-Life Balance, Organizational Citizenship Behavior*

1 Introduction

In recent years, rapid technological advancements have brought about significant changes across various sectors, including education. One technology that has garnered considerable attention is Augmented Reality (AR). AR technology integrates virtual elements into the real world through software and various connected devices such as mobile phone cameras, tablet cameras, webcams, or other related equipment (Azuma, 1997; Sicaru et al., 2018; Nizar et al., 2020; Bednarczyk & Templin, 2020; Malta et al., 2023). Virtual images are displayed on the screens of these devices (Pradibta & Nurhasan, 2021; Pradibta, 2018; Eswaran & Raju, 2023; Angel et al., 2022). These virtual images can interact with users in real time, appearing as static 3D images, animations, or multimedia that includes sound, depending on the design of each media format. AR's capabilities enhance the learning experience by creating deeper interactions and making content more engaging (Kraut & Jeknić, 2015). AR is transforming the way we learn at the primary, secondary, and university levels. For instance, AR is being utilized in Science, Technology, Engineering, Arts, and Mathematics (STEAM) education, inspiring greater student enthusiasm for learning (Jesionkowska et al., 2022). AR technology has been applied to improve learning outcomes in secondary school biology (Weng et al., 2020), in chemistry education (Zhang et al., 2023), in mathematics (Volioti et al., 2023), and in electronics engineering (Tuli et al., 2022), as well as in engineering drawing courses (Tiwari et al., 2024). It is also used for learning foreign languages and cultures (Di Fuccio et al., 2024) and for teaching foreign languages (Çelik et al., 2022), where it aids in improving learning outcomes and boosting student motivation (Huang et al., 2021). Additionally, AR can be utilized in historical education (Efstathiou et al., 2017; Azhar et al., 2019), allowing students to visualize and better understand past events.

In Thailand, the Ministry of Education recognizes the importance of teaching local history such as the history of the Mipanya community and its way of life by emphasizing community-led learning. Local areas become media and learning resources for students. The Ministry of Education has implemented a policy to strengthen reading, writing, and studying history through contemporary communication methods, incorporating AR technology to make learning more engaging. This approach encourages systematic thinking and analysis, making history enjoyable and engaging for students.

Champada is an important native plant in the southern of Thailand. It is not only highly nutritious but also part of local wisdom that has been passed down for generations. This fruit is delicious and has numerous health benefits. Additionally, it plays a significant role in the culture and way of life of the villagers in the area. However, the current issue is that people in the region do not recognize the importance of Champada, which serves as a local symbol and holds sentimental value for people in Nakhon Si Thammarat and nearby provinces. There is a saying, "If you want to eat Champada, you can eat it in Lan Saka District." Due to the farmers' growing preference for cultivating economically lucrative crops such as durian and mangosteen, Champada trees are being cut down, leaving less than 10% of the agricultural area. This shift has resulted in the younger generation and other residents beginning to lose knowledge and appreciation for Champada, leading to a decline in its consumption.

Given these problems, the researcher recognizes the importance of the culture, way of life, and local wisdom related to Champada in Lan Saka, Nakhon Si Thammarat Province. To foster conservation and learning within the community, especially among the youth in a sustainable manner, integrating modern technology into education is crucial. Utilizing AR technology to learn about Champada can create a more engaging and effective learning experience. Students and youth can explore and learn about Champada in a realistic format, making education more enjoyable and accessible. The use of AR technology also plays a crucial role in raising awareness and promoting the sustainable conservation of the native Champada plant, particularly among youth who may not be familiar with Champada and its cultural significance. Learning through this technology not only enhances knowledge but also supports the long-term preservation of Thailand's cultural heritage and biodiversity. Therefore, this research article aims to develop learning media for local wisdom and the use of Champada through AR technology. Additionally, it seeks to evaluate the satisfaction of this learning media among youth students in the community of Lan Saka District, Nakhon Si Thammarat Province.

2 Conceptual Framework

In this development of AR learning media on local wisdom and the utilization of Champada, the researchers employed the ADDIE model as the framework for studying, designing, and developing the media, as shown in Fig 1.

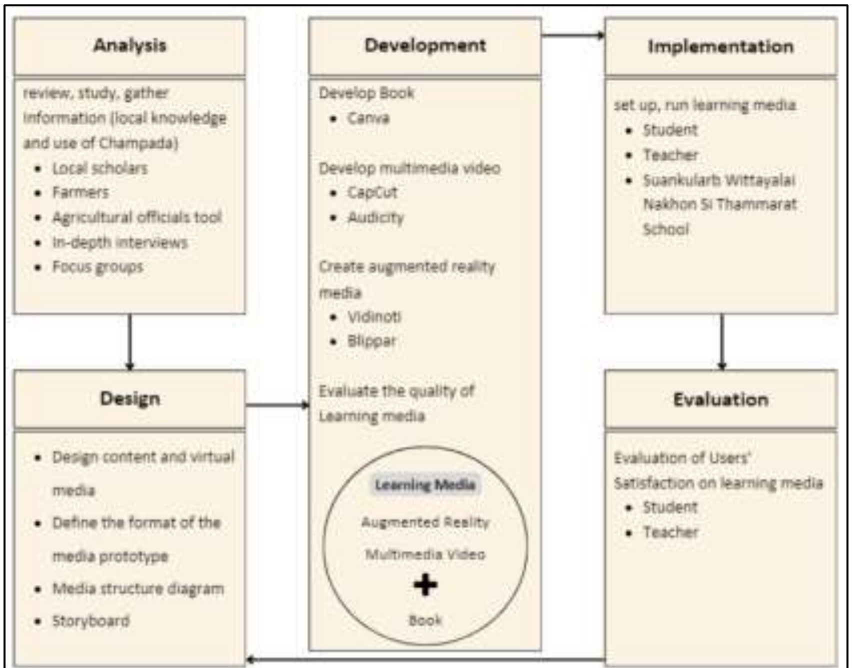

Fig 1. Conceptual Framework of the Study

3 Literature review

3.1 Definitions of Augmented Reality

Augmented Reality (AR) technology enhances the real world with virtual elements (Azuma, 1997). It superimposes computer-generated environments onto the real world, allowing users to experience a blend of the physical and digital worlds (Sünger & Çankaya, 2019). Virtual environments added to the real environment display information to the user that cannot be directly detected with their senses. The information transmitted by virtual environments can assist users in acquiring knowledge, entertainment, or performing daily tasks (Billinghurst et al, 2015).
AR can be achieved with various types of devices such as mobile phones, tablets, and head-mounted displays. From the application of this variety of devices, Ludwig and Reimann (2005) defined Augmented Reality as "human-computer interaction that adds virtual objects to real senses provided by a video camera in real time." Similarly, Kapp and Balkun (2011) defined AR as "a predominantly real-world space in which virtual elements are inserted in real time." These definitions align with the definition by Azuma (1997), one of the pioneering researchers in this field. Augmented Reality encompasses three main elements:

1) combining real and virtual environments
2) interacting in real time
3) registering 3D objects

Augmented Reality (AR) is distinct from Virtual Reality (VR); these two technologies are not the same. AR overlays digital information or virtual elements onto the real world, allowing users to experience this through the use of a smartphone or tablet camera. The camera captures images of the real world and adds digital elements to them in real-time. In contrast, VR simulates a three-dimensional computer-generated virtual world that can be interacted with in a way that resembles the real world. This is experienced by the user using a VR headset, which tracks the user's movements and adjusts the display accordingly. Therefore, VR presents a fully immersive virtual world experience, while AR presents a virtual world experience overlaid on the real world (Rosellini, 2023). Despite their similarities in utilizing computer-generated virtual data, AR and VR serve different purposes. AR differs from VR in that it does not attempt to block the real surrounding environment from the user. VR is generally applied for creating unique experiences such as playing games or virtual field trips, whereas AR is often used for learning, navigation, or practical real-world applications such as medical visualization, annotating maintenance and repair of tools, etc (Malta et al., 2023; Al-Ansi et al, 2023)

3.2 Historical Development of Augmented Reality

AR has evolved significantly since the 1950s, beginning with Morton L. Heilig's Sensorama in 1957. The Sensorama device included vibrating seats, artificial winds, smells, and sounds as a cognitive testing technology, engaging the five senses through simulations such as riding a motorcycle, riding a bicycle, riding a dune buggy, flying a helicopter, and belly dancing (Alharthi, 2015). Later in 1966, Ivan Sutherland, a professor of electrical engineering at Harvard university and his student Bob Sproull developed the first head-mounted display. This device, called the Sword of Damocles, is considered the birthplace of modern AR (Sutherland, 1968).
The term "augmented reality" was first used by Thomas Caudell and David Mizell in 1992. They designed a head-mounted display to ensure the accuracy of the cable assembly process in aircraft manufacturing, which saved the company time and money (Caudell & Mizell, 1992). Following in 2000, Bruce Thomas developed the mobile game ARQuake, marking the first augmented reality video game (Piekarski & Thomas, 2002). As technology, especially smartphone technology, has continued to advance, the application of AR has greatly increased.

3.3 Tracking Techniques

According to Azuma's (1997) definition, augmented reality technology must fulfill three main elements, which are combining real and virtual environments, being interactive in real-time, and being registered in 3D objects.
The third condition, "registered in 3 D objects," refers to the ability of an AR system to project virtual content onto a physical environment in such a way that it appears to be part of the real world. The user's real-world location and orientation must be determined to achieve this registration. This can be accomplished through location estimation using the GPS system or by detecting the position of a physical object, such as an image marker or magnetic tracking source. The real-world location of an AR system depends on the application and the technology used.
There are two phases of technology used to register in 3D objects, namely the registration phase and the tracking phase (Syed et al., 2023). Tracking techniques are crucial for providing users with a realistic sense of movement in the virtual and augmented reality world. If the tracking system is selected correctly and appropriately, registration in 3D objects during the tracking phase can be divided into two types:

1) Marker-less tracking techniques, these techniques can be further divided into two types:
   1.1) Sensor-based
   1.2) Computer vision-based

   Each type has various tracking methods, such as magnetic tracking technology, infrared tracking, and simultaneous localization and mapping (SLAM).
2) Marker-based tracking techniques, these are divided into two groups:
   2.1) Fiducial markers: These can use a variety of materials such as paper, plastic, cardboard, or color LEDs.
   2.2) Tag-based markers: These include direct and indirect tracking methods such as barcodes, QR codes, or RFID tags.

In AR applications that use marker-based tracking, the system works by scanning markers to produce realistic images, whether it be a 3D model, object, text, image, video, or animation on the device. This typically requires AR software that allows users to scan markers using a camera. This type of AR is also called recognition-based AR or image recognition, which relies on the identification of markers, user-defined images or physical objects for the AR to function. Marker-based AR requires a marker to activate the augmentation. Markers come in various formats that the camera can recognize and process easily, independent of the surrounding environment. Markers can be paper or physical objects that exist in the real world such as logos, packaging, posters or brochures (Paladini, 2018; Alkhabra et al., 2023).

3.4 Image Tracking in Augmented Reality

Presenting information to users using AR is gaining significant attention. This approach combines desired information with images from the camera to add dimension to the user's perception. Typically, the data merged into a camera image is a computer-generated image using computer graphics techniques. The working process of AR technology consists of three processes (Chochaiyatich, 2021):

1) Image analysis begins with creating an image database or marker that the creator has set up. For the marker search process, it starts with converting the image data obtained from the camera. The system then searches the database (marker database) that stores information on the size and format of the designed marker and analyzes it to calculate the 3D position value for use.

2) Calculating 3D position values (pose estimation) involves calculating the 3D matrix values of the marker to establish a relationship between captured camera coordinates and symbol position coordinates in the database. The system searches, compares, and analyzes the obtained values with the data stored in the software.

3) 3D rendering involves creating a 3D model, 2D image, or video to display on coordinates obtained from the calculated 3D position (pose estimation) into the image obtained from the camera in the first process, resulting in a virtual image.

The main components of using image tracking in AR include:

3.1) AR code or marker: Used to determine the location of objects.

3.2) Camera or sensor: Devices such as video cameras, webcams, mobile phone cameras, or other sensors are used to detect the location of the AR code or marker and send the information to the AR engine.

3.3) AR engine: A transmitter that processes readable data and passes it into the software or processing section to display image.

3.4) Display: This component displays the information sent by the AR engine in the form of images or videos. Another method is to combine the camera, AR engine, and display into a single device, such as a mobile phone or tablet, as shown in Fig 2.

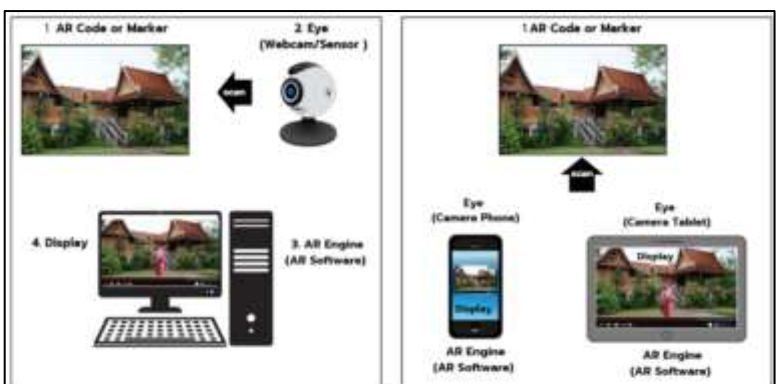

Fig 2. Image Tracking in Augmented Reality

3.5 Learning media with Augmented Reality

Today's AR technology has been utilized in numerous applications, including education and training, entertainment and gaming, shopping, business, navigation and exploration, healthcare, and trade fairs and events (Mendoza-Ramírez et al., 2023). AR technology is currently being used to support learning more extensively because it helps students visualize concepts and understand processes more clearly, making it easier and faster to grasp the content. Additionally, it enhances the learning experience in innovative ways. Some phenomena may be difficult to access in real-life situations, but AR technology can bridge this gap.

In recent years, a significant number of studies have been published that apply AR in various aspects of the educational process (Bacca et al., 2014), demonstrating the modernization and increased value of teaching with this technology (Dunleavy & Dede, 2014; Voogt & Knezek, 2018). The accessibility of AR is also becoming more feasible, allowing it to be applied at all educational levels, from preschool to university, and supporting self-learning for individuals of all age groups. Examples of research that utilize AR technology in learning media include Aladin et al. (2020), who introduced AR-TO-KID, an AR application created for preschool children aged 5 to 6. This application aims to improve English language pronunciation for school-aged children who are not native English speakers. Volioti et al. (2023) used AR in teaching mathematics to Grade 6 students, allowing them to learn mathematical concepts through problem-solving and promoting hands-on learning with the application "Cooking Math". Volioti et al. (2022) used AR to teach geography content to 5th and 6th grade students. Although the geography content presented was at a high level and too challenging for some students, everyone accepted Augmented Reality technology and was very receptive to the teaching process. Weng et al. (2020) used AR technology to improve the learning outcomes and attitudes of ninth-grade students towards biology. The use of AR technology significantly improved students' learning outcomes and attitudes towards biology. Gargrish et al. (2020) utilized AR technology to aid students encountering difficulties with understanding geometry and spatial concepts, which can be challenging for some learners. Altmeyer et al. (2020) used AR in physics education by experimenting with real-time data measurement of electrical circuit components. Harun et al. (2020) used AR to enhance students' learning, skills, and expertise regarding Fleming's rule in electromagnetism, addressing limitations in laboratory access and providing practical learning in science and engineering education despite expensive equipment and time constraints. Huang et al. (2021) used AR in foreign language teaching for university students, where AR helped improve learning outcomes and increase student motivation. Andriyandi et al. (2020) applied AR as an interactive educational medium to help students study the Tajweed of the Quran accurately. This is important in Islam as proper and correct recitation of the Quran is required. Elivera and Palaoag (2020) applied AR to learning about history by presenting historical events, allowing students to visualize and understand events better. González (2020) applied AR to improves students' motivation to learn about topics related to Cultural Heritage (CH) refers to the representation of historical places and traditional customs of a specific city or country.

In Thailand, the Ministry of Education has developed innovative AR media for learning about history, patriotism, religion, and the monarchy. This is used in assessments to develop learning for students under the concept of "Phumchai Phak Rak KhwamPen Thai Rianru Prawattisat Thai Chak Thanabat An Song Khunkha," enabling students to study Thai history with understanding, enjoyment, and challenge. Students can learn Thai history independently through this innovation, which features numerous images, each telling the story of a different historical era (Rohitsathien, 2020). From the literature review of Augmented Reality, the summary can be depicted as shown in Fig 3.

Fig 3. Summary of Augmented Reality

3.6 ADDIE Model

The ADDIE Model is one of the most common models in the field of instructional design. This model serves as a guideline to help content developers and instructional designers develop content and instructional design efficiently and effectively. The ADDIE model process can be applied to develop any instructional product in any environment, whether online or face-to-face. The ADDIE model is an instructional design guideline based on systematic principles, which is generally accepted due to its clear steps that can be used in designing and developing media or teaching products (Aldoobie, 2015; Holden, 2015; Lu & Side, 2022). It consists of five steps:

1) Analysis is considered the foundation for all other steps of the design process. During this step, it is essential to define the problem, identify its root causes, and determine potential solutions. This may include needs and task analysis. Results of this phase include the learner profile, description of constraints, needs, problem statement, and task analysis.

2) Design is a process that involves using the results from the analysis phase to plan strategies for developing teaching and learning. During this phase, the designer must outline how to achieve the teaching goals established during the analysis phase and consider teaching strategies to suit the grouping of learners and content. Some elements of the design process may include writing explanations, target population, learning analytics, writing objectives and test items, choosing a delivery system, and sequencing. The outputs of the design phase are the inputs for the development phase.

3) Development builds on both the analysis and design phases. The purpose of this step is to create lesson plans, teaching materials, and various documents, which may include hardware and software.

4) Implementation is the actual application of the teaching media, whether in a classroom or laboratory setting. The aim of this phase is to deliver teaching efficiently and effectively, promote students' understanding of the content, support student mastery of objectives, and ensure that students transfer their knowledge from teaching to practical application.

5) Evaluation measures the efficiency and effectiveness of the media. Assessment should occur throughout the entire instructional design process, during and after implementation. This step checks for any problems or obstacles at each step to continuously improve and resolve them.

4 Methodology

The technology used to develop AR media combines the real world and virtual reality through software and connected devices, displaying results on the screen via a computer, tablet, or smartphone. The researcher has applied the principles of systematic media design and development according to the ADDIE Model, which consists of the following five steps:

1)Analysis Stage: The researcher studies and collects information regarding local wisdom and the use of Champada from local philosophers, Champada agriculturists, and agricultural officials in Lan Saka District, Nakhon Si Thammarat Province in total of 12 individuals. This is done using in-depth interviews with a semi-structured interview form and group discussions to obtain information for creating learning media. Additionally, information on the development of learning media with AR technology and other relevant information from articles, journals, conference reports, books, and reliable websites is studied. After data collection, analysis is conducted to determine the objectives, scope, limitations, and importance of the research project.

2)Design Stage: Using information obtained from the analysis stage, content and virtual media are designed. The format of the learning media is established to serve as a model. The approach involves presenting knowledge through AR, utilizing multimedia videos to complement the book. This helps students understand the content effectively and promoting clearer learning aligned with the objectives. There will be an outline of the book's content and the AR section in the book, as shown in Fig 4.

Fig 4. Outline of the contents of the book

A storyboard for laying out the design layout between normal content and the addition of AR in the content is created, as shown in Fig 5. The storyboard for multimedia video content is shown in Fig 6.

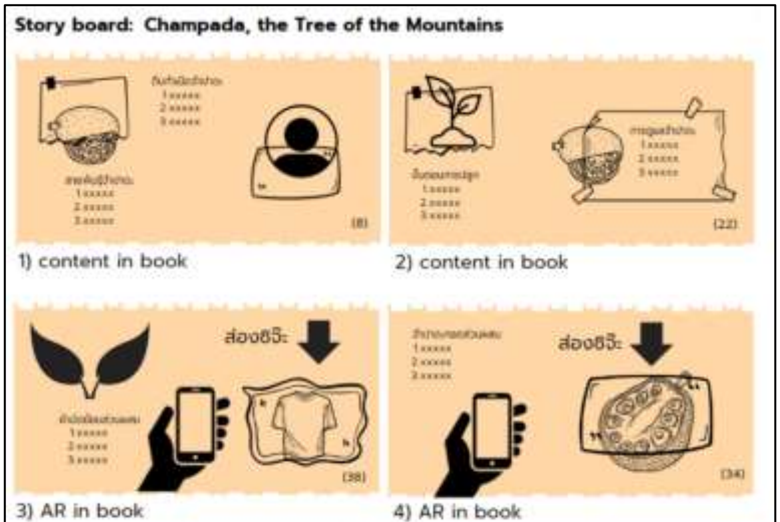

Fig 5. Storyboard for the design layout between normal content and augmented AR content

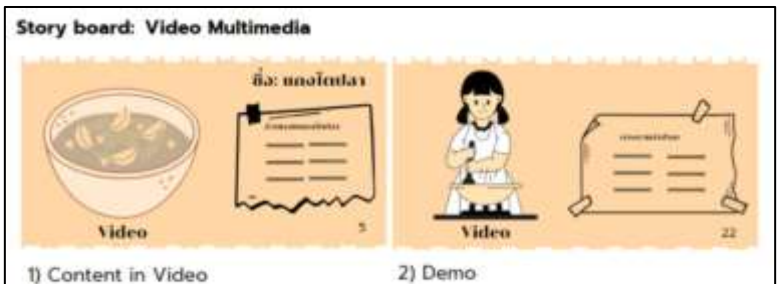

Fig 6. Outline of content in a multimedia video

3)Development (Development): This step involves developing the learning media according to the content outline and the storyboard that has been designed. The details are as follows:

3.1) Using the online program, Canva, for developing the books.

Fig 7. Example of a book with AR added to the content

3.2) Developing multimedia videos with CapCut, video editor, and Audacity audio recording program.

Fig 8. Multimedia video development

3.3) Creating AR media in the Blippar online program, which includes an Image Marker and Content Creator, then placing the Image Marker on top of the book in Augmented Reality.

Fig 9. Creating AR media in the online program Blippar

Fig 10. Example of placing an Image Marker on a book and evaluating its effectiveness in practice

3.4) Evaluating the quality of AR technology learning media by 3 experts. The evaluation results indicate a very good quality level ($\bar{x}$ = 4.90, S.D. = 0.13).

4)Implementation Step: The AR technology learning media, evaluated for content and media by experts, is put into practice with a sample group of 30 individuals. All participants are students and youth living in Lan Saka District, Nakhon Si Thammarat Province, selected through a purposive sampling process. Additionally, a study on their satisfaction is conducted.

Fig 11. Using AR technology learning media

5)Evaluation Step: In this step, the researcher analyzes the results of the study on satisfaction with AR technology learning media. The data analysis and statistics used for the analysis include frequency, mean, and standard deviation. The results are compared with the evaluation criteria using a 5-level rating scale as follows:

5.1) An average of 4.51 – 5.00 indicates the highest level
5.2) An average of 3.51 – 4.50 indicates a high level
5.3) An average of 2.51 – 3.50 indicates a moderate level
5.4) An average of 1.51 – 2.50 indicates a low level
5.5) An average of 1.01 – 1.50 indicates the lowest level

In conducting research, the researcher proceeded to receive ethical review from the Human Research Ethics Committee of Nakhon Si Thammarat Rajabhat University. Consent was obtained from the target group and measures were taken to protect the rights of the participants providing information. The objectives of the research project were clearly explained, and appointments were made to conduct the research.

5 Results

A summary of the research results is explained according to the research objective framework, which consists of two items:

1) Develop learning media on local wisdom and the use of Champada with AR technology, consisting of eight content sections:

1.1) Tracing the History of Champada's Hometown: This section covers basic information about Champada, including its origin, common name, and scientific name.

1.2) Relatives of the Champada Species: This section discusses plants in the same species group as Champada and Champada species found in the southern provinces of Thailand.

1.3) From Seedling to Maturity, Oh! Champada: This section covers planting, caring, and harvesting Champada.

1.4) Kora Champada: This section shares folk wisdom on protecting Champada fruits from important insect pests.

1.5) The Lifestyle of Orchard Farmers: This section presents the way of life of villagers working with Champada.

1.6) Visit a Champada Orchard: This section presents content about Champada grown in orchards, including interviews with agriculturists and orchard owners about planting, caring, and generating income from selling Champada.

1.7) Benefits of Champada: This section discusses the benefits of every part of Champada, from the roots, leaves, bark, and fruit to the sap.

1.8) Processing of Champada: This section covers various ways Champada is processed.

Each of the eight chapters will include multimedia videos to enhance the content in AR format, featuring eight stories. These stories cover lifestyle, a visit to a Champada orchard, demonstrations on how to fry Champada, stir-fry Champada, cook young Champada in curry, cook Champada seeds in Kaeng Tai Pla, tie-dye with Champada leaves, and weave Kero Champada. The steps for using AR technology learning media are shown in Fig 12.

Fig 12. Media for learning with AR technology

2) Evaluate the satisfaction of AR technology learning media with youth students in the Lan Saka District community, Nakhon Si Thammarat Province.

The evaluation of the satisfaction of AR technology learning media with youth and students in the community in Lan Saka District, Nakhon Si Thammarat Province shows that the overall average satisfaction is at a high level, equal to 4.13, with an overall standard deviation of 0.53. When considering the first three evaluation items, it is found that the media is easy to use, engaging, and captivating, with a mean of 4.47 and a standard deviation of 0.51 which indicates a high level of satisfaction. This is followed by the media's enhancement of understanding of the content and knowledge about Champada, which has a mean of 4.33 and a standard deviation of 0.71, also at a high level. Additionally, the use of images, colors, and font sizes is deemed appropriate, with a mean of 4.23 and a standard deviation of 0.43, indicating a high level of satisfaction. The satisfaction results are presented in Table 1.

Table 1 Evaluation results of satisfaction with learning media developed using AR technology

No.	Item	Mean	S.D.	Interpretation
1.	The objectives of the media are clearly stated.	3.90	0.92	High
2.	The media presents content in a structured and sequential manner.	3.97	0.49	High
3.	The media covers essential content comprehensively and clearly.	4.07	0.45	High
4.	It connects prior knowledge with the new knowledge provided by the media.	3.93	0.64	High
5.	This media enhances understanding of the content and knowledge about Champada.	4.33	0.71	High
6.	The media is appropriate for the allotted learning time.	4.20	0.41	High
7.	The media allows learners to achieve the stated objectives.	4.10	0.40	High
8.	The use of images, colors, and font sizes is appropriate.	4.23	0.43	High
9.	The layout of elements on each page of the media is user-friendly.	4.07	0.37	High
10.	The media is easy to use, engaging, and captivating.	4.47	0.51	High
Average of mean		4.13	0.53	High

6 Discussions

Discussion of the research results will be explained according to the framework of the research objectives. which consists of 2 items:

1) Develop learning media on local wisdom and the use of Champada with AR technology consists of eight content sections: The following discussion presents the results of this development process. Experts evaluated the content and media quality with a good score ($\overline{x}$ = 4.90, S.D. = 0.13). This high-quality rating is attributed to the media development process, which adopted the principles of media design and development according to the ADDIE Model, consisting of five stages:

1.1)Analysis stage: The researcher collected information on local wisdom and the usage of Champada from local philosophers, Champada farmers, and agricultural officials in Lan Saka District, Nakhon Si Thammarat Province. Additional sources included articles, journals, conference reports, books, and reliable websites. This comprehensive data collection ensured that the information was high quality and aligned with the objectives and the scope.

1.2)Design stage: The information obtained from the analysis stage was used to design the content and multimedia media by creating the outline of the book contents and the storyboards of the multimedia video content. The contents were presented in AR, which supplemented the book with multimedia videos, helping students understand the contents effectively. This approach promotes clear and engaging learning, consistent with Jesionkowska et al. (2022); Weng et al. (2020); Volioti et al. (2023); Huang et al. (2021); Efstathiou et al. (2017); and Azhar et al. (2019), which demonstrated that AR enhances learning enthusiasm and content comprehension.

1.3)Development stage: Learning materials were developed according to the content outline and the storyboards. Canva was used for book development, while CapCut and Audacity were used for developing multimedia videos. Blippar was used to create AR media, including an image marker and content creator. The image marker was then placed on the top of the book in AR. Three experts evaluated the quality of the AR technology learning media in terms of content and media, and the evaluation results were of great quality, making the learning media suitable for usage.

1.4)Implementation stage: The AR technology learning media evaluated for content and media by experts was put into practice.

1.5)Evaluation stage: The satisfaction of the users, consisting of 30 students and youths from Lan Saka District, Nakhon Si Thammarat Province, was evaluated.

2) Evaluate the satisfaction of AR technology learning media with the students in the Lan Saka District community, Nakhon Si Thammarat Province:

2.1)The satisfaction of AR technology learning media with the students in the Lan Saka District community, Nakhon Si Thammarat Province was high with an average value of 4.13 and an overall standard deviation of 0.53. When considering the first three evaluation items, it was found that: this media is easy to use, interesting, and intriguing, with an average value of 4.47, indicating a high level of satisfaction; 2) this media provides a better understanding of the content and knowledge about Champada, with an average value of 4.33, also at a high level; and 3) the appropriateness of the use of images, colors, and font size, with an average value of 4.23, indicating a high level of satisfaction.

The evaluation of the satisfaction with AR technology in education is consistent with existing research. For example, Alkhabra et al. (2023) stated that AR technology can enhance retention learning, critical thinking and practical skills after using AR were better than before using AR. Additionally, using AR technology in biology teaching significantly increased students' learning outcomes and attitudes towards the subject Weng et al. (2020) also found that the use of AR technology significantly improved the learning outcomes and attitudes of ninth-grade students towards biology, particularly at the analytical level.

2.2) The results obtained from the satisfaction evaluation of the AR technology learning media with the group of students in Lan Saka District community, Nakhon Si Thammarat Province, have shown that the AR technology can greatly enhance learning efficiency and student satisfaction.

This is consistent with other research results mentioned above. Additionally, a study by Abdul Hamid et al. (2021) found that AR technology creates a better learning experience for students and helps effectively increase their learning skills. However, the AR technology still presents some challenges, such as the need for design that should consider the ease of users, including engineering students. The study by Volioti et al. (2022) also highlights the challenges of using AR technology in teaching highly complex content, which students may find difficult to use. Therefore, the development and improvement of AR technology in any learning environment should be focused on designing learning media that suits the target user group. It is also essential to provide knowledge and training to teachers to ensure they are proficient in using this technology. This will maximize the efficiency of using the AR technology in education.

7 Conclusions and future research

7.1 Conclusions

This study of the satisfaction of AR technology learning media with a group of students in the Lan Saka District community, Nakhon Si Thammarat Province, found that AR technology can significantly increase learning efficiency and student satisfaction. Students felt that the AR media was interesting, easy to use, and helped them understand the content better. This aligns with the goal of developing media intended for students, allowing youth to learn about Champada, raise awareness, and promote the sustainable conservation of the native plant Champada.

Although the results of this study show the effectiveness of AR technology in increasing learning efficiency and satisfaction, there are several future research directions related to AR technology:

1) Expanding the sample size: This study used a small sample size from a single community. Future research should expand the sample size and conduct studies in different areas to increase confidence in the research results and enable wider application of the findings.

2)Study of long-term effects: This research focuses on evaluating short-term effects. Future research should examine the long-term impact of using AR technology on student learning and satisfaction, including tracking learning outcomes over various periods.

3)Technology development and improvement: The design and development of AR technology still need improvement to suit the target user group, making it more user-friendly. Research should focus on developing tools that help teachers and students use AR technology effectively.

4) Teacher training: Using AR technology in teaching requires knowledge and skills. Training teachers to be proficient in using AR technology will help implement this technology effectively in the classroom.

5) Development of policies and standards for AR technology: Future research should focus on developing clear policies and standards for using AR technology in education to ensure its effective and safe usage in the classroom.

6) Comparative studies with other technologies: Research should conduct comparative studies on the effectiveness of AR technology versus other learning technologies, such as 2D learning, game-based learning, or mixed-media learning, to provide comprehensive information and identify the most suitable technology for teaching and learning.

7.2 Future Research

Future research should aim to build a deeper understanding of the impact of AR technology on learning and teaching, including developing and improving the technology to be appropriate for the target user group and creating clear policies and standards for its use in the education system. AR technology can potentially transform learning and teaching in the education system. Future research should focus on developing this technology to be more appropriate and beneficial for education, including creating clear policies and standards to ensure the effective and safe usage of AR technology in the classroom.

7.3 Research Contribution and Applications:

The findings of this study highlight the potential of integrating Augmented Reality (AR) into educational and cultural initiatives to enhance learning and preserve local wisdom. AR technology serves as an innovative tool for policymakers and educators to address the declining awareness of cultural heritage among younger generations. By providing interactive and engaging learning experiences, AR can be effectively used in schools, community workshops, and public events to promote a deeper appreciation of cultural assets. The research outcomes have been applied to secondary school students in Lan Saka and Chang Klang districts, Nakhon Si Thammarat Province, to foster awareness, love, and pride in their local identity and culture. Local administrative organizations and educational institutions can further integrate AR-based learning media into their curricula or community outreach programs to strengthen cultural preservation efforts. The flexibility of AR content, which incorporates multimedia elements like videos and 3D animations, ensures accessibility and relevance for diverse audiences. For the tourism sector, AR-enhanced storytelling offers a unique opportunity to create immersive experiences for visitors, enriching local tourism by bridging cultural heritage with modern technology.

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