Article

Development of New Distance Learning Platform to Create and Deliver Learning Content for Deaf Students

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Abstract: With the increasing transformation of using distance learning platforms in educational institutions, deaf student instructors in schools and universities have no specialized platform for remotely delivering learning content for deaf students with sign language translation videos. This study suggests a new asynchronous distance learning platform for deaf students with particular capabilities to assist deaf student instructors in developing and delivering educational materials over distance. Nineteen educational technology experts, seven instructors for deaf students, and sixteen undergraduate deaf students participated in this study to assess the proposed platform. Qualitative methods were used to collect data using online questionnaires. According to the findings, the suggested platform is suitable for distance learning when creating and delivering educational materials with sign language translation videos for deaf students. Deaf students could easily access and study the courses remotely with the help of the proposed platform.

Keywords: distance learning platform; deaf student instructors; distance education; learning content of deaf students

1. Introduction

The World Health Organization (WHO) estimated that there are presently more than 5% of people worldwide that need rehabilitation for their "disabling" hearing loss (432 million adults and 34 million children). Over 700 million people, i.e., one in ten people, are predicted to have a hearing loss that is incapacitating by the year 2050 [1]. Consequently, there would be a rise in the proportion of deaf students in educational institutions, especially in higher education. Currently, integrating digital learning tools into the teaching and learning process is one of the most preferred methods of educating deaf students. These tools would assist deaf student instructors in developing adequate learning content depending on visuals for deaf students. This requires the expansion of the use of ICT in schools and universities with deaf students. In this research, a deaf student means an undergraduate student who has hearing loss or cannot hear well anything related to learning.

Although studies addressing the use of ICT for deaf students are scarce [2], several previous studies showed that using some digital learning tools helps deaf students learn, such as distance learning environments [3], augmented reality technology [4,5], digital games [6], e-learning portals [7], and mobile learning apps [8]. Using distance learning with deaf students works on delivering multiple forms of learning content with sign language translations. In addition, it would overcome some deficiencies of traditional learning of deaf students in schools and universities, such as limited recognition and reading texts of learning contents, lack of professional sign language translators in classrooms, unavailability of out-of-class learning content as well as learning content repetition, and limit multi-visual learning styles for presenting learning content.

One of the most significant issues facing deaf student instructors in schools and universities in the era of digital learning is the need for new, specialized educational software that enables them to create and deliver deaf students' learning content remotely. However, there is currently a limitation in the developed platforms, namely lack of specialized features to enable deaf student instructors to create and administer their students' educational materials easily.

This study proposes a new, asynchronous distance learning platform tool named Distance Learning Platform for Deaf Students (abbreviated to DLPDS) to assist deaf student instructors in remotely developing and distributing interactive learning materials that are non-auditory with sign language videos for deaf students. We conducted a usability evaluation for the proposed platform over three qualitative experiments. The first experiment focused on educational technology expert review to assess the proposed platform's contributions in supporting deaf students' learning, help for deaf student instructors, the usefulness of the platform's functions for deaf students, and usability of the proposed platform. The second experiment focused on deaf student instructors reviewing the proposed platform to see whether it would aid in educating deaf students and satisfied their expectations for the teaching process. The third experiment focused on deaf students to gauge their opinions of the suggested DLPDS. Additionally, we received ideas for enhancements to the DLPDS's current edition. According to the usability evaluation findings, both educational technology experts and instructors of deaf students concurred that the proposed platform might assist deaf educators in providing well-established instructional materials. Additionally, the DLPDS was a pleasant tool for deaf students to learn material remotely.

This research aimed to develop an asynchronous distance learning platform suitable for deaf students and explore a usability evaluation of the proposed platform with educational technology experts and target users. This study focused on three research questions. RQ1: What are the perceptions of educational technology experts about the proposed platform? RQ2: What are the perceptions of deaf student instructors about the proposed platform? RQ3: What are the perceptions of deaf students about the proposed platform?

2. Development of the DLPDS

2.1. The DLPDS Platform Overview

The proposed platform covers all learning content of deaf students' courses. The primary users of this platform are deaf student instructors with an administrator mode and deaf students with a student mode in schools and universities. In the administrator mode, instructors can use nine graphical user interface tools of the proposed DLPDS and have full authority to administer the tools, as shown in Table 1 and Figure 1. The tools of the DLPDS are designed to facilitate adding learning content based on ready-made templates without the need for programing language skills from deaf student instructors. The deaf student mode provides the students with eight tools for displaying learning content and supporting good learning experiences for deaf students.

This study constructed the DLPDS using the CakePHP framework, HTML, CSS, and MySQL database. Edraw max and MS PowerPoint 365 were used to design platform graphics icons. In addition, to ensure the proper operation of the DLPDS without any technical issues, we previously tested all the tools in practice. The DLPDS was made available for operational usage as a web application on the IIS local server.

2.2. Pedagogical Background for DLPDS Design

We rely on multiple pedagogical principles when developing the suggested platform. First, we designed the tools for the proposed platform based on visual learning methodologies to deliver online learning content in multiple visual formats, including written texts, images, videos, and graphics. Deaf students must use their other senses for learning. Visual

learning tools are, therefore, essential for deaf students. They can learn and make notes while using a visual representation of the content.

Table 1. Deaf student instructor main tools of the DLPDS.

	Tool Name	Aim	Main Management Actions
1.	**Platform Users**	Provide a login system for the DLPDS to both deaf student instructors and deaf students.	✓ Create, edit, and delete for DLPDS user account. ✓ View for user accounts. ✓ Search for a user account. ✓ Login for the platform. ✓ Log out form the platform.
2.	**Lecture Creator**	Construct and publish the lectures/lessons contents in various educational domains with sign language videos for target deaf students.	✓ Create a new lecture, edit and add sign language video, and delete all lecture parts. ✓ Display for all lecture/lesson parts. ✓ Search in lectures/lessons by lecture domain.
3.	**Educational Graphics**	Construct visual educational graphics (such as infographics, mind maps, charts, posters, etc.) with sign language videos regarding the lecture/lesson contents.	✓ Create, edit, and delete educational graphics. ✓ Display educational graphic details with actual design size. ✓ Search in educational graphics by the domain name. ✓ Download the educational graphic file.
4.	**Educational Stories**	Construct visual educational stories contents (such as video stories, etc.) with sign language videos.	✓ Create, edit, and delete for educational story content. ✓ View educational story details with actual design size. ✓ Search in educational story library by the domain name. ✓ Download the educational story file.
5.	**Educational Inquiries**	Construct a reply with a sign language video to deaf students' educational inquiries.	✓ Create, edit, and delete educational inquiry content. ✓ View educational inquiry details. ✓ Search in educational inquiry library by title.
6.	**Visual Quizzes**	Construct visual quizzes (as an assignment or final quiz) with sign language videos for deaf students and receive their answers.	✓ Create, edit, and delete all quiz parts. ✓ start quiz.
7.	**Sign Language skills**	Create an online sign language skill with video to enhance deaf students' level in sign language.	✓ Create, edit, and delete for online sign language skill ✓ View sign language skill details
8.	**Performance Reports**	Generate reports for students' quiz scores and log activities.	✓ Generate report.
9.	**Support tool**	Create an online support case (such as how to use the platform, learning support, etc.) with a video for deaf students.	✓ Create, edit, and delete support cases. ✓ View support case.

Figure 1. Deaf student instructor mode user interface of the DLPDS.

Second, several elements from multimedia learning theory were implemented in the design of the suggested platform tools. These include the multimedia principle, which states that combining graphics with text can frequently communicate more effectively and efficiently than just text alone; the spatial contiguity principle, which states that text and graphics related to that text should be placed close together in instructional message designs; and the segmenting principle, which states that complex content can be made simpler by breaking it down into smaller parts [9]. As a result, the suggested platform helps deaf student instructors develop and deliver learning materials targeted explicitly at deaf students by the principles of multimedia learning theory.

Third, the design of platform tools combines visual learning content and the sign language translation video at the same pace because previous studies' results [10,11] confirmed that the combination of learning content and sign language videos in deaf students' learning was effective.

2.3. Development of Learning Content by Deaf Student Instructors

The development of learning content inside DLPDS consists of two rounds: the first round is that the deaf student instructors build learning content related to deaf students' courses but without a sign language video. The DLPDS features provide ready-made templates to instructors of deaf students, so they may create learning content without having to deal with programming challenges. They can also add multimedia elements for learning materials except for audio files.

Regarding creating a sign language video, the second round assumes three cases of creation of sign language translation videos for learning contents in the proposed DLPDS, as shown in Figure 2: In the first case, the deaf student instructors who have sign language skills can make a translation and explanation of the sign language video for learning content. In the second case, they can co-operate with a sign language translator in translating learning content. In the third case, they can adopt start-up artificial intelligence (AI) applications of sign language in translating learning content to make sign language translations, such as the Hand Talk and Virtual Sign apps. The sign language videos can be captured by the camera app and screen recording software and then uploaded into the

DLPDS tools. Figure 3 shows the main steps for deaf student instructors to create learning content in the proposed DLPDS as pertains to five core tools: lectures, educational graphics, educational stories, educational inquiries, and visual quizzes.
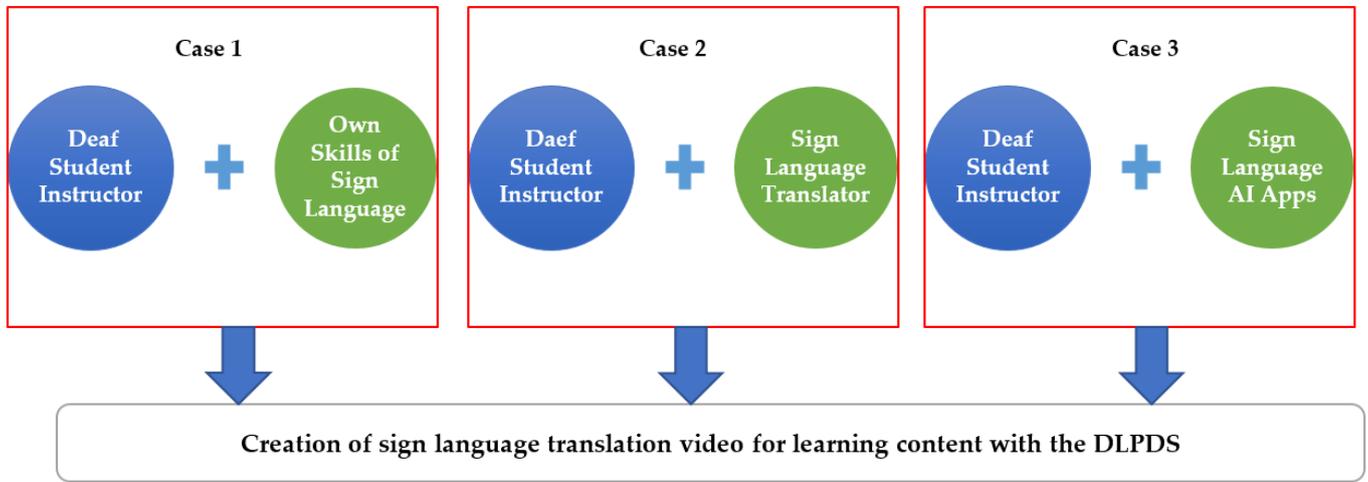

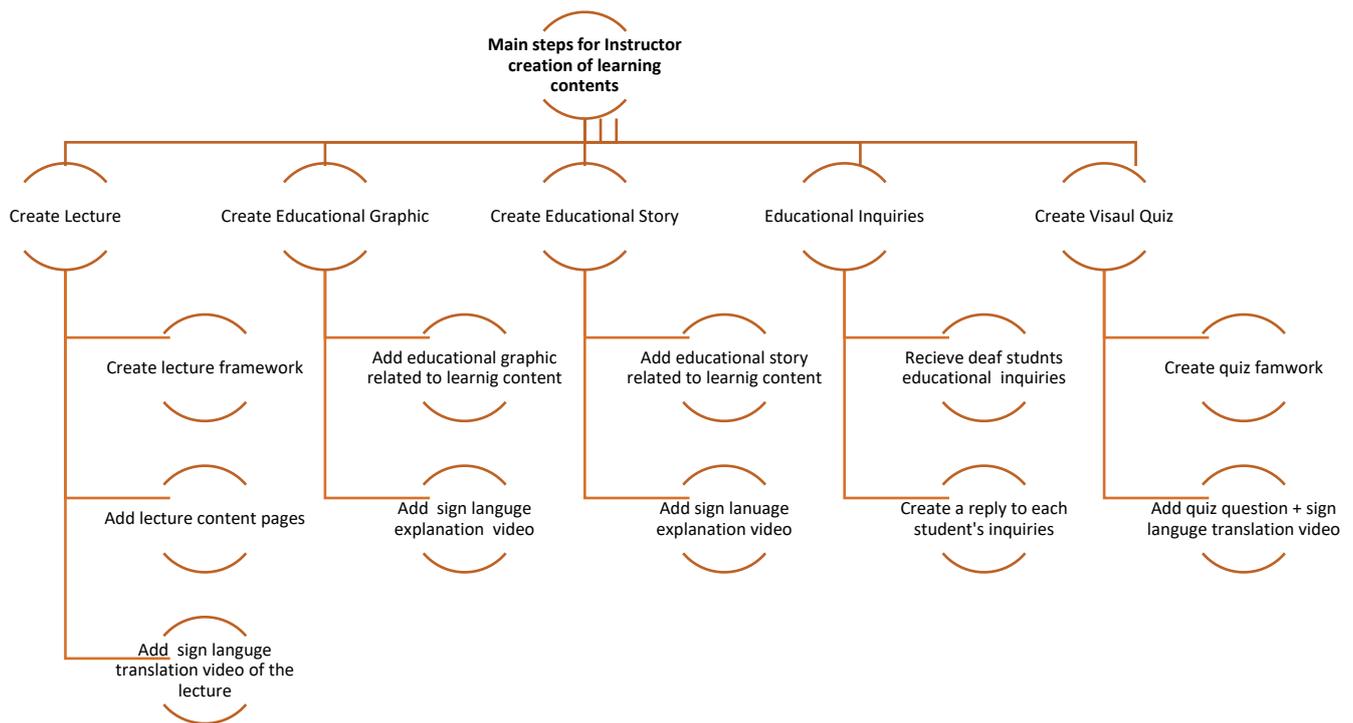**Figure 2.** Creation cases of sign language translation video for learning content with DLPDS.

Figure 3. Main steps for deaf student instructor creation of learning content in the DLPDS.

2.4. Deaf Students' Main Learning Process with the DLPDS

Figure 4 illustrates the typical learning process of deaf students with the proposed DLPDS. First, after access to the platform, deaf students learn the lectures' contents plus content explanations with sign language videos throughout the lecture tool. Then, they display and practice the educational graphics related to learning content with sign language videos throughout the educational graphics tool. Next, they display and practice the educational stories related to learning content with sign language videos. Then, they send educational inquiries with sign language videos to instructors if wanted and receive responses through

the inquiries tool. Finally, they conduct quizzes translated with sign language videos to obtain feedback about their performance during their learning with the DLPDS.
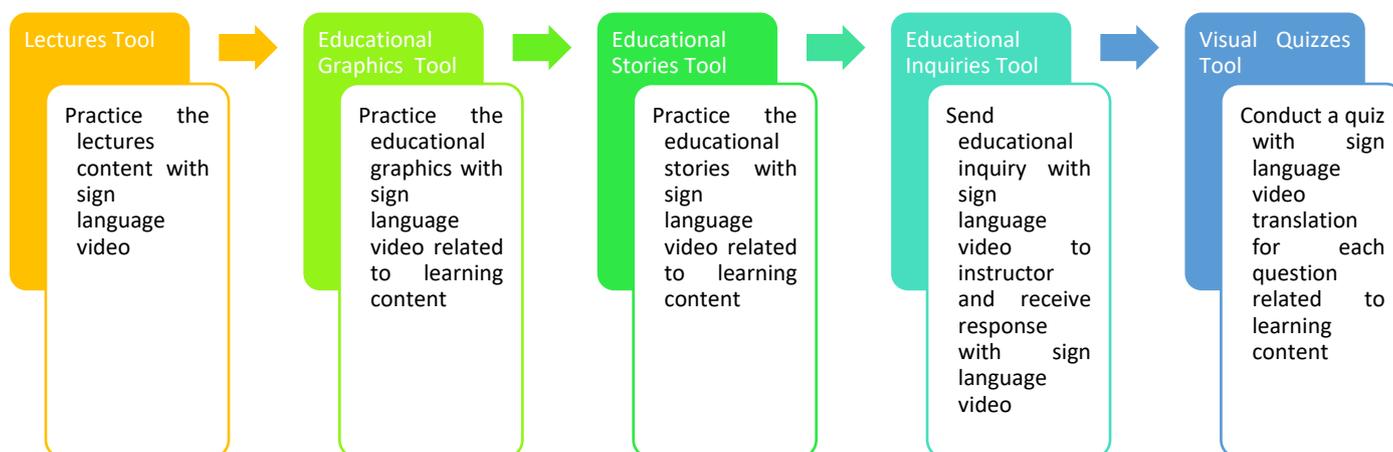
Lectures Tool	Educational Graphics Tool	Educational Stories Tool	Educational Inquiries Tool	Visual Quizzes Tool
Practice the lectures content with sign language video	Practice the educational graphics with sign language video related to learning content	Practice the educational stories with sign language video related to learning content	Send educational inquiry with sign language video to instructor and receive response with sign language video	Conduct a quiz with sign language video translation for each question related to learning content

Figure 4. Main learning process activities for a deaf student in the DLSDS.

2.5. Importance of the DLPDS for Deaf Students and Deaf Student Instructors

The proposed DLPDS offers extra advantages for deaf student instructors and end-user deaf students based on the present usability evaluation method of the proposed platform and the features of the function tools. The current version of the DLPDS is important for deaf student instructors, deaf students, and educational institutions for the following reasons: For deaf student instructors, the DLPDS offers adapted, specialized ICT solutions for asynchronous distance learning for deaf students. It enables them to display a variety of visual representations of instructional materials that are non-auditory, including lectures, educational stories, and educational graphics. It allows deaf student instructors to create an appropriate electronic assessment for deaf students. For deaf students, the DLPDS provides sign language videos with educational material to assist deaf students in overcoming their reading challenges. It allows remote learning resources for deaf students, particularly during crises. It helps deaf students apply self-learning. It provides multiple repetitions of the learning materials for deaf students anywhere and anytime. It may be utilized in educational institutions to implement blended learning in addition to remote learning, smart classroom teaching, and flipped learning for deaf students.

2.6. Difference between the DLPDS and Existing Distance Learning Platforms

Even though there are several distance learning platforms (DLPs) available today, such as Moodle, Blackboard, Microsoft Teams, and others; we created a new, asynchronous DLP specifically for deaf students. In comparison with other existing DLPs, the developed DLPDS includes some special features and a graphical user interface suitable for deaf students. Existing DLPs' general design does not include specialized tools related to deaf students learning and characteristics because they are designed for hearing students and only not for deaf students; our DLPDS contains new features and functional tools such as the educational inquiries tool that enables deaf students to submit educational inquiries to the instructor with a sign language translation video and view replies to all students as well as the visual quizzes tool enabling deaf students to take quizzes easily with a sign language translation video for each question. Moreover, the DLPDS has specialized visual representation learning content tools (lecture tool, educational graphics tool, and educational stories tool) for presenting multiple forms of learning content with sign language translations videos for deaf students. Although both DLPs and the DLPDS include tools for creating learning content for courses, the learning content tools are divided to include a lecture tool, educational graphics tool, and educational stories tool in the DLPDS, which has an entire design with different user interfaces and ways of presenting

learning material with sign language videos. The DLPDS also provides a new learning tool that enables deaf student instructors to add and update lifelong learning material in sign language to enhance deaf students' skills during use of the platform. Existing DLPs have several tools such as online communication tools (live chat, and video conference), that the DLPDS does not include. Nonetheless, we created the DLPDS to offer a simple platform for deaf student instructors to create and distribute instructional content more suitably for deaf students.

3. Platform Usability Evaluation

An asynchronous distance learning platform tool suitable for deaf students was developed in this study. The main objective of this research is to explore educational technology experts', deaf student instructors', and deaf students' perceptions of the proposed platform as part of the DLPDS usability evaluation as well as to detect any usability issues with the developed platform. To answer the RQs, three experiments were conducted involving 19 educational technology experts, 7 deaf student instructors, and 16 undergraduate deaf students. The same version of the proposed platform was used in the three experiments. Three qualitative data collection instruments were designed especially for this study and were guided by recent studies on supportive ICT tools for instructors and system development [12–14]. The first was an online questionnaire with educational technology experts. This consisted of demographic questions and 22 positive, five-point Likert scale, closed-ended questions about a review of the value of the DLPDS in supporting the learning of deaf students, help for deaf student instructors, use of the platform functions for deaf students, and the easy-to-use nature of the proposed platform. It included one open-ended question to collect educational technology experts' feedback on the proposed DLPDS. The second instrument was an online questionnaire with deaf student instructors. This consisted of demographic questions and seven positive, five-point Likert scale, closed-ended questions about the review of the proposed DLPDS. It included one open-ended question to collect deaf student instructors' feedback on the proposed DLPDS. The third instrument was an online questionnaire for deaf students. This consisted of demographic questions and five positive, five-point Likert scale, closed-ended questions about the review of the proposed DLPDS. It included one open-ended question to collect deaf students' feedback on the proposed DLPDS.

For the analysis procedure, we used descriptive statistics, including mean and standard deviation for closed-ended questions and feedback analyses for open-ended questions comments. Ethics consent was obtained from all participants of the study as volunteers (written consent from both educational technology experts and deaf student instructors and oral consent from deaf students), and a written consent from the dean of faculty was obtained to conduct the research experiments with participants (deaf student instructors and deaf students). The following are details about the three experiments.

3.1. First Experiment with Educational Technology Experts

3.1.1. Participants

Nineteen educational technology specialists from South Valley University in Egypt, ranging in age from 24 to 47 (mean = 31.11, SD = 5.51), were the participants in this experiment. They have between 1 and 25 years of experience in the field of educational technology (mean = 8.26, SD = 6.38). Thirteen of them were faculty in the educational technology department at the same university: an assistant professor (2), an assistant lecturer (6), and a demonstrator (5). The remaining were researchers in the educational technology domain. On 12 March 2022, seventeen were given a training session with the proposed DLPDS, and two received that training on 29 March.

3.1.2. Procedure

They used a computer lab at their university to carry out the experiment training with the version of the suggested platform. Before the training, we provided user accounts

platform modes and the electronic DLPDS guide. They first used a web browser to access the platform and then received training from one researcher on using the created tools. They answered an online questionnaire for educational technology experts after their training session.

3.1.3. Instrument

For this experiment, the online questionnaire for educational technology experts was designed to achieve expert review. This questionnaire aimed to evaluate the proposed DLPDS in terms of the value of the DLPDS in supporting the learning of deaf students, help for deaf student instructors, use of the platform functions for deaf students, and the easy-to-use nature of the proposed platform. It contained six sections, including 22 closed-ended questions formulated in positive design with a five-point Likert scale and one open-ended question to gather educational technology experts' suggestions and comments on the proposed DLPDS.

The following is the detail of each section. Section 1: Demographic information for educational technology experts; Section 2: Four closed-ended questions to identify the value of the suggested platform in assisting deaf students' learning; Section 3: Four closed-ended questions to confirm whether the proposed platform was helpful for deaf student instructors in schools and universities; Section 4: Eight closed-ended questions to evaluate whether each proposed function was useful for deaf students learning process; Section 5: Six closed-ended questions to detect the easy-to-use nature of the proposed platform; Section 6: One open-ended question related to educational technology experts' comments on the proposed platform.

3.1.4. Results and Discussion

The questionnaire's descriptive statistics results of the educational technology experts' perceptions towards the proposed DLPDS are presented in Table 2 and Figure 5. From questions 1–4 in Section 2, around 96% (strongly agree and agree) of the participants believed that the proposed DLPDS would support the learning of deaf students, with the overall mean = 4.75. From questions 5–8 in Section 3, around 97% (strongly agree and agree) of the participants agreed that the proposed DLPDS would be helpful for deaf student instructors, with the overall mean = 4.70. From questions 9–16 in Section 4, around 99% (strongly agree and agree) of the participants confirmed that the proposed DLPDS function tools were useful and suitable for deaf students, with the overall mean = 4.80, and around 92 % (strongly agree and agree) of them pointed out that the DLPDS was easy to use in Section 5 with the overall mean = 4.68. In addition, 100% of the participants had an entirely positive attitude (strongly agree and agree) regarding Q3, Q4, Q6, Q7, Q9, Q10, Q12, Q13, Q15, and Q16. Around 89% of the participants had a less positive attitude regarding Q2, Q17, Q18, and Q19. Based on the results, the general approval indicated that around 96% of all participants had a positive attitude (strongly agreed) toward the proposed DLPDS, with the overall mean = 4.73.

In Section 6, 11 of the 19 respondents (57.9%) answered the open-ended question on educational technology experts' comments towards the proposed platform DLPDS. The qualitative data coding (inductive coding) method was used to analyze the open-ended question. This analysis aimed to detect educational technology experts' positive attitudes toward DLPDS, the features that need to be improved, and new suggested features of the proposed platform DLPDS. The coding of analyses experts' responses included four categories (entirely positive comments towards the proposed DLPDS, positive comments towards the proposed DLPDS with improvement, suggestions for improving current features of the proposed DLPDS, suggestions for adding a new feature to the proposed DLPDS).

Table 2. Educational technology experts' perceptions of the proposed DLPDS (N = 19).

Questions Items	SA	A	N	D	SD	Mean	Standard Deviation
Section 2: Platform Value to Support Learning of Deaf Students							
1. The DLPDS is considered a new teaching aid suitable for supporting the learning of deaf students remotely.	18	0	1	0	0	4.89	0.46
2. The DLPDS is suitable for constructing e-content for all courses for deaf students.	14	3	2	0	0	4.63	0.68
3. Using such a platform would facilitate the learning of deaf students remotely.	17	2	0	0	0	4.89	0.32
4. The feature of platform functions is adequate for the learning of deaf students.	11	8	0	0	0	4.58	0.51
Overall Mean						4.75	
Section 3: Platform Helpful for Deaf Student Instructors							
5. Using such a platform would assist deaf student instructors in establishing diverse visual learning content for deaf students.	14	4	1	0	0	4.68	0.58
6. The proposed platform would help the deaf student instructors in teaching the content to deaf students remotely.	11	8	0	0	0	4.58	0.51
7. Using such a platform would assist deaf student instructors in creating and publishing the learning content for deaf students without web programming difficulties.	14	5	0	0	0	4.74	0.45
8. Using such a platform would assist deaf student instructors in delivering sign language visual responses remotely for deaf students' inquiries.	16	2	1	0	0	4.79	0.54
Overall Mean						4.70	
Section 4: Usefulness of Platform Tools for Deaf Students							
9. The tool "Lecture Creator" is useful in creating and publishing the lectures/lessons contents in various educational domains with sign language videos for deaf students.	15	4	0	0	0	4.79	0.42
10. The tool "Educational Graphics" is useful in creating and publishing visual educational Graphics (such as infographics, mind maps, etc.) with sign language videos for deaf students.	17	2	0	0	0	4.89	0.32
11. The tool "Educational Stories" is useful in creating and publishing visual educational Stories contents (such as video stories, etc.) with sign language videos for deaf students.	15	3	1	0	0	4.74	0.56
12. The tool "Educational Inquiries" is useful in creating and publishing replies with sign language videos to deaf students' educational inquiries.	17	2	0	0	0	4.89	0.32

Table 2. *Cont.*

Questions Items	SA	A	N	D	SD	Mean	Standard Deviation
13. The tool "Visual Quizzes" is useful in creating and publishing a quiz with a sign language video for deaf students and receiving their answers.	15	4	0	0	0	4.79	0.42
14. The tool "Sign Language Skill" is useful in creating and publishing sign language skills with video via the internet to enhance deaf students' level in sign language.	16	2	1	0	0	4.79	0.54
15. The tool "Performance Reports" is useful in generating reports for deaf students' quiz scores and log activities.	13	6	0	0	0	4.68	0.48
16. The tool "Support" is useful in creating and publishing support cases via the internet (such as how to use the platform, learning support, etc.) with videos for deaf students.	16	3	0	0	0	4.84	0.37
Overall Mean						4.80	
Section 5: Easy-to-use Nature of the Proposed Platform							
17. The proposed DLPDS platform has an acceptable design interface.	15	2	2	0	0	4.68	0.67
18. Interaction with the DLPDS is clear and understandable.	16	1	2	0	0	4.74	0.65
19. One can learn to use the proposed platform quickly without difficulties after a short-term training.	16	1	2	0	0	4.74	0.65
20. The DLPDS functions work very well without technical problems.	12	6	1	0	0	4.58	0.61
21. The DLPDS helps users in overcoming errors while constructing learning content.	13	5	0	1	0	4.58	0.77
22. The proposed platform DLPDS is easy to use.	16	2	1	0	0	4.79	0.54
Overall Mean,						4.68	

Note: SA (5), strongly agree; A (4), agree; N (3), neutral; D (2), disagree; SD (1), strongly disagree.

Based on the analysis, the results refer to two experts from the total sample (10.5%) who positively commented on the proposed DLPDS. One of the experts said, "Really, really, really great effort", and another expert stated, "Excellent environment". In addition, one expert from the total sample (5.3%) gave positive comments with the following improvement suggestion: "A wonderful and distinguished effort, but it would be better to consider adjusting the method of adding questions and their answers, making sure that all the buttons are translated into the Arabic version, ensuring that the searched data is extracted within the excel file, and adjusting the printing process without the print screen function."
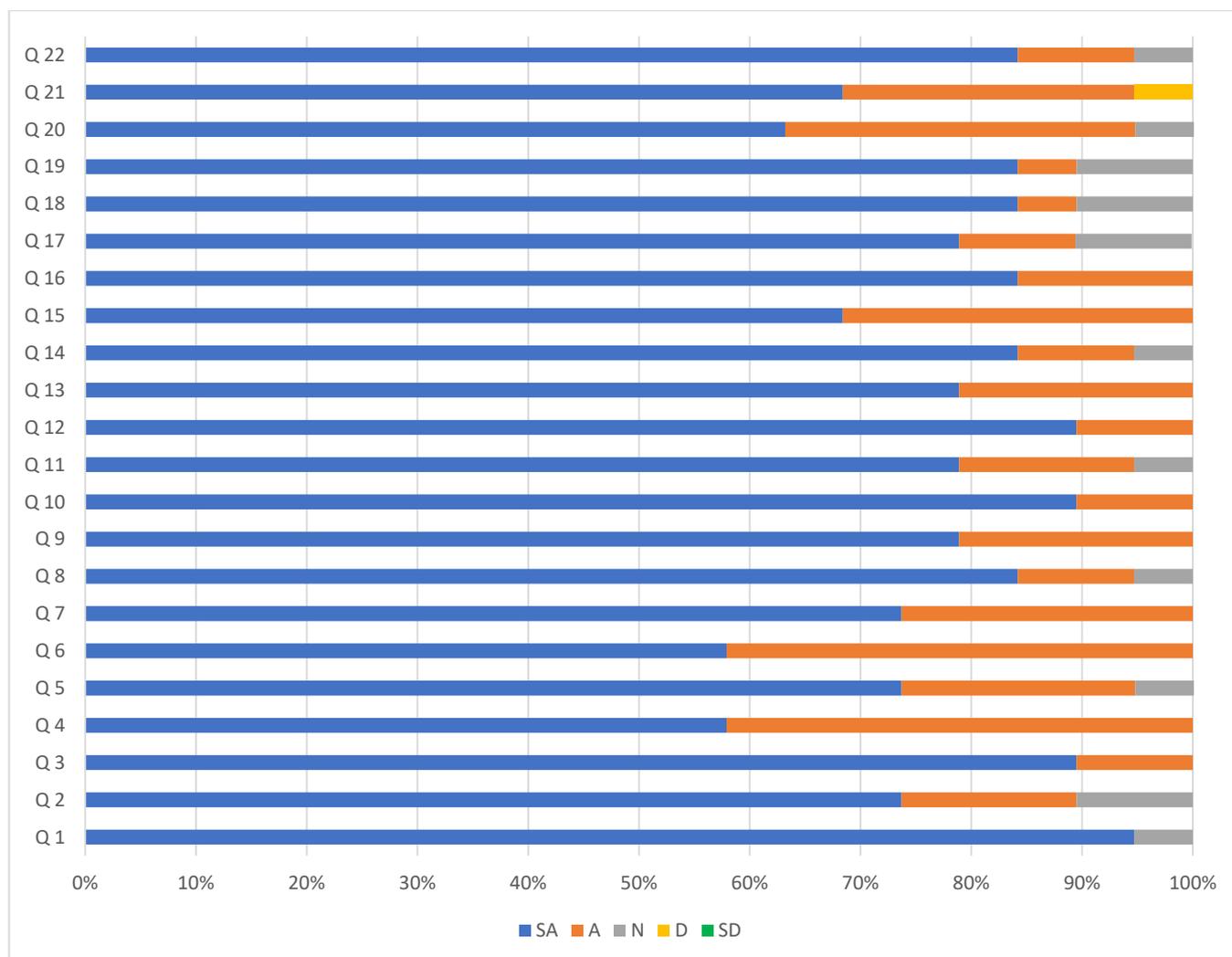
Figure 5. The result of the educational technology experts' questionnaire.

Moreover, six experts out of the total sample (31.6%) suggested improvising some current features of the proposed DLPDS, and their responses were as follows:

- "Adding the feature to enlarge the image in full screen so that the student can control it better";
- "Adding FAQs in the support list—adding other types of questions—specifying a true and false mark each one in a line";
- "In the part about creating a test, if possible, you need to modify in terms of doing all the steps of creating the question in one stage to prevent distraction";
- "Adding color to new unanswered inquiries, Inflexibility of setting choices for answering questions, A time and date for test delivery should be added to adjust the learning and assessment process, Adding the possibility of skipping the question and returning to it again to think about it";
- "Making a video guide for dealing with the platform for the deaf students, adding a list of students in one excel file, Closing the search in lectures for different levels, adding a search to the lecture title, Creating an Arabic guide to deal with the platform, Explanation of the extensions available for adding files, Adding a picture in response to inquiries";
- "The platform needs to translate texts written for deaf students into sign language, the report should be more accurate to include the time the learner was active on the environment and should not be limited to login data".

Lastly, two experts out of the total sample (10.5%) suggested adding some new features to the proposed DLPD as follows:

- "Adding other features to the platform, such as Gamification, to entice students and attract them towards learning";
- "Adding an announcement function to notify the new events at both the students and instructor modes."

3.2. Second Experiment with Deaf Student Instructors

3.2.1. Participants

The testing participants were seven university deaf student instructors between 26 and 50 years of age (mean = 35.43, SD = 9.88). All of them were faculty from the department of art education (1) and home economics (6) from South Valley University, Egypt. They have teaching experience from 3 to 27 years (mean = 13.43, SD = 10.42). The academic rank of participations were associate professors (3), assistant lecturers (3), and demonstrators (1) in the same university. They were assigned one training session with the proposed DLPDS on 17 April 2022.

3.2.2. Procedure

The process was very similar to the evaluation performed by the educational technology experts. Additionally, they answered a questionnaire posted online for deaf student instructors.

3.2.3. Instrument

The questionnaire for deaf student instructors aimed to evaluate the instructor's perceptions of the proposed DLPDS. It contained three sections: the first section was about demographic information for instructors of deaf students; the second one included seven closed-ended questions formulated in a positive design with a five-point Likert scale (5: strongly agree, 4: agree, 3: neutral, 2: disagree, 1: strongly disagree); the last one was a one open-ended question to gather deaf student instructors' suggestion and comments.

3.2.4. Results and Discussion

The perspectives of the deaf student instructors on the proposed DLPDS are shown in Table 3 and Figure 6. The mean score for questions Q1 and Q2 was 4.43, indicating that deaf student instructors agreed that the proposed DLPDS would enable deaf students to learn remotely and help them be taught more effectively. With this proposed platform (DLPDS), they want to teach upcoming courses to deaf students. This is evident from the mean value for Q3 of 4.29. The participants clearly concurred that the suggested DLPDS is a beneficial tool for creating and delivering the learning content with sign language videos to deaf students, as shown by the mean of Q4 of 4.71. The mean score for Q5 was 4.43, illustrating that creating learning content in the proposed platform is easy. The DLPDS would assist instructors of deaf students in creating a variety of visual learning materials for deaf students. The mean for Q6 was 4.57, which makes this apparent. The suggested DLPDS is suitable for creating and delivering e-content for multiple courses for deaf students, as demonstrated by the average score of 4.29 for Q7. Furthermore, 100% of the participants had a completely positive attitude (strongly agree and agree) regarding Q3 to Q7. Around 86% of the participants had a less positive attitude regarding Q1 and Q2. According to the questionnaire results, around 96% of all deaf student instructors had favorable opinions regarding implementing the proposed DLPDS in the teaching process with deaf students. The total mean, which is 4.45, shows that participants generally approved.

Table 3. Deaf student instructors' perceptions regarding the proposed DLPDS (N = 7).

Questions Items		SA	A	N	D	SD	Mean	Standard Deviation
1.	The proposed platform would facilitate the learning of deaf students remotely.	4	2	1	0	0	4.43	0.79
2.	The proposed platform would contribute to better teaching deaf students.	4	2	1	0	0	4.43	0.79
3.	I would like to teach upcoming courses to deaf students with this proposed platform (DLPDS).	2	5	0	0	0	4.29	0.49
4.	The proposed platform is considered a useful tool for creating and delivering learning content with sign language videos to deaf students.	5	2	0	0	0	4.71	0.49
5.	Constructing learning content in the proposed platform is easy.	3	4	0	0	0	4.43	0.53
6.	The DLPDS would help construct diverse visual forms of learning content for deaf students.	4	3	0	0	0	4.57	0.53
7.	The DLPDS is suitable for constructing e-content for all courses for deaf students.	2	5	0	0	0	4.29	0.49
	Overall Mean						4.45	

Note: SA (5), strongly agree; A (4), agree; N (3), neutral; D (2), disagree; SD (1), strongly disagree.
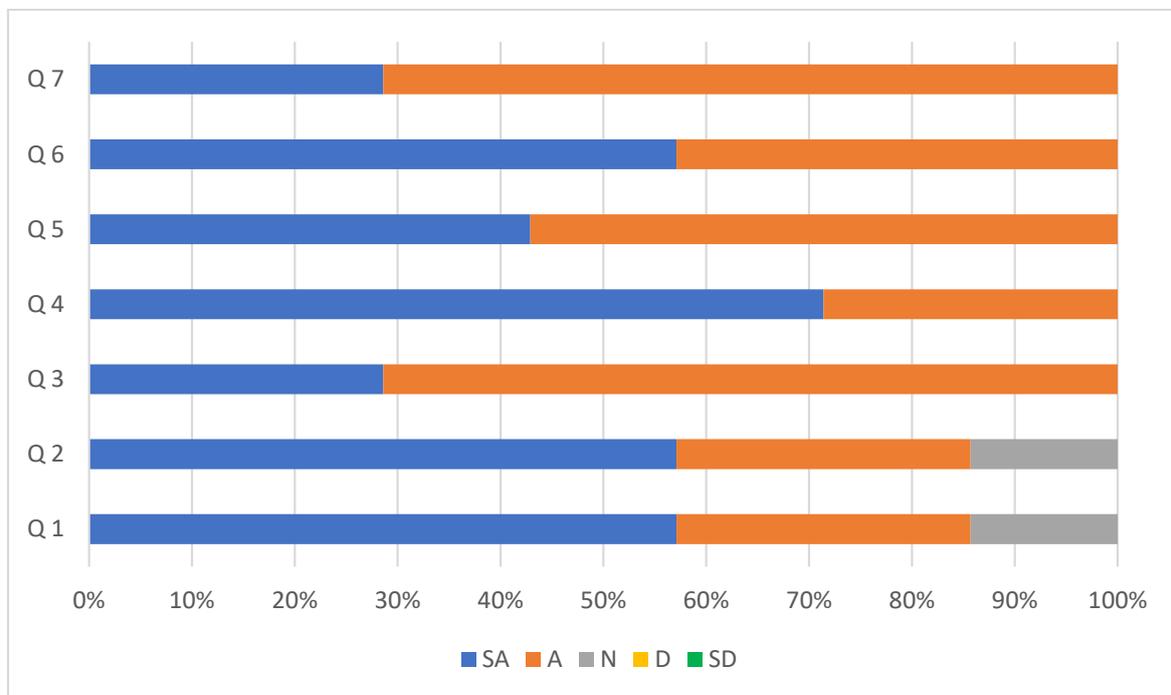

Figure 6. The result of the deaf student instructors' questionnaire.

Question 8: Four of the seven deaf student instructors (57.1%) answered the open-ended question related to general comments and suggestions for the current version of

the proposed DLPDS. The qualitative data coding (inductive coding) method was used to analyze the open-ended question. This analysis aimed to detect deaf student instructors' positive attitudes toward DLPDS and the features that need to be improved in the proposed platform DLPDS. The coding of deaf student instructors included two categories (positive comments towards the proposed DLPDS and suggestions for improving current features of the proposed DLPDS). Based on the analysis, the results refer to one deaf student instructor from the total sample (14.3%) who commented positively towards the proposed DLPDS. The deaf student instructor said, "good job", and three deaf student instructors out of the total sample (42.9%) suggested improving some current features of the proposed DLPDS, and their responses were as follows:

- "There are several things that must be taken into consideration (1) On the instructor's page regarding creating tests, when the question type is a multiple choice, it is preferable to put the question, choose the answer items, and specify the correct answer and score in one step to shorten the time. (2) On the student's page when browsing the topics, it is preferable for the student to appear next to each topic all the activities that were uploaded by the instructor, whether content, video, story, or questions in the form of icons, and the student reviews one of them by simply clicking on it. (3) The platform is excellent and suitable for normal students and deaf students. (4) It is preferable to facilitate the instructor regarding the translation of content and activities in sign language because not all instructors can do so, so it is preferable to add some translation programs based on artificial intelligence available so that the program performs the translation process, and the instructor has to submit it to the student";

- "To be divided into courses so that the student sees everything related to the course specified in front of him on one page.—When the instructor answers the students' inquiries, the instructor mode should directly show the videos of the students' questions so that he can answer them.—And to activate color notifications, for example, for questions that have not been answered";

- "Please change the name of the content to lectures and practical lessons instead of lectures only so that students can know that the platform includes all content and not only the theoretical side. Please add a notice or alert when receiving an inquiry about the subject I am teaching from students. Please mark the questions that have been answered so that the responses are not repeated. Please categorize inquiries according to a subject so as not to be confused... and for that, it is easy to find and respond to my inquiry. Please divide the lectures and practical lessons according to the subjects so that it is easier for the student to find the subject he wants to access easily without wasting time."

3.3. Third Experiment with Deaf Students

3.3.1. Participants

The participants of this experiment were sixteen undergraduate deaf students (11 males and 5 females) who ranged from the first to fourth grade of the faculty of specific education at South Valley University, Egypt. They majored in art education (12) and home economics (4). They ranged in age from 20 to 26 (mean = 22.81, SD = 2.10). They were assigned one training session with the proposed DLPDS on 18 April 2022.

3.3.2. Procedure

They utilized a computer lab at their institution to conduct the experiment training using the Arabic version of the suggested platform. Before the session, we gave each participant a user account for the deaf student mode. First, they used a web browser to access the platform. Next, they received one training session from one researcher on how to use the produced tools and display some learning content examples. They answered an online questionnaire for deaf students after their training session. As facilitators for this

experiment, two volunteer Arabic sign language translators took part in interpreting the training session and questionnaire questions for deaf students.

3.3.3. Instrument

The questionnaire for deaf students was aimed to evaluate the deaf students' perceptions of the proposed DLPDS. It contained two sections: the first one is about demographic information for the participating deaf students; the second one included six questions, namely five closed-ended questions formulated in positive design with a five-point Likert scale (5: strongly agree, 4: agree, 3: neutral, 2: disagree, 1: strongly disagree) and one open-ended question to gather any deaf students' suggestions and comments if possible.

3.3.4. Results and Discussion

Table 4 and Figure 7 illustrate the deaf students' perceptions regarding the proposed DLPDS. The mean score for question item Q1 was 4.69, indicating that deaf students agreed that the proposed DLPDS would be useful for learning the content of courses remotely. The participants confirmed that the DLPDS would help them learn better and provide several visual forms for learning content with sign language videos. This is evident from the mean for Q2 and Q4 of 4.94. They would like to learn all courses with this proposed platform (DLPDS). This is evident from the mean value for Q3 of 5. The participants concurred that the proposed platform is easy to use, as shown by the mean of Q5 of 4.56. Moreover, 100% of the participants had an utterly positive attitude (strongly agree and agree) regarding Q2 to Q4. Around 88% of the participants had a less positive attitude toward the easy-to-use nature of the platform in Q5. According to the questionnaire results, around 96% of all deaf students generally agreed that the proposed DLPDS is an acceptable distance learning tool, with the overall mean of 4.83.

Table 4. Deaf students' perceptions of the proposed DLPDS. (N = 16).

Questions Items	SA	A	N	D	SD	Mean	Standard Deviation
1. The proposed platform would be useful for learning the content of courses remotely.	14	1	0	0	1	4.69	1.01
2. The proposed platform would help me in learning better.	15	1	0	0	0	4.94	0.25
3. I would like to learn all courses with the proposed platform.	16	0	0	0	0	5	0.00
4. The proposed platform would provide several visual forms for learning content with sign language videos.	15	1	0	0	0	4.94	0.25
5. The proposed platform is easy to use.	11	3	2	0	0	4.56	0.73
Overall Mean						4.83	

Note: SA (5), strongly agree; A (4), agree; N (3), neutral; D (2), disagree; SD (1), strongly disagree.

3.4. General Discussion for All Evaluation Experiments Results

Generally, the results show that around 96% of overall educational technology experts who participated in the study confirmed that the proposed DLPDS can be considered an acceptable learning environment for deaf students, including assisting deaf students' learning, being helpful for deaf student instructors, providing suitable tools for deaf students, and being easy to use. Around 96% of all the deaf student instructors agreed that the proposed DLPDS can be relied on for teaching deaf students, and around 96% of all deaf students agreed that the proposed DLPDS as a distance learning tool would enable deaf students to learn remotely. However, based on the analysis results of open-ended

questions feedback, six educational technology experts and three deaf student instructors introduced completely improvement-related feedback for the proposed DLPDS regarding some practical issues of the proposed function, such as the lecture creator tool, educational inquiries tool, visual quizzes tool, and general user interface design. The results also include the comments of two educational technology experts who suggested adding new features to the suggested platform, such as a gamification tool and notification alerts for new events for both the deaf student instructor mode and the deaf student mode.
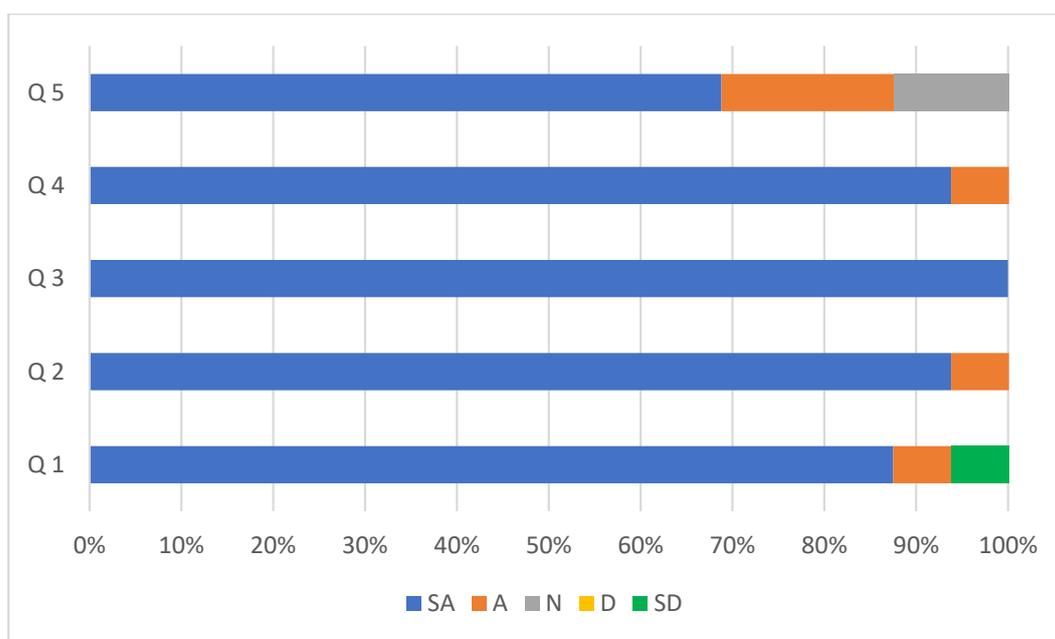
Figure 7. The result of the deaf students' questionnaire.

Some previous studies have already focused on delivering learning content to deaf students remotely, such as [15], which presented a pedagogical model to deliver inclusive educational materials in a MOOC with Portuguese Sign Language based on the VirtualSign technology automatic translation for deaf students, and [16], which introduced a web-based e-learning platform that teaches deaf children to learn and write letters and numbers. Moreover, [17] presented a bilingual virtual learning platform for Brazilian deaf students. Furthermore, [18] adapted LMS Moodle for mathematics learning for deaf Jordanian pupils. Compared with this literature, the primary distinction of our proposed platform is the presence of a distance learning platform that supports deaf student instructors in creating and delivering learning materials for deaf students with sign language videos. The proposed platform considers a general framework that consists of several tools developed specifically for teaching deaf students and can be used by any deaf student instructor. For deaf students, these tools improve the number of different ways that learning knowledge is represented visually, including the lecture creator, educational graphics, educational stories as well as educational inquiries, and visual quizzes.

Some literature is limited to automated translation from one written language to sign language, such as [15]. On the other hand, our proposed platform is more flexible for sign language translation because it accepts uploading independent sign language videos not only for written text but also other forms of learning content translated by deaf student instructors or sign language translators and from any AI technology specialized in sign language translation. This feature increases the generality of our suggested platform.

4. Conclusions

In this study, we developed a new distance learning platform for enabling deaf student instructors to create and deliver asynchronous learning content with sign language videos

for deaf students. The main features of the developed platform include creating lectures, educational graphics, educational stories, educational inquiries, and visual quizzes. The DLPDS was evaluated through qualitative usability evaluation, including three online questionnaires for exploring educational technology experts', deaf student instructors', and deaf students' perceptions of the proposed platform to detect any usability issues with the developed platform. Nineteen experts in educational technology, seven university deaf student instructors, and sixteen undergraduate deaf students participated in the study. The participants were trained with the same version of the proposed platform that we developed. Descriptive statistics and analysis were used in this study. For the RQ1, the result confirmed that the educational technology experts generally affirmed the created DLPDS. For the RQ2, the results also showed that the deaf student instructors had a positive attitude towards the platform as an ICT solution for teaching deaf students. For the RQ3, the results also confirmed that the established DLPDS is an acceptable learning environment to apply with undergraduate deaf students. However, the results of the feedback analysis of open-ended questions regarding educational technology experts and deaf student instructors showed some features that need to be improved regarding the lecture creator tool, educational inquiries tool, visual quizzes tool, and general user interface design. The proposed DLPDS will be updated based on usability evaluation results, especially regarding improvements to some platform features. The impact of the updated version of the proposed platform will be tested practically in enhancing the learning outcomes of undergraduate deaf students in multiple courses.

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