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Educational tool kits for basic traditional Thai dancing for learners with visual impairment

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Abstract: With the ever-evolving world, means of education have developed through multimedia and internet, allowing learners to learn more effectively, with more reach and less boundaries. Thailand, as one of the developing countries, has also been evolving its education systems through multimedia teachings while incorporating online media. However, the visually impaired group of learners fell behind especially in traditional Thai dancing lessons, which require contact-based cues from instructors. The gap widened as the COVID-19 situation prohibits physical touches, making some group of Thai students with visual impairment falling behind in traditional Thai dancing classes. In this work, a learning toolkit, comprising microcontroller and 3D-scanned media, was developed and used to enhance the learning efficiency of traditional Thai dancing in a visually impaired group of learners. The control group demonstrated 27.4% and 193.3% improvement between pre-test and post-test scores in theoretical multiple-choice tests and practical performance tests, respectively. Through the ANOVA and T-score analysis, statistically significant improvements were confirmed in the experimental group. This work has demonstrated that our developed toolkit can be used to teach students with visual impairment in mid-high school range of age without prior visual cues.

Subjects: Collaborative Design; Mechanical Engineering Design; Learning Difficulties; Dance; Art

Keywords: Traditional Thai Dance; microcontroller; 3D printing; visually impaired; audiobook; multimodal

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Sariya Hongyeesibed, PhD, is a lecturer from Faculty of Humanities and Social Sciences, Chiang Mai Rajabhat University, Thailand, whose area of expertise ranges from performing arts, traditional Thai dance, teaching arts, contemporary dance, and preservation of local/tribal dance in Thailand's northern region. She's passionate about distributing arts to less privileged group of audiences in Thailand and all.

PUBLIC INTEREST STATEMENT

This work utilizes microcontrollers to create a multimodal innovative learning toolkit for students with visual impairment to learn Thai Dance. The toolkit developed in this work could reduce the workload of instructors allowing students to independently exercise or learning new moves without having the instructor to individually aid each student in each part of contact-based lesson.

1. Introduction

With the widespread of COVID-19 during 2019–2022, humanity had faced a global challenge where mankind needed to be able to work and communicate remotely more than ever before. Education, too, had evolved in such an aspect as evidenced by the significant increase in online class or the use of applications such as MS Teams or Zoom for educational purposes. A systematic review and meta-analysis of evidence on COVID-19 learning deficits 2.5 years into pandemic were conducted, and the research yielded a conclusion that COVID-19 affects learning deficits with no statistical differences between grades, but with larger learning deficits in poorer countries (Betthäuser et al., 2023), especially in families with economical disadvantages (Van Lancker & Parolin, 2020). As most media requires visual cues, this evolution had left the learners with visual impairment to become even less privileged in the current state of evolving education system.

In this globalized world, equality in education is a matter of great importance to governments around the world. The pervasiveness of technology and the accessibility of the Internet make the world go even faster. Establishing clear boundaries between cultures is starting to become a fuzzy idea as the entire globe starts becoming a cultural melting pot. However, globalization can erode the authenticity of cultural traditions such as performing arts in its original forms, necessitating a focus on preservation of cultural integrity in such melting pot, especially in Thailand. To bridge such a gap in performing arts education, in this work, an innovative learning toolkit for learners with visual impairment was developed using microcontroller and 3D scanned media along with audiobook. The toolkit was replicated for five copies and used in the visually impaired group (referred to as the study group in this article).

2. Literature review

Through online learning, learners can learn the online content via media such as YouTube, Coursera, or Khan Academy. These platforms allow students worldwide to learn from world-class institutes and instructors. COVID-19 has had a significant impact on the education of all students, but it has particularly affected students with visual impairment as information was distributed through screens and software (Senjam, 2020). The sudden shift to online learning has made it difficult for these students to access and participate in their education, leading to a significant gap in their learning and development as many online resources and tools, such as PDF documents and video lectures, are not easily accessible to the group putting them at a significant disadvantage (Senjam, 2020). In that light, assistive technologies, such as screen readers and braille displays (Loomis, 1981; Simón & Huertas, 1998), are essential for students with visual impairment to access and participate in their non-contact education, but tools such as refreshable Braille display can be expensive and may not be easily available to all students (Zdravkova & Krasniqi, 2021). Early family intervention in the rehabilitation of young students with visual impairment has also been reported (Provenzi et al., 2022), but the social distancing during COVID-19 also reduced the contacts direly needed in the visually impaired group (Senjam, 2020). However, such frameworks can also be proven difficult during the period of COVID-19 where social distancing is heavily encouraged, further crippling the learning efficiency of the visually impaired group. This point also highlights another disadvantage on the visually impaired group as in-person support and guidance are also keys to education of the students with visual impairments. Many students with visual impairment rely on in-person support from teachers, interpreters, and other support staff to access their education. Integrated on-site classes had also been conducted in order to aid learners with visual impairments in becoming contributing member of the society (Mani, 1998), this method also required on-site human interactions with the learners. The sudden shift to online learning has also made it difficult for students to access the support and assistance they need to use these technologies effectively. Tools such as audiobooks (Ekaterina, 2012) are largely employed for the education of the blinds, some along with interactive multimodal lessons (Alatas & Solehat, 2020) especially in art education and showcases (Coster & Loots, 2004) along with in-person support and guidance for students with visual impairment as virtual learning environment needs to be provided for them as well (Russ & Hamidi, 2021).The shift to online learning has made it difficult for these students to receive the same level of support and assistance, leading to a further gap in their learning and development (Senjam, 2020). Regardless of

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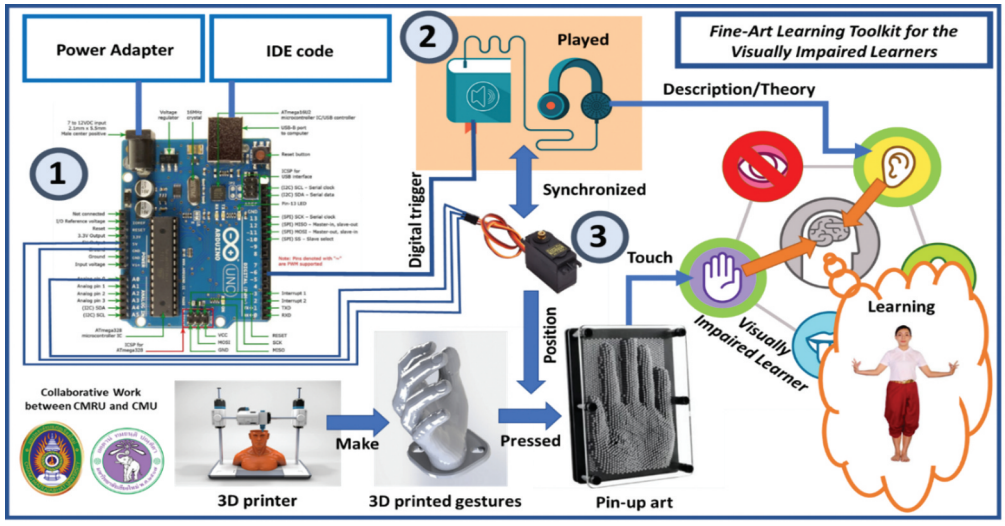

Figure 1. Schematics of toolkit development.

recent developments, improvement of the non-contact learning platform for niche education such as Thai dancing, especially for the visually impaired group, is yet to be addressed.

Thai dancing is an important part of Thailand's cultural heritage and has a rich history that dates back centuries. It is a unique art form that reflects the country's diverse cultural influences and traditions. Preserving Thai dancing is essential for several reasons. Thai dancing is an important cultural expression that reflects the country's unique identity and history. It is a source of pride and cultural recognition for the Thai people, and its preservation helps to keep the country's cultural traditions alive (Potiwetchakul, 2010) and helps creating jobs for the locals as they function to preserve the heritage. Although development for teaching students with visual impairment to learn Ballet and western dances had been well developed and employed (Bishop & Rhind, 2011; Doyle, 1981; Intravaia, 1989; Papadopoulos & Scanlon, 2002), even capoeira dance program heavily relying on sound and touch for the study group has been successfully employed (Esatbeyoglu et al., 2023) and such tools for Thai dancing remain a relatively unexplored area.

Therefore, in this work, 3D scanned media was created and used along with audiobook in a multimodal media toolkit, allowing students to use by just pressing simple arcade-game buttons to navigate through nine Thai dance lessons, whose diagram is as illustrated in Figure 1. This is aimed to create stand-alone media that students with visual impairment with no prior visual cues in Thai dancing can use and learn Thai dancing.

3. Methodology

In creating the learning modules for the study group to learn Thai dance, each part of the multimodal media was developed and synchronized together as follows.

3.1. The development of 3D scanned media

To produce the 3D scanned media used in this multimodal media, 3DEM application was used to capture a series of photos of the object from different angles, which were then processed to create a digital 3D model of different parts of the dancers via the front camera of an iPhone equipped with two infrared cameras for facial recognition. Once the 3D scan was completed, the mesh-based version of the model was, then, edited using MeshMaker software to improve its accuracy and details. This may have involved manually adjusting the position of individual vertices or smoothing out rough edges. The edited mesh was then exported to an STL file, which is a widely used file format for 3D printing. The STL file was then imported into Ultimaker Cura 4.6 to render

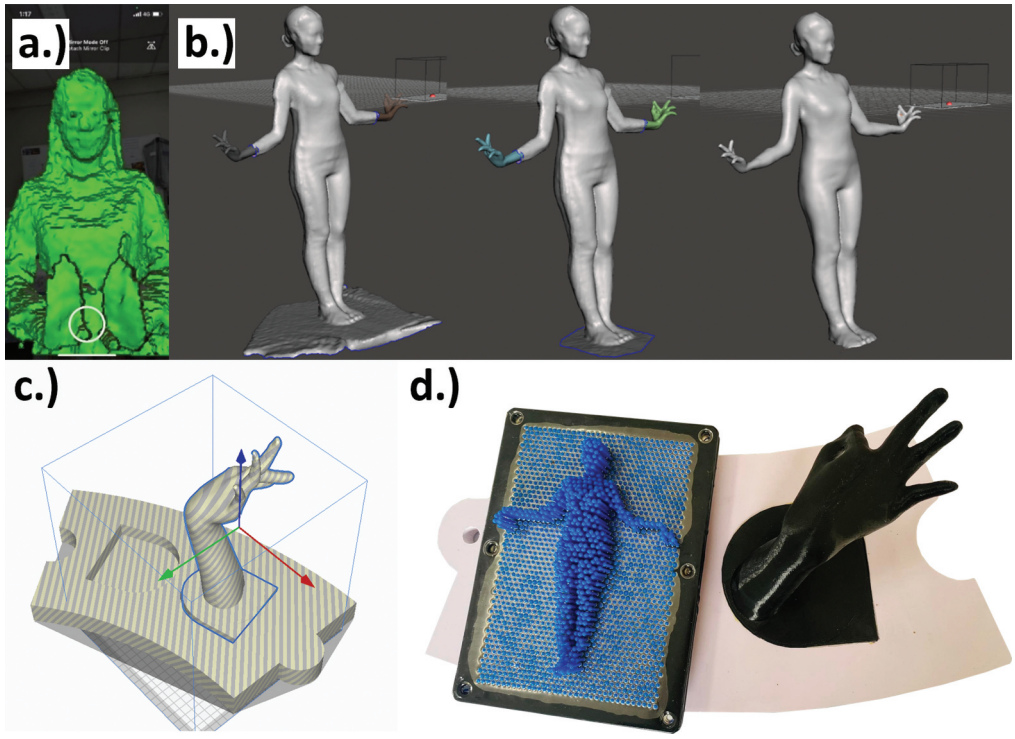

Figure 2. Illustration of (a) scanning and (b) polishing of the 3D scanned models, (c) slicing process for 3D printing, and (d) 3D printed media along with the tactile display.

and slice the file layer-by-layer for 3D printing by 3D printer, Ender Creality 3 Pro as shown in Figure 2(c).

In this work, the application was in the teaching of Thai dance lessons to students with visual impairment. By creating 3D scans of the movements and positions used in Thai dance, automated, touch-based lessons can be created. The 3D scans could be manipulated and examined from different angles, providing a more comprehensive and interactive learning experience. The 3D scanned lessons were developed based on nine Thai classical dance vocabulary: Jeeb Kwum, Jeeb Ngai, Tung Wong Bon, Tung Wong Klang, Tung Wong Lang, Yok Tao Phra, Yok Tao Nang, Gao Na, and Gradok Tao. In each lesson, two models are provided as shown in Figure 2(d). The fully 3D printed model on the right of Figure 2(d) was employed to give detailed description of each pose (in this case, the fine layout of the fingers), while the semi-3D model on the left side of Figure 2(d) was created and pressed on pins to give the students texture contrast while touching and showing the full-body posture. The models are moved in synchronization with the accompanying audiobook. The models were then placed on a table of diameter of 1.20 m with touching height appropriate for middle-school students.

3.2. The design of the controller unit

The controller unit is mainly controlled by an Arduino UNO R3 model articulating two stepper motors, one for circular motion using a timing belt and the other for upward and downward motion using a linear actuator while playing audiobook lessons. The stepper motors used in this case were NEMA 23 models, which are widely used in a variety of applications due to their high torque and reliability. A TB6600 motor driver was used to drive these stepper motors. To control the movement of the stepper motors using the Arduino UNO R3, the first step was to connect the motors to the microcontroller using the TB6600 motor driver. The motor driver acted as an interface between the Arduino and the stepper motors, allowing the microcontroller to send signals to the motors to control their movement.

The timing belt system for the first stepper motor was then set up using an HTD-3 M model attached to a standard pulley connected to the platform that moved in a circular motion when the

stepper motor rotated. The linear actuator for the second stepper motor was also set up in a similar manner. This involved attaching the linear actuator to the stepper motor and attaching the other end of the actuator to a platform moved up and down when the stepper motor rotated. To control the movement of the stepper motors using the Arduino UNO R3, a code was written and uploaded to the microcontroller using the Arduino Integrated Development Environment (IDE utilizing the Arduino's Stepper library) to define the step angle and number of steps for each stepper motor. Arduino pins were connected to the TB6600 motor driver for controlling the motion of the contact-based lessons. After the code was uploaded to the UNO R3 unit, the stepper motors were tested using the serial monitor to send commands and ensure that they were moving correctly. The movement of two NEMA 23 stepper motors was controlled by an Arduino UNO R3 model using a TB6600 motor driver and an HTD-3 M timing belt. Through combining these parts into the learning toolkit, one can have an automatic machine that can play audiobook accompanied by touchable 3D scanned lessons as demonstrated in Figure 3.

3.3. Statistical analysis and learning efficiency test

After the development of the media, the media was verified and tested by experts prior to practical field use by the study group via a pilot study. To ensure that all the safety and performance issues were addressed, a pilot test was conducted on a small group of 10 middle school students with complete blindness from the Northern Region School for the Blind and 20 blind folded middle school students without visual impairment under careful observation by experts such as engineering experts from Chiang Mai University, seasoned teachers from the Northern Region School for the Blind.

Pre-test and post-test comprising practical tests observed by teachers and 10 multiple-choice questions were applied to 50 students with visual impairment from Northern Region School for the Blind, Chiang Mai, Thailand, all of whom are diagnosed with visual acuity worse than 3/60 (blindness) from grade 6 to 12 education level. In this study, a practical test and a multiple-choice test were administered to two groups of students as a pre-test and a post-test to evaluate the effectiveness of a new multimodal media for the study group. The practical test consisted of an evaluation of replicating Thai traditional dance vocabulary, consisting of nine forms and a total score of 36. The multiple-choice test consisted of 10 questions designed to test the theoretical knowledge learned through the lesson.

To test the toolkit's learning efficiency, students were divided into two groups. Each group consisted of 25 students with visual impairment diagnosed with blindness from mid to high school range in Northern Region School for the Blind, Chiang Mai, Thailand. To contrast this point, the control group only used an audiobook as their learning material, while the experimental group used multimodal media in addition to the audiobook. The pre-test and post-test scores of the control group and experimental group were conducted and compared to determine whether the usage of the multimodal media was more effective at improving student performance for the study group. Throughout this test, all students were assisted by teachers with teaching experiences with students with visual impairment with research assistants with B.A. graduate degree from school of performing arts teaching program from Chiang Mai Rajabhat University as evaluators.

To analyze the statistical nature of the outcomes, analysis of variance (ANOVA) was used to compare the means of the study groups along with T-score, a standardized score that represents the number of standard deviations a score is from the mean. ANOVA and T-scores can be used to analyze pre-test and post-test data in educational research (Keselman et al., 1998) to evaluate the effectiveness of interventions or compare the performance of different groups of students. The results and the nature of the collected data will be discussed in the following section.

4. Results and discussion

The results of this study were analyzed to determine the effectiveness of the developed toolkit for students with visual impairment from mid to high school range in Northern Region School for the

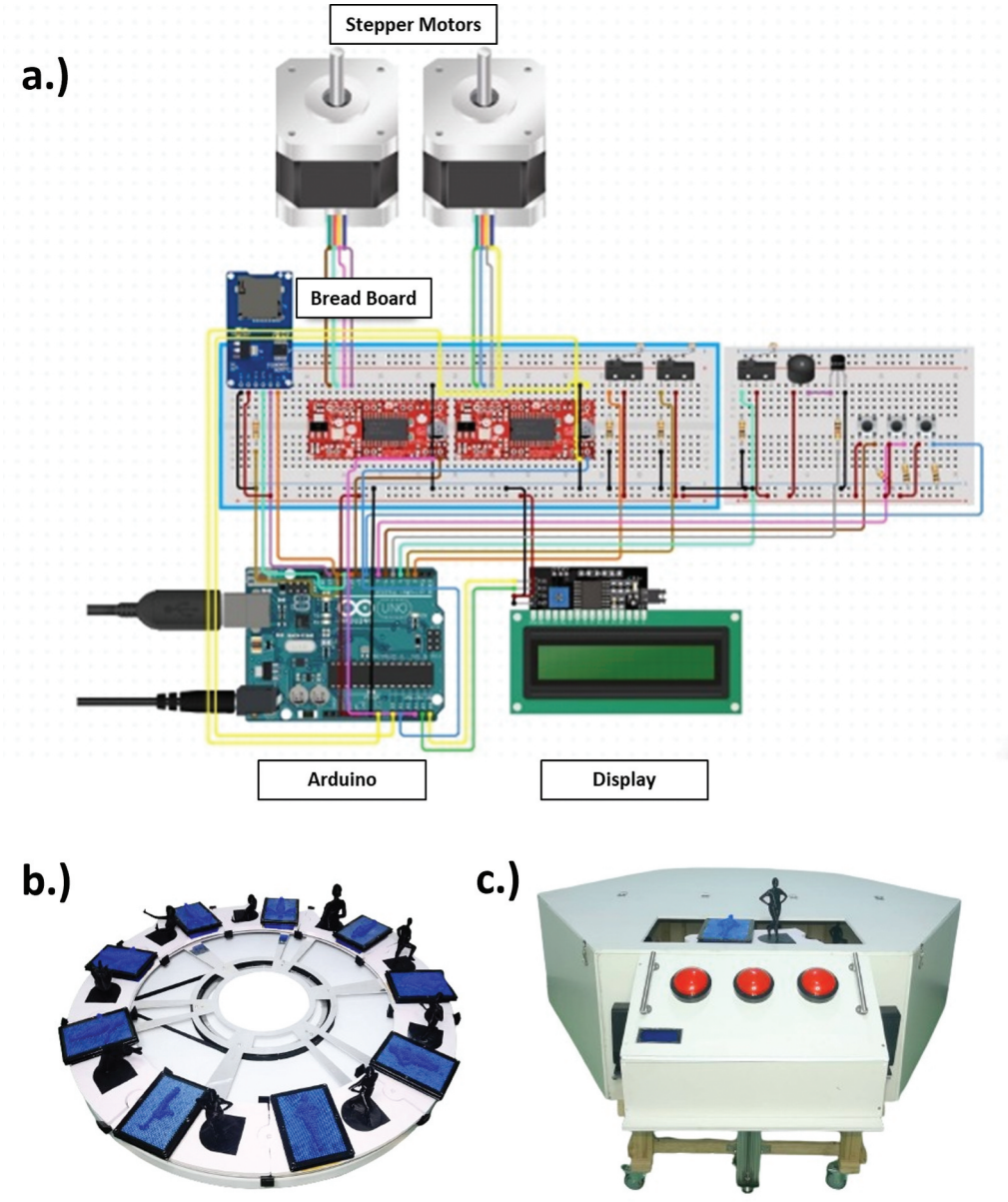

Figure 3. Final designs of the toolkit developed and used: (a) schematics of electronic connections of the Arduino microcontroller and (b) rotating part of the module covered in (c) safety cover and control box with one lesson lifted up for display.

Blind, Chiang Mai. The practical test and multiple-choice test scores were collected and analyzed using statistical analysis methods, including the ANOVA and T-scores used to compare the pre-test and post-test scores of the control group and experimental group and determine whether the use of such media had a significant impact on student performance. The results of the statistical analysis showed that the experimental group, which used the multimodal media in addition to the audiobook, had significantly higher scores on both the practical test and the multiple-choice test compared to the control group, which only used the audiobook as demonstrated in Figure 4. It can be implied from the results that the experimental group demonstrated significantly improved performance in both theoretical multiple-choice problem tests and more so in practical tests.

Furthermore, statistical analysis through ANOVA and t-score comparison between the experimental and control group was conducted and concluded in Table 1. In all groups, the average gain $\bar{D}$ is positive; however, not all gains in each corresponding category are statistically significant (with $p<0.05$). In multiple-choice tests, experimental group performed better than

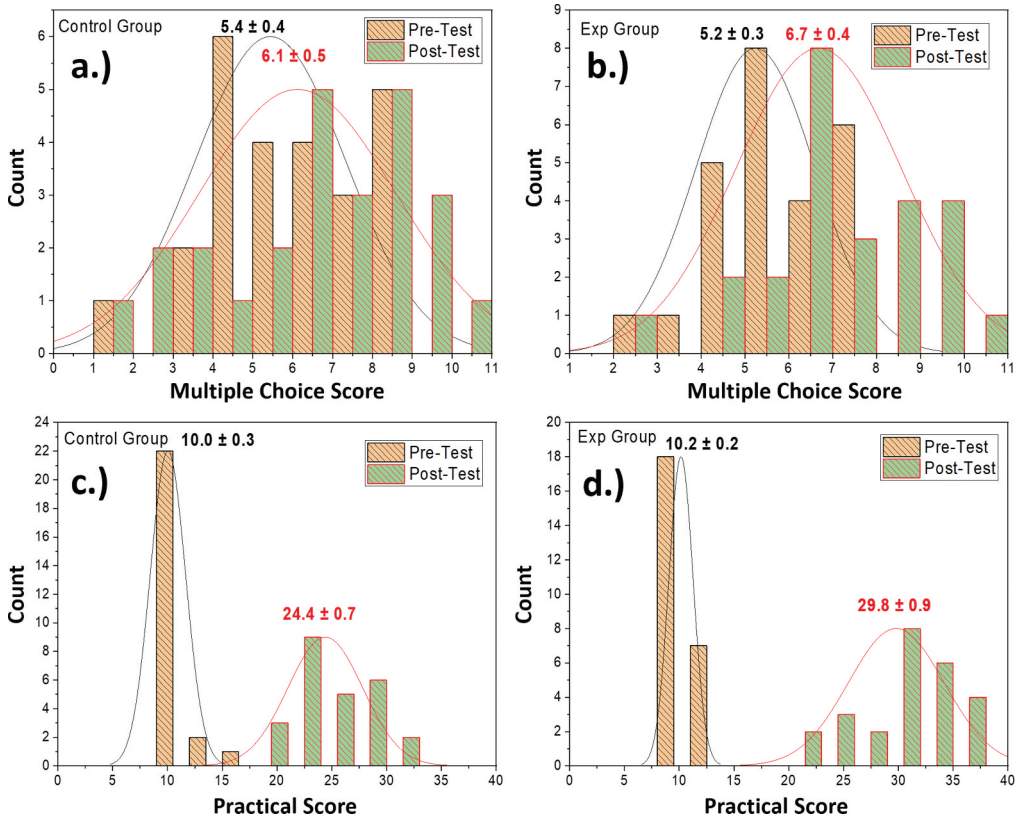

Figure 4. Pre-test and post-test score distribution of (a), (c) control group and (b) and (d) experimental group for the theoretical multiple-choice problem test and practical performance test, respectively.

the control group with the average gain of 1.44 (27.4% improvement from the pre-test) and 0.68 (12.5% improvement from the pre-test) out of 10, respectively. Although the p-value for the experimental group showed $p = 0.003 < 0.05$ demonstrating statistically significant differences between the scores of pre-tests and post-test examinations, the value of score improvement still falls within the standard deviation of the gain value, making it debatable if the toolkit was somewhat helpful for theoretical tests. On the other hand, in practical tests, the experimental group performed better than the control group with the average gain of 19.64 (193.3% improvement from the pre-test) and 14.36 (143.0% improvement from the pre-test) out of 36, respectively. It is also noteworthy that in the experimental group, the improvements after lessons are far more significant in practical skills, statistically. This is likely since most of the theoretical knowledge of traditional Thai dance are covered in audio book partm while for practical part, the models did help envisioning the dance poses and stances more effectively compared to the usage of audio books alone.

The success in using the toolkit with the experimental group could be attributed to several factors as multimodal media benefit from sensory systems in combination. It could also be implied from the results that the touch-based learning lessons element of the toolkits played a crucial role in this study. It had been demonstrated that contact-based lessons are proven to be particularly more effective media for the visually impaired group as demonstrated in capoeira dance lesson led by Esathbeyoglu and team (Esatbeyoglu et al., 2023) and contact-based dance lesson platform led by Victoria Marks (Kleege, 2014). This work does not only address the issues of learning deficits of the visually impaired group but also creates a new and effective method for the visually impaired group to independently learn lessons. This is limited to not just Thai dance but also many other subjects that require abstract visual cues or even crafting skills useful for the group. As there have been usage of mixed braille-based language for mathematics and science education for visually impaired group along with mobile

Table 1. Conclusion of statistical data obtained from performance comparison between the pre-test and the post-test using the tool kits of the control and experimental group

Group		N	Full scores	Pre-test		Post-test		$\bar{D}$	σ_D	Gain's t-score	p-Value (1-tailed)
				$\bar{X}$	S.D.	$\bar{X}$	S.D.				
Prac	Cont.	25	36	10.04	1.62	24.40	3.42	14.36	3.78	4.61	5.75E−24
	Exp.	25	36	10.16	1.11	29.80	4.37	19.64	4.51		1.54E−26
MP	Cont.	25	10	5.44	1.89	6.12	2.47	0.68	3.11	1.42	2.80E−1
	Exp.	25	10	5.24	1.36	6.68	1.88	1.44	2.33		3.25E−3

e-learning application for such a purpose (Shoaib et al., 2023), such a module can also be used in integration with the toolkit in this work to improve the efficiency. Furthermore, in the light of health and exercise for the visually impaired group, technologies have also been proven useful for the group as extra cues can be implemented without having to rely on instructors to physically contact the student one-by-one, which can be time- and resource-consuming (Rector et al., 2015). The toolkit developed in this work could reduce the workload of instructors, allowing students to independently exercise or learn new moves without having the instructor to individually aid each student in each part of contact-based lesson.

5. Conclusions

In conclusion, this study aimed to evaluate the effectiveness of a new multimodal media for students with visual impairment by comparing the performance of two groups of students: a control group that only used an audiobook and an experimental group that used the developed toolkit with touch-based lessons in addition to the audiobook. The pre-test and post-test scores of the control group and the experimental group were compared using statistical analysis methods, including ANOVA and T-scores. The results of the statistical analysis showed that the experimental group had significant improvement between pre-tests and post-tests on both the practical test and the multiple-choice test compared to the control group, indicating that the use of the toolkit was proven effective at improving student performance for the study group. Our work laid fundamental frameworks for the education of students with visual impairment and highlights the potential of the multimodal media as a valuable tool for enhancing the learning experience and improving academic performance of the group by strengthening comprehension via automated touch-based lessons along with audio cues. This opportunity is not limited only to dancing lessons, but the method can also be extended to other fields with more abstract concept such as physics and mathematics or fields with motor skills such as craftmanship or exercises for the study group.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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