Development of a Chef Uniform Ethics Learning Kit Using Augmented Reality (AR) for Hearing Impaired Students in Polytechnics

Nurul Yusnainy Yusof [1], Mohd Erfy Ismail[1]*, Zuan Azhary Mohd Salleh[1], Irwan Mahazir Ismail[2], Ahmad Zaki Mohamad Amin[3]

[1] *Faculty of Technical and Vocational Education,*
   Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

[2] *School of Education,*

[3] *Universiti Utara Malaysia, Sintok, 06010, MALAYSIA*
   Centre for Foundation Studies in Science,
   Universiti Malaya, Kuala Lumpur, 50603, MALAYSIA

*Corresponding Author: erfy@uthm.edu.my
DOI: https://doi.org/10.30880/ojtp.2025.10.02.007

Abstract

Hearing-impaired students face difficulties in understanding the ethics of wearing the chef uniform due to limited communication, lack of standardized sign language terms, and insufficient interactive teaching aids. These challenges reduce their understanding and motivation in learning, highlighting the need for more visual and engaging learning tools. The purpose of this study is to develop a chef uniform ethics learning kit using Augmented Reality (AR) for hearing-impaired students, with a focus on enhancing their visualization, understanding, and motivation through a more interactive and accessible learning experience. The study employs a Design and Development Research (DDR) approach and uses the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model as the instructional design framework. The sample consists of 10 hearing-impaired students enrolled in their second semester of the "Sijil Khas Operasi Katering" program at Politeknik Ibrahim Sultan (PIS), Johor. The findings indicate that the use of the AR-assisted learning kit significantly improves the visualization, understanding, and motivation of hearing-impaired students in understanding chef uniform ethics. The levels of visualization, understanding, and motivation of hearing-impaired students demonstrated high achievements after using the AR-assisted learning kit. Additionally, no significant differences were found between male and female hearing-impaired students, suggesting that the AR-assisted chef uniform ethics learning kit benefits all hearing-impaired students equally, regardless of gender. The results of this study highlight the potential of AR in supporting inclusive education and improving learning outcomes for students with special needs, offering an innovative approach for future educational tools in vocational programs. In conclusion, this study emphasizes the positive impact of AR in creating an inclusive, engaging, and effective learning

environment for hearing-impaired students, in alignment with the goals of inclusive education in Malaysia.

1. Introduction

The advancement of technology in education is not only a priority for educators and students but also an important step in achieving the Sustainable Development Goals 2030 (SDGs), specifically quality education (Haleem et al., 2022). The application of Augmented Reality (AR) as a teaching aid directly supports the Fourth SDG, which is to ensure inclusive, equitable, and quality education and promote lifelong learning opportunities for all, including students with special needs. In line with the Malaysia Education Development Plan (PPPM), AR technology focuses on providing quality and inclusive education and enhancing the quality of teaching in vocational and technical education, especially for students with special needs.

Students with hearing impairments refer to individuals who experience a complete or partial loss of the ability to hear, which can affect their ability to receive and process information verbally. According to Olusanya et al. (2019), an individual's hearing level can be assessed based on the range of decibels (dB) they can hear, such as mild hearing loss being 26 to 40 dB, moderate hearing loss being 41 to 60 dB, and severe hearing loss being between 61 to 80 dB, while 81 dB and above is considered profound. Students with mild hearing impairment can usually still follow verbal learning despite experiencing some difficulties, whereas students with moderate to severe hearing impairment often face more significant challenges in the learning process.

Visualization is the presentation of information in graphic form with the aim of conveying information, concepts, or ideas visually to the recipient (Ching & Nasri, 2021). A more visual and interactive learning approach is needed to ensure that hearing-impaired students can better understand the concepts being taught. According to Ismail et al. (2024), the combination of simple text and clear graphics facilitates cognitive processing while reducing the cognitive load on students to understand learning through visualization. In the world of education, AR plays an important role in providing a more interactive and visual learning experience. AR technology combines the real world and digital elements, allowing hearing-impaired students to experience the real world through displayed digital information (Samaradivakara et al., 2025).

Overall, learning methods using AR can now be adapted to be more visual, interactive, and easier for them to understand. The use of AR not only helps students understand lessons better but also boosts their motivation and self-confidence. This step is also in line with the nation's aspiration to provide inclusive and quality education for all. Therefore, the continuous commitment to leveraging innovative technologies such as AR is crucial to ensure that no one is left behind in the current educational landscape, especially those who require additional support.

2. Problem Statement

Although there has been significant progress in providing educational access for students with special needs, students with hearing impairments continue to face challenges in achieving quality and inclusive education. These challenges are often linked to communication barriers, the lack of sign language proficiency, and the limited use of visual teaching aids, all of which collectively hinder the learning process (Marschark et al., 2019; Mealings et al., 2024).

In visualization, hearing-impaired students rely heavily on visual information such as written materials, charts, images, and videos to support their learning. The absence of appropriate visual aids can cause difficulties in following lessons, lead to feelings of isolation, and negatively affect their academic performance (Birinci & Sariçoban, 2021; Akay, 2021). Furthermore, gender differences have also been observed, with male students reported to benefit more from improvements in visualization and understanding when learning through AR compared to female students (Aboudahr et al., 2023). This indicates the importance of integrating technology-based visual aids to strengthen student engagement and learning outcomes.

Next, in terms of understanding, the absence of standardized sign language vocabulary for subject-specific concepts creates a substantial barrier to comprehension among hearing-impaired students (De Sisto et al., 2022). This issue is further compounded by instructors' limited proficiency in sign language, which restricts effective delivery of subject content (Chong et al., 2021). In addition, gender-based differences influence understanding strategies. Research by Aboudahr et al. (2023) shows that male students generally demonstrate higher levels of understanding when learning with AR compared to female students. These findings highlight the importance of adopting multimodal instructional approaches that can accommodate different learning preferences across genders.

When it comes to motivation, hearing loss not only affects students' academic achievement but also reduces their willingness to actively participate in learning activities. Without adequate support, students often feel marginalized, which diminishes their motivation and overall interest in learning (Husin et al., 2023). Research by López-Belmonte et al. (2022) also indicates slight gender differences, where male students tend to display higher motivation than female students when using AR. Nevertheless, studies such as Quintero et al. (2019) confirm that

AR significantly enhances motivation and interaction for both male and female students, suggesting its potential as an inclusive teaching tool.

In conclusion, hearing-impaired students continue to face barriers in learning, particularly within conventional educational settings that lack specific teaching support or appropriate instructional tools. The absence of standardized sign language vocabulary and instructors' limited sign language skills remain significant obstacles to understand (Almos et al., 2025). Despite these issues, there has been limited focus on the use of AR for teaching specialized content such as the ethics of wearing a chef uniform, especially in the context of technical and vocational education for hearing-impaired learners (Husin et al., 2023). Therefore, integrating technology such as Augmented Reality (AR) into inclusive education is essential to improve visualization, comprehension, and motivation among hearing-impaired students and to ensure effective academic achievement.

3. Methodology

This study uses the Design and Development Research (DDR) approach popularized by Richey & Klein (2007). According to Yusof et al. (2020), the DDR approach is a concept of study developed systematically and orderly, involving the processes of analysis, design, development, and evaluation based on empirical research. This study uses the ADDIE Model as the framework for DDR. The development of a chef uniform wearing ethics learning kit based on Augmented Reality (AR) uses the ADDIE model instructional design framework, which encompasses the aspects of Analysis, Design, Development, Implementation, and Evaluation.

Prior to the main study, expert validation and a pilot study were conducted to ensure the reliability and functionality of the research instruments. The questionnaire was validated by three experts, while five experts assessed the AR-based chef uniform ethics learning kit. The pilot study sample consisted of six alumni from the Catering Operations Program at Politeknik Ibrahim Sultan, all of whom had hearing impairments, ensuring that the characteristics of the pilot sample matched those of the actual study respondents. The pilot study findings for each aspect are presented in Table 1, which indicates a good reliability value, making it effective for use as an instrument in the main study.

Table 1 *Reliability analysis for each instrument aspect*

Aspects	Quantity Item	Cronbach's Alpha
Visualization	6	0.757
Understanding	6	0.821
Motivation	6	0.745

Based on these outcomes, the final questionnaire was refined, comprising four sections: Demographics, visualization, understanding, and motivation, to systematically evaluate the effectiveness of the AR-based learning kit in enhancing the learning experiences of hearing-impaired students. The instrument used in this study is a questionnaire that employs a 4-point Likert Scale, which comprises four sections: Part A, B, C, and D, as shown in Table 2. The population in this study involves ten respondents, namely hearing-impaired students who are enrolled in the catering operations course at PIS and are learning the ethics of wearing a chef's uniform. The sampling method used is total sampling because this method is suitable when the population involved is small and easily accessible (Babbie, 2021).

Table 2 *Main aspects in the questionnaire*

Part	Aspects	Quantity
A	Demographic	4
B	Visualization	6
C	Understanding	6
D	Motivation	6

3.1 Analysis Phase

This phase involves identifying the learning problems faced by hearing-impaired students and lecturers. The data were collected through an interviews with the Head of the Special Certificate in Catering Operations program and lectures at PIS. In addition, interviews were conducted with hearing-impaired students enrolled in the Catering Operations Program, using Malaysian Sign Language (BIM) with the assistance of a translator. After analysis from the initial study conducted, it can be concluded that hearing-impaired students face difficulties in understanding the ethics of chef uniform wearing due to the lack of appropriate teaching aids (ABBM) and limited communication

with lecturers. Another issue that can be observed is the lack of sign language equivalents for certain terms in the chef uniform ethics, making it difficult for hearing-impaired students to understand the information clearly. The use of slides or oral explanations accompanied by sign language without interactive visual aids can make learning boring and less effective. Therefore, the development of an Augmented Reality (AR) assisted learning kit was created to assess the levels of visualization, understanding, and motivation of students with hearing impairments.

3.2 Design Phase

This study employs Cognitive Multimedia Theory as proposed by Mayer (2002), which posits that learning is optimized when information is conveyed through multiple cognitive channels, specifically the visual channel (eyes) and the auditory channel (ears). There are three principles proposed in the Cognitive Multimedia Theory, which are dual-channel information processing, limited capacity, and active processing. Cognitive Multimedia Theory suggests that presenting information in both text and visual forms can help reduce students' cognitive load and enhance their understanding of the concepts being taught (Wan Ali & Wan Yahaya, 2022). According to the dual-channel information processing principle, learning is more effective when information is presented simultaneously through both visual and auditory channels. Although students with hearing impairments cannot fully utilize the auditory channel, visual elements such as text, images, videos, and animations can be employed to convey information more clearly. This study aims to ensure that the information delivered through AR is easily understandable and not overly complex, allowing students with hearing impairments to concentrate on the ethics of wearing a chef uniform without feeling overwhelmed. Active processing occurs when learners engage actively in processing information. In this study, AR is utilized to provide opportunities for students to interact with learning materials in an active and meaningful way.

In this phase, it focuses on the layout of the user interface (UI) and storyboard for the AR assisted learning kit. AR is developed using the ZapWorks platform, which is a web-based AR development tool that enables the creation of interactive and visual experiences easily accessible through mobile applications. The user interface (UI) design is user-friendly and intuitive, incorporating clear multimedia elements such as buttons, icons, and text to facilitate student interaction. Storyboards are used to plan a systematic learning flow, with visual elements such as images and 3D models that help students understand the correct and incorrect wearing of chef uniforms, as well as the list of required uniforms. This design phase ensures that learning is more effective and easier to understand, while also enhancing the motivation of hearing-impaired students through the use of visual and interactive elements.

3.3 Development Phase

The development phase is a crucial step in the process of creating a learning kit on the ethics of chef uniform wearing using AR technology, which involves translating the planning and design from the previous phase into an actual product. At this stage, the ZapWorks platform is used to develop the user interface (UI) and interactive AR content, ensuring an effective and engaging learning experience for students with hearing disabilities. The user-friendly and intuitive interface design, accompanied by clear visual icons and text, allows students to interact with the application easily. Additionally, multimedia elements such as images, videos, and 3D models were chosen to enhance students' understanding without the need for audio elements, in line with their requirements. The development process also involves the creation of QR codes to access AR content through mobile devices, enhancing the usability of this learning kit. With the use of various platforms such as Canva, CapCut, ZapWorks, and Quizizz, the developed learning content becomes more interactive, easy to understand, and suitable for the needs of hearing-impaired students, while also providing flexibility in teaching. The Fig. 1 illustrates the development of AR using ZapWorks platform.

Fig. 1 *Development of AR using ZapWorks*

Following the development of the AR-assisted learning kit, an evaluation was conducted by five experts from Universiti Tun Hussein Onn Malaysia (UTHM) and institutions involved in teaching students with hearing impairments in the Catering Operations program from PIS. The evaluation instrument comprised three main sections: Section A, which assessed the design aspects; Section B, which assessed content and interactivity; and Section C, which assessed product functionality. The results shown the evaluation of the AR-assisted learning kit demonstrated overall high effectiveness across design, content, interactivity, and functionality. The design assessment received excellent ratings, with all experts agreeing on the layout, user-friendliness, safety, and appropriateness of text and color, although graphic elements scored slightly lower, with 80% for clarity and 60% for visual appeal, suggesting minor improvements were needed. The AR application performed strongly in content and interactivity, with all experts confirming that the learning objectives were met and that interface elements were generally intuitive and functional, except for button size, which received a 90% rating. Functionality assessment also showed very good results, with unanimous agreement that the kit was accessible via iOS, Android, and QR code, and effectively supported students with hearing impairments; usability scored 90%, reflecting a single expert's concern. Overall, the learning kit was highly effective, with only minor enhancements recommended for graphics, button size, and usability.

3.4 Implementation Phase

After the Augmented Reality (AR) assisted learning kit was developed, the implementation phase was carried out in this study. The AR-based learning kit that was designed was used by all second-semester hearing-impaired students at Politeknik Ibrahim Sultan. At this stage, students interact with AR technology in real learning situations to assess the effectiveness and functionality of the developed materials. The developed learning kit is evaluated by hearing-impaired students involved in the catering operations program. Thus, the level of assessment of hearing-impaired students in terms of visualization, understanding, and motivation towards the use of Augmented Reality (AR) can be detected through this phase. The Fig. 2 shows hearing-impaired students using smartphones to interact with learning kits with the help of Augmented Reality (AR) applications.
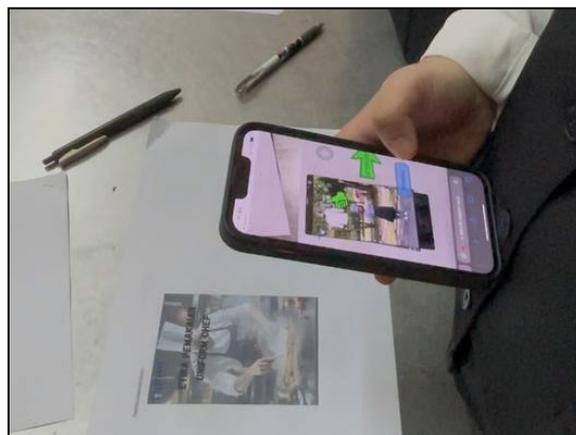

Fig. 2 *Students explore the AR-assisted learning kit*

3.5 Evaluation Phase

The evaluation phase is the final stage in the ADDIE instructional design model, which aims to assess the effectiveness and functionality of the developed and implemented learning materials. In this study, the evaluation was conducted to identify the level to which the use of Augmented Reality (AR) technology can support the learning process of hearing-impaired students. A questionnaire was distributed to ten hearing-impaired students to collect data related to the aspects of visualization, understanding, and motivation regarding the use of an AR-assisted chef uniform ethics learning kit. This questionnaire was constructed with consideration for the communication needs of hearing-impaired students, including the use of easily understandable language. The data collected was analyzed using SPSS software to examine the levels of visualization, comprehension, and motivation of hearing-impaired students towards the Augmented Reality (AR) assisted learning kit.

4. Findings

The questionnaire was distributed to hearing-impaired students after they used the AR-assisted chef uniform ethics learning kit. This questionnaire uses a Likert Scale with four levels of agreement with the options of strongly disagree, disagree, agree, and strongly agree. The mean score range is used to analyze the study results based on the 4-point Likert Scale used in the questionnaire. Table 3 shows the mean score range for the 4-point Likert Scale by Alico and Guimba (2015), which is used in this study to interpret the levels of visualization, understanding, and motivation of hearing-impaired students towards the use of the chef uniform ethics learning kit assisted by Augmented Reality (AR).

Table 3 *Mean score range (Alico & Guimba, 2015)*

Mean Score	Interpretation
1.00 – 1.74	Low
1.75 – 2.49	Moderately Low
2.50 – 3.24	Moderately High
3.25 – 4.00	High

4.1 Part A: Respondents Demographics

Table 4 shows the analysis of data from the frequency and percentage of respondents' demographics. Data analysis from the questionnaire shows that 4 male respondents (40.0%) were involved in the study, while 6 female respondents (60.0%) were also involved. This explains that the female respondents more than the male respondents. Students with hearing impairments who have less than six months of experience using Augmented Reality (AR) applications numbered 4 respondents (40.0%), followed by students with no experience, who numbered 6 respondents (60.0%). Through this study, it was found that all hearing-impaired students who answered this questionnaire have knowledge about the ethics of wearing a chef's uniform. This is evidenced by the number of hearing-impaired students who possess knowledge about the ethics of wearing a chef's uniform, which amounts to 10 people (100%).

Table 4 *Demographic findings of respondents*

Demographics	Frequencies	Percentages (%)
Gender		
Male	4	40.0
Female	6	60.0
Experience using AR		
More than 1 year	0	0
Less than 6 months	4	40.0
Never	6	60.0
Know about the ethics of wearing a chef's uniform		
Yes	10	100.0
No	0	0

4.2 Part B: Students' Level of Visualization in the Use of Chef Uniform Ethics Learning Kit Using Augmented Reality

Based on the research findings obtained in Table 5, it shows the level of assessment of hearing-impaired students towards the visualization aspect after using the chef uniform ethics learning kit assisted by Augmented Reality (AR). The highest mean score recorded was 3.50, which indicates the first, second, and third items: "I can clearly see the chef's uniform through AR without a sign language interpreter," "I understand the learning content through visuals in AR," and "I easily follow the instructions for wearing the chef's uniform through the video in AR". All three items share the highest mean score. Meanwhile, the item regarding the visualization aspect with the lowest mean score is 3.30 through the statement " I easily understand the guidelines for chef uniform ethics through AR displays.". Overall, most interpretations of the mean score for the assessment level of hearing-impaired students regarding the visualization aspect are at a high mean score.

Table 5 *Mean and standard deviation interpretation for the aspect visualization*

No.	Item	Mean Score	Standard Deviation	Mean Interpretation
V1	I can clearly see the chef's uniform through AR without a sign language interpreter.	3.50	.53	High
V2	I understand the learning content through visuals in AR.	3.50	. 53	High
V3	I easily follow the instructions for wearing the chef's uniform through the video in AR.	3.50	.53	High
V4	I easily understand the guidelines for chef uniform ethics through AR displays.	3.30	.48	High
V5	I feel that AR technology makes the display of the chef's uniform more interesting.	3.40	.52	High
V6	I got a clearer picture of the proper ethics for wearing a chef's uniform.	3.40	.52	High
Overall Score		3.43	.52	High

4.3 Part C: Students' Level of Understanding in the Use of Chef Uniform Ethics Learning Kit Using Augmented Reality

Based on the research findings obtained in Table 6, it shows the assessment level of hearing-impaired students regarding understanding aspects after using the chef uniform ethics learning kit assisted by Augmented Reality (AR). The highest recorded mean score was 3.50, which corresponds to the fifth item, "I understand the correct chef's attire through the AR kit without the help of a sign language interpreter". Next, the lowest mean score recorded was 3.10, which is "I easily understand difficult concepts when using the AR-assisted learning kit". Overall, most interpretations of the mean score for the assessment level of hearing-impaired students regarding the aspect of understanding are at a high mean score.

Table 6 *Mean and standard deviation interpretation for the aspect understanding*

No.	Item	Mean Score	Standard Deviation	Mean Interpretation
U1	I easily understand difficult concepts when using the AR-assisted learning kit.	3.10	.32	Moderate High
U2	I find it easy to use the AR-assisted learning kit without any confusion.	3.30	.48	High
U3	I clearly understand the image of wearing a chef's uniform through the AR-assisted learning kit.	3.30	.48	High
U4	I easily understand the ethics of wearing a chef's uniform through AR.	3.40	.52	High
U5	I understand the correct chef attire through the AR kit without the help of a sign language interpreter.	3.50	.53	High
U6	I feel that the AR visual experience helps enhance my understanding.	3.30	.48	High
Overall Score		3.77	3.31	High

4.4 Part D: Students' Level of Motivation in the Use of Chef Uniform Ethics Learning Kit Using Augmented Reality

Based on the research findings obtained in Table 7, the level of assessment of hearing-impaired students regarding motivation aspects after using the chef uniform etiquette learning kit aided by Augmented Reality (AR) is shown. The highest mean score recorded was 3.50, which corresponds to the sixth item, "I am confident that this AR-assisted learning kit helps enhance my knowledge in the taught topic". Next, for the items regarding the aspect of motivation with the lowest mean score of 3.30, through the statements "I am interested in the use of AR technology in learning" and "I am focused during learning using AR technology". Overall, most interpretations of the mean score for the assessment level of hearing-impaired students regarding the aspect of motivation are at a high mean score.

Table 7 *Mean and standard deviation interpretation for the aspect motivation*

No.	Item	Mean Score	Standard Deviation	Mean Interpretation
M1	I am interested in the use of AR technology in learning.	3.30	.48	High
M2	I am focused during learning using AR technology.	3.30	.48	High
M3	I am interested in learning when using the AR learning kit.	3.40	.52	High
M4	I feel excited when using the AR display.	3.40	.52	High
M5	I hope AR technology is used in other subjects as well.	3.40	.52	High
M6	I am confident that this AR-assisted learning kit helps enhance my knowledge in the topic.	3.50	.53	High
Overall Score		3.38	.51	High

4.5 Differences in Visualization, Understanding, and Motivation Aspects Between Gender

Table 8 shows the results for the differences in visualization, understanding, and motivation based on gender. Data analysis shows no significant difference between for the visualization aspect of male and female hearing-impaired students regarding the use of the chef uniform ethics learning kit assisted by Augmented Reality (AR), U = 9.00, z = -0.66, p = .507. Analysis of the understanding aspect also showed no significant difference between the male and female hearing-impaired students regarding the use of the chef uniform ethics learning kit assisted by Augmented Reality (AR), where U = 11.00, z = -0.227, p = .820. Finally, the aspect of motivation also did not show a significant difference between male and female students. The obtained values are U = 8.50, z = -0.775, p = .438. In conclusion, the study findings indicate that gender does not show a significant difference from the aspects of visualization, understanding, and motivation of male and female hearing-impaired students towards the use of the chef uniform ethics learning kit assisted by Augmented Reality (AR) technology. The analysis results found that the p-values for all three aspects (Visualization, Understanding, and Motivation) were greater than 0.05, indicating no difference between male and female hearing-impaired students.

Table 8 *Differences in visualization, understanding, and motivation between genders*

Aspects	Gender	n	Mean Rank	Mann-Whitney U	Nilai Z	Sig. (2-tailed)
Visualization	Male	4	6.35	9.00	-.664	.507
	Female	6	5.00			
Understanding	Male	4	5.75	11.00	-.227	.820
	Female	6	5.33			
Motivation	Male	4	6.38	8.50	-.775	.438
		6	4.92			

5. Discussions

The visualization level of students with hearing impairments showed high achievement after using the chef uniform ethics learning kit using Augmented Reality. AR technology provides a more interactive and immersive

visual experience, where hearing-impaired students can see the wearing of the chef's uniform through a combination of virtual elements and the real world. This study aligns with the research conducted by Lai & Cheong (2022), which states that AR enhances student visualization by providing opportunities for students to interact with and view objects using AR. In this context, the use of AR in learning the ethics of chef uniform allows hearing-impaired students to see clearly and in detail every aspect of the chef uniform that needs to be worn, such as color, texture, and arrangement of clothing, which forms the overall picture of a chef's wearing ethics in the kitchen. A study by Samaradivakara et al. (2025) also shows that AR used in the educational context can help hearing-impaired students gain a clearer and more effective learning experience.

Furthermore, this study also shows that hearing-impaired students achieve a positive level of understanding in comprehending the ethics of wearing a chef's uniform when using AR-assisted learning kits. The findings show that hearing-impaired students understand the information clearly and effectively through the visual display provided in the AR-assisted learning kit. Students can directly see the wearing of the chef's uniform and the list of chef's attire such as aprons, jackets, and chef hats in visual form through the AR display. This is in line with the study conducted by Murniarti et al. (2023), which emphasizes AR in education involving special needs students, facilitating the delivery of learning concepts in a clearer, more interactive, and easily understandable visual manner. AR can enhance understanding and build knowledge for students with hearing impairments who rely entirely on vision to receive information (Fernandes et al., 2023). The use of AR provides students with the opportunity to access information visually, understand concepts practically, and build a deeper understanding without relying on sign language interpreters and auditory input.

In addition, hearing-impaired students achieved a positive level of motivation after using the the chef uniform ethics learning kit using Augmented Reality. During the study, hearing-impaired students appeared interested in learning about the contents of the AR-assisted learning kit. All the hearing-impaired students took this opportunity to explore the ethics of wearing a chef's uniform in AR form. Some hearing-impaired students who had never used AR before were very excited and enjoyed using it for the first time. The implementation of AR technology provides opportunities for hearing-impaired students to learn the ethics of wearing a chef's uniform in a more engaging way. The findings of this study are in line with the research by (Tuli et al., 2022; Ustun et al., 2022), which found that AR can enhance student motivation because students are attracted to new technology that can develop their interest in learning.

Next, the findings indicate that there is no significant difference between male and female hearing-impaired students in terms of visualization, understanding, and motivation towards the use of the chef uniform ethics learning kit using Augmented Reality. The AR-assisted chef uniform ethics learning kit was designed with the needs of all hearing-impaired students, regardless of gender, focusing on clear and easily understandable visualization. The findings of this study align with the research by Jamen et al. (2021), which states that visualization among male and female students increases with the use of Augmented Reality (AR)-assisted learning kits. Male and female hearing-impaired students were given equal access to the use of the AR-assisted chef uniform ethics learning kit during the study, allowing students to actively engage with the same technology and learning materials. The findings of this study are in line with the research conducted by Barmaki et al. (2023), which states that there is no difference in the level of understanding between male and female students due to equal access to the use of AR-assisted learning tools.

6. Conclusion

In conclusion, this study shows that the application of AR technology has a positive impact on hearing-impaired students in all three aspects examined. This study found that the use of AR in the learning process has shown high levels of visualization, understanding, and motivation for hearing-impaired students. Learning the ethics of chef uniform wearing visually makes it easier for hearing-impaired students to understand the correct and incorrect ways of wearing a chef uniform without relying on a sign language interpreter. Furthermore, the use of AR in learning chef uniform ethics also makes the learning process more engaging and interactive, and enhances the intrinsic motivation of students. This AR-based learning kit can be tested across polytechnic institutions in Malaysia that offer the Catering Operations program, particularly for students with hearing impairments in future studies. By expanding the use of AR in educational contexts, it can provide a more inclusive and comprehensive learning experience for students with special needs.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Penerbit
UTHM

Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Nurul Yusnainy Yusof, Mohd Erfy Ismail; **data collection:** Zuan Azhary Mohd Salleh; **analysis and interpretation of results:** Nurul Yusnainy Yusof, Mohd Erfy Ismail, Irwan Mahazir Ismail; **draft manuscript preparation:** Zuan Azhary Mohd Salleh, Ahmad Zaki Mohamad Amin. All authors reviewed the results and approved the final version of the manuscript.*

References

Aboudahr, S. M. F. M., Govindarajoo, M. V. A., Olowoselu, A., & Sani, R. M. (2023). Investigating moderating influence of gender on augmented reality and students satisfaction: Experiences in cultures and linguistic diversity. *Asian Journal of University Education, 19*(3), 447–461.

Akay, E. (2021). The use of audio-visual materials in the education of students with hearing loss. *International Education Studies, 14*(7), 1–8. https://doi.org/10.5539/ies.v14n7p1

Alico, J., & Guimba, W. (2015). Level and causes of pre-university students' English test anxiety: A case study on Mindanao State University. *Researchers World: Journal of Arts, Science & Commerce, 3*(1), 1–10.

Aljedaani, W., Krasniqi, R., Aljedaani, S., Mkaouer, M. W., Ludi, S., & Al-Raddah, K. (2023). If online learning works for you, what about deaf students? Emerging challenges of online learning for deaf and hearing-impaired students during COVID-19: A literature review. *Universal Access in the Information Society, 22*(3), 1027–1046. https://doi.org/10.1007/s10209-022-00897-5

Almos, R., Lintangsari, A. P., & Hidayat, H. N. (2025). Intellectual mapping of the sign language role in deaf education: Forecasting future reforms. *International Journal of Evaluation and Research in Education, 14*(1), 146–156. https://doi.org/10.11591/ijere.v14i1.28265

Babbie, E. (2021). *The practice of social research* (15th ed.). Cengage Learning.

Barmaki, R. L., Kim, K., Guo, Z., Wang, Q., Yu, K., Pearlman, R., & Navab, N. (2023). A large-scale feasibility study of screen-based 3D visualization and augmented reality tools for human anatomy education: Exploring gender perspectives in learning experience.

Birinci, F. G., & Sariçoban, A. (2021). The effectiveness of visual materials in teaching vocabulary to deaf students of EFL. *Journal of Language and Linguistic Studies, 17*(1), 628–645. https://doi.org/10.52462/jlls.43

Ching, N. C., & Nasri, N. M. (2021). Penggunaan kaedah visualisasi dalam pengajaran dan pembelajaran perbendaharaan kata bahasa Inggeris. *Jurnal Dunia Pendidikan, 3*(3), 11–22. http://myjms.mohe.gov.my/index.php/jdpd

Chong, A. A., Yee, V., Bee, R., & Hussain, M. (2021). Language barriers in deaf-centred classrooms: Perspectives from Malaysian deaf adults. *Journal of Special Needs Education, 11*(1), 15–27.

De Sisto, M., Vandeghinste, V., Egea Gómez, S., De Coster, M., Shterionov, D., & Saggion, H. (2022). Challenges with sign language datasets for sign language recognition and translation. In *Proceedings of the LREC 2022 Workshop on Sign Language Resources and Recognition* (pp. 15–24). https://www.corpusvgt.be/

Fernandes, N., Leite Junior, A. J. M., Marçal, E., & Viana, W. (2023). Augmented reality in education for people who are deaf or hard of hearing: A systematic literature review. *Universal Access in the Information Society, 23*(3), 1483–1502. https://doi.org/10.1007/s10209-023-00994-z

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3,* 275–285.

Husin, A., Ibrahim, S., & Nor, S. (2023). Strategi dan teknik PdPc bagi mengendalikan murid berkeperluan khas ketidakupayaan pendengaran dalam pendidikan inklusif. *Unpublished manuscript.*

Ismail, M., Che Kob, C. G., Abdullah, N., & Zamzuri, F. K. (2024). Perspektif guru terhadap elemen multimedia di dalam modul sequin topik reka bentuk fesyen pada mata pelajaran reka bentuk dan teknologi tingkatan satu. *Asian Pendidikan, 4*(1), 43–52. https://doi.org/10.53797/aspen.v4i1.5.2024

Jamen, K. J. (2021). Keberkesanan 3-D molecular visualization augmented reality (V-Max) terhadap pencapaian dan kemahiran visualisasi pelajar dalam topik ikatan kimia. *Special Edition NARTC, 6,* 101–110. http://upikpolimas.edu.my/ojs/

Lai, J. W., & Cheong, K. H. (2022). Adoption of virtual and augmented reality for mathematics education: A scoping review. *IEEE Access, 10,* 13693–13703. https://doi.org/10.1109/ACCESS.2022.3145991

López-Belmonte, J., Moreno-Guerrero, A.-J., Marín-Marín, J.-A., & Lampropoulos, G. (2022). The impact of gender on the use of augmented reality and virtual reality in students with ASD. *Education in the Knowledge Society, 23,* Article e28418. https://doi.org/10.14201/eks.28418

Marschark, M., & Knoors, H. (2019). *Language development and education of deaf children.* Oxford University Press.

Mayer, R. E. (2002). Multimedia learning. In B. H. Ross (Ed.), *Psychology of learning and motivation* (Vol. 41, pp. 85–139). Academic Press. https://doi.org/10.1016/S0079-7421(02)80005-6

Mealings, K., Miles, K., Tran, Y., Smith, T., & Buchholz, J. M. (2024). Listening and learning challenges for deaf or hard of hearing students during different classroom scenarios: An itinerant teachers of the deaf perspective. *Speech, Language and Hearing.* https://doi.org/10.1080/2050571X.2024.2372181

Murniarti, E., Prayitno, H., Wibowo, G. A., & Rochmah, E. Y. (2023). Implementing augmented reality in inclusive education: Experiments and potential. *International Journal of Science and Society, 5*(2), 50–63. http://ijsoc.goacademica.com

Olusanya, B. O., Davis, A. C., & Hoffman, H. J. (2019). Hearing loss grades and the International Classification of Functioning, Disability and Health. *Bulletin of the World Health Organization, 97*(10), 725–728. https://doi.org/10.2471/BLT.19.230367

Quintero, J., Baldiris, S., Rubira, R., Cerón, J., & Velez, G. (2019). Augmented reality in educational inclusion: A systematic review on the last decade. *Frontiers in Psychology, 10,* 1835. https://doi.org/10.3389/fpsyg.2019.01835

Richey, R. C., & Klein, J. D. (2007). *Design and development research: Methods, strategies, and issues.* Routledge.

Samaradivakara, Y., Pathirage, A., Ushan, T., Sasikumar, P., Karunanayaka, K., Keppitiyagama, C., & Nanayakkara, S. (2025). Tailored real-time AR captioning interface for enhancing learning experience of deaf and hard-of-hearing (DHH) students. http://arxiv.org/abs/2501.02233.

Tuli, N., Singh, G., Mantri, A., & Sharma, S. (2022). Augmented reality learning environment to aid engineering students in performing practical laboratory experiments in electronics engineering. *Smart Learning Environments, 9*(1), 1–17. https://doi.org/10.1186/s40561-022-00207-9

Ustun, A. B., Simsek, E., & Karaoglan-Yilmaz, F. G. (2022). The effects of AR-enhanced English language learning experience on students' attitudes, self-efficacy and motivation. *TechTrends, 66*(6), 798–809. https://doi.org/10.1007/s11528-022-00767-0

Wan Ali, W. N. A., & Wan Yahaya, W. A. J. (2022). Bridging Mayer's cognitive theory of multimedia learning and computational thinking in tackling the cognitive load issues among young digital natives: A conceptual framework. *Asean Journal of Teaching and Learning in Higher Education, 14*(2), 59–79. https://doi.org/10.17576/ajtlhe.1402.2022.05

Yusof, Y. M., Ayob, A., Md Saad, M. H., Affandi, H. M., & Hussain, A. (2020). Need analysis for the development of a microcontroller instructional module programming literacy. *Bulletin of Electrical Engineering and Informatics, 9*(2), 507–513. https://doi.org/10.11591/eei.v9i2.2077