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Designing E-Courses for Hearing Impaired Students: Practices and Challenges

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Abstract

The paper deals with the problem of designing educational e-courses for teaching deaf and hard-of-hearing students taking into consideration their special educational needs. The paper presents the practices of online learning for such students at Kalashnikov Izhevsk State Technical University.
The paper is aimed at publishing the results of research related to designing electronic courses for deaf and hearing impaired students, including adaptation of the videos, the use of an e-dictionary of terms, graphic and text materials illustrated by e-courses on Descriptive geometry and English language taught at Kalashnikov ISTU.
The study was conducted at the Centre for inclusive education at Kalashnikov Izhevsk State Technical University, the experiments involved 11-19 hearing-impaired students majoring in Mechanical Engineering. The students were asked to participate in a series of experiments involving the use of video materials, different graphic forms of information presentation and an electronic terms dictionary. The participants were asked to answer test questions about presented material, fill in questionnaires and discuss the experiment.
As a result of our study, the following typical structure of an e-course units was proposed: each unit starts with the introduction of an e-vocabulary of terms (in Russian sign language), followed by a test for comprehension of the presented terms, then presents the theoretical material in the form of video lectures with subtitles, lecture notes, activity book, step-by-step instructions to perform tasks and additional materials.

Keywords: distance technologies, e-learning course, teaching students with hearing impairments

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Introduction

The problem of designing educational online courses for teaching deaf and hard-of-hearing students is of great current interest for researchers and educationalists working in the field of inclusive education. According to a survey conducted at the Kalashnikov Izhevsk State Technical University, only 3% of the students with hearing impairments surveyed took any online courses other than university courses. This is much less than the number of students without hearing impairments (52%) (Krasavina, Ponomarenko, Zhujkova & Serebryakova, 2019). A big difference was also found in watching educational videos, subscribing to educational resources, and participating in online webinars. In Russia, students with hearing impairments cannot fully use the educational potential of the Internet due to the lack or the inconsistency of educational resources with their special needs in information perception.

Indeed, providing online learning for deaf and hearing-impaired students in Russia faces many challenges related to specific physical, psychological and cognitive features in their learning profile. This paper addresses three main problems: students' inability to perceive information in audio format, their slow and limited perception and deficiencies of mental activity, and their limited ability to work independently.

Purpose and objectives of the study

Thus, the paper is aimed at publishing the results of research related to designing e-courses for deaf and hearing impaired students, focusing on three main challenges: (1) effective replacement of audio information with its visual representation; (2) adaptation of online educational materials to deaf students' specific cognitive processes and (3) encouraging their self-study and educational initiatives.

Literature review

In spite of rapid development of online learning and growing number of online courses in the last few years, it appears that there is a lack of effective e-learning resources for deaf and hearing impaired students that take into consideration their special educational needs (El-Soud, Hassan, Kandil & Shohieb, 2010; Pappas et al., 2018; Krasavina, Ponomarenko, Zhujkova & Serebryakova, 2019).

El-Soud and colleagues classified available educational e-resources for deaf and hard of hearing students into four main categories (2010): centralized sign language learning systems (providing interactive content and interactive tools – chat rooms, messages, etc) (Khwaldeh, Matar & Hunaiti, 2007; Ng et al., 2008);

content producing systems (providing tools for deaf people to generate content by themselves) (Efthimiou & Fotinea, 2010); text-to-sign browsers (automatically converts the Web page content to SL) (https://signly.co/); and online sign languages dictionaries (https://www.spreadthesign.com). Unfortunately, there are few platforms and resources available for Russian signers and hearing impaired Russian language users due to little interest in this area of research.

Learning profile of a deaf or hearing impaired student significantly depends on such factors as the type of deafness, its level, the equipment the individual is used to, and the age of hearing loss. In general, when teaching this group of students, the researchers agree on such common problems as low integral indicators of general abilities (Ponomarenko et al., 2019), poor memory and poor reading and writing skills (Nunes & Moreno,1998; Ponomarenko et al., 2020). Other problems include lack of motivation and learning initiatives (Gibbs & Jenkis, 1992; Khwaldeh, Matar & Hunaiti, 2007). Together with principles and guidelines by the Web Accessibility Initiative of the World Wide Web Consortium these should be taken into consideration when creating online resources for deaf and hard of hearing students. Among others, the suggested solutions are the use of practical examples, interactive feedback (Clark & Mayer, 2016), micro-modules (Toledano, 2006) and special graphics (Drigas, Vrettaros, & Kouremenos, 2004). This paper focuses on such challenges as effective replacement of audio information with its visual representation; adaptation of online educational materials to deaf students' specific cognitive processes and encouraging their self-study and educational initiatives.

Information Visualization

Since deaf and hard-of-hearing students mostly perceive information visually, the visualization of the educational material is essential in the educational process. It is recommended to create electronic courses or conduct classes in multimedia classrooms with various information transmission devices, as this simultaneously facilitates and accelerates the learning process (Efimenko, Mokrecova & Samsonov, 2016; Oreshkina & Gurov, 2018; Voroncova, 2019). Using images is also proved to be effective for deaf people who use sign language (Bueno, Fernández del Castillo, Garcia & Borrego, 2007).

Web Accessibility Initiative guidelines of the World Wide Web Consortium provides general recommendations related to text alternatives, captions, sign language interpretation, navigation, etc.. However, the process of visualizing information characterized by graphic design, use of diagrams, tables, font size, and text content, is not fully understood for students with hearing impairments. At the moment, there are few recommendations for the use of certain pedagogical solutions for such students regarding knowledge presentation, both on paper and electronic media (Mikheenkova & Smirnova, 2007).

Conventional options for adapting video materials for people with hearing impairments are captions and sign language interpretation. Technically, it is easier and faster to use captions, since it does not require the participation of a sign language interpreter and can be performed using standard software. Perhaps for this reason, captions are most often used in the mass media; in addition, broadcasting with captions is legally recommended for all-Russian public channels by Accessible Environment, the State Program of Russian Federation (2019). However, captions text also needs to be adapted to be fully understood by some hearing impaired individuals (Borshhevskij, 2016; Kuchkina, 2018).

However some reputed researchers consider Russian sign language to be deaf individuals' first language and the main means of their interpersonal communication (Zajceva, 2006), whereas Russian language is their second language, and they do not speak it perfectly. Historically, the use of Russian sign language in school teaching is a controversial issue in Russian educational system (Zajceva, 2006), but currently a number of works emphasizes the need for bilingual education using sign language (Vygotskij, 1983; Zajceva, 2006). Some foreign studies can serve as an evidence for this approach, proving that such training improves reading and writing skills, expands the horizons and positively affects the effectiveness of training (Heiling, 1995; Estes, 1977). However, more research is needed to gain a clearer understanding of the use of sign language in the educational process, including the creation of online learning resources.

Adaptation of educational materials

The level of cognitive development of hearing impaired students generally corresponds to the indicators of the intellectual norm and tends to increase over time, provided that an effective learning environment is created (Pappas et al., 2018; Ponomarenko, Krasavina, Zhuykova & Serebryakova, 2019). However, deaf students generally have lower rates of cognitive processing speed, poor problem-solving skills and academic performance. This means they need more time to complete certain tasks, including reading, doing math, listening, and taking notes. The majority of students with hearing impairment have inertia of thinking and poor attentional set-shifting; their intellectual processes are slow, as it is the pace of work, so it is necessary to provide for the optimal amount of information and include different media and variable activities. Regular repetition of new material is also recommended (Ponomarenko, Krasavina, Zhuykova & Serebryakova, 2019).

The most important recommendations for adapting educational material include lexical and grammatical transformations of the text, avoiding metaphors, proverbs, sayings, phraseological units, using short and easy-to-read phrases, and analyzing the word order in a sentence (Borshhevskij, 2016).

In Russian educational research students' self-study is conventionally granted an essential role in the educational process. Self-study or independent work is considered "the highest form of educational activity" (Zimnaya, 2004), "the basis of quality education" (Podlasy, 2008), "an important means of developing students 'cognitive abilities" (Esipov, 1961).

Scientific and pedagogical literature review has shown that self-study objectives generally include developing students' ability to assimilate educational material, improving their study skills and cognitive abilities as well as independence and self-learning skills (Zimnaya, 2004; Kodjaspirova, 2006).

One of the most effective tools to increase students' motivation and catalyze self-study is gamification (Kusuma et al., 2018; Akchelov & Galanina, 2019). Over the past few years, gamification has been widely studied and discussed as an effective element of students' involvement (Cabot, López, Álvaro, Ortega, Herraiz, 2018). Gamification also provides good results in teaching students with hearing impairments (Shohieb, 2018 Costa, Marcelino, Neves, Sousa, 2019; Recommendations for Gamified Solutions and Social Interaction, 2020), and is therefore a promising field for further study.

Akchelov and Galanina provide a review of basic gamification models including PBL model, K. Werbach and D. Hunter model, Yu-kai Chou model, and others (2019). The PBL model is the basic gamification model. This model uses the three most common game mechanics: points, badges, and leaderboards. Although the PBL model has a number of disadvantages (limited use of other game mechanics; focus on external motivation, no long-term effect) (Schlag, 2018), the results showed that it is effective in motivating and engaging students, since they put more effort into learning during the experiment (Huang & Hew, 2015). In this paper we discuss the use of PBL model for teaching English language online.

Methodology

As part of a comprehensive study, we conducted a series of experiments that dealt with various problems in the field of online education for deaf and hard-of-hearing students. The experiments involved from 11 to 19 students of the Inclusive education Center at Kalashnikov Izhevsk State Technical University. The first part of the experiments related to the visualization of information: students were presented with information in various forms: videos with subtitles, videos without sign interpretation, graphics, tables, etc. The students were asked to complete some comprehension tasks and then answer the questionnaires. The second part of the experiments concerned the adaptation of educational material to the students' perception and cognitive characteristics: students were asked to complete tasks in an adapted electronic course in Descriptive Geometry, and then to answer the questionnaire. To catalyze students' self-study, they were involved in an online language marathon, implying PBL gamification model.

After the online marathon, students' involvement was compared to that in conventional online course (number of task completed, timely pass, participation) and questionnaire answers were analyzed.

Results

The results of the first series of experiments related to the visualization of information are shown in Table 1 and Table 2.

Table 1. Average test scores for different representations of information.

Information representation	Table	3D column chart	2D chart	Pie chart	Text
Average score	2,308	2,208	2,09	2,45	1,73

When comparing samples for different representations of information, the following results were obtained (with Student's t-test): the difference between graphical representations of information (tables, three-dimensional charts, 2D charts, pie charts) is not statistically significant, but the difference between graphical and textual representations of information is statistically significant. Similar tests conducted in English gave similar results, with the difference between the graphical and textual representation of the information being even more significant (Ponomarenko et al., 2020).

Table 2. Average score for completing the tasks with video content.

Gist, average score		Detailed comprehension, average score	
Video with captions	**Video with sign interpretation**	**Video with captions**	**Video with sign interpretation**
1,72	0,36	10,36	4,45

The analysis of the obtained results (Student's t-test) showed that the difference between the obtained results on the use of different types of dubbing is statistically significant (Krasavina et al., 2021).

Table 3 shows the evaluated types of work and the students' scores in the adapted distance course on descriptive geometry. All students received positive assessment. The main difficulties were associated with independent reading and understanding of the text lecture material (Zhuykova et al., 2020).

As for the language marathon, it was held in the following mode: every day students were given simple practical tasks and received daily feedback with points, leaderboards were provided weekly, and best players were assigned statuses or badges, graphically designed in the form of gestures.

To facilitate context learning, special videos with captions were filmed, and the tasks included various types of graphic information: images, tables, and charts.

Table 3. Assignments scores in the adapted distance course on descriptive geometry

Basic elements	**Tests,%**			**Solving problems in a workbook, %**			**Control work, %**			**Graphic tasks, %**		
	0-2	**3-4**	**5**	**level 1**	**level 2**	**level 3**	**0-9**	**9-12**	**12-15**	**0-2**	**3-4**	**5**
Theme 1	0	25	75	8	67	25						
Theme 2	0	33	67	16	59	25	25	58	17	0	67	33
Theme 3	0	17	83	8	69	33						

After the marathon, the results showed that the percentage of completed tasks increased significantly (in the second week it reached 90%, whereas for conventional self-study course this parameter was 63%). The number of tasks completed on time also increased (63% vs. 45%). The questionnaire showed positive attitude of students to such learning resources, many described their participation in it as "interesting". In addition, 81% of students responded positively to the question about further participation in such marathons, and 45% suggested new topics for future marathons.

Discussion

When teaching deaf and hard-of-hearing university students, it is necessary to visualize information using graphic forms, such as images, charts and diagrams, in order to facilitate its perception. Illustrative materials should contain a minimum number of words sufficient to understand the depicted information, and should be accompanied by explanations from the teacher. For better assimilation, it is recommended to use a combination of graphic means of information representation. At the moment, it is established that there is no statistically confirmed difference in the efficiency of data presentation using different types of charts.

The ability to independently create graphs, tables and diagrams is an important skill to be developed when training future engineers. Perception and processing of large amounts of information is a sensitive spot for deaf and hard-of-hearing students. Independent structuring and visualizing of information can improve its understanding and the students' ability to process voluminous textual information. An interesting area of research in teaching students with hearing impairment may be the study of the correlation between the ability to structure information (make graphs and tables) and the academic performance of students.

The graphical representation of the data can be used in teaching any discipline, both technical and humanitarian. For example, tasks for drawing up tables and graphs when studying texts in English will not only allow students to remember and better understand information, but also improve their general information processing skills.

As for captions, the main factors that explain the advantage of using them in video materials instead of sign language can be divided into external and internal factors related to information perception.

The first category includes factors such as:

- the existence of several "dialects" of Russian sign language (for example, the gestures used by students from Bashkiria differ from those used by students from Udmurtia);
- different degrees of proficiency in sign language (as a rule, hard-of-hearing students with late hearing loss, are not good signers);
- technical problems (it is not always possible to provide simultaneous sign interpretation).

As for internal factors, they are related to the perception of different types of information from the cognitive psychology point of view. Most of the students said that they do not have time to simultaneously monitor and correlate the image on the screen and sign interpretation. The difference in the speed of perception and processing of text subtitles and sign language interpretation can be explained by important differences between sign language and Russian (in this case, written) (Krasavina, Ponomarenko, Serebryakova, Zhuykova, 2021).

The problem of mastering abstract concepts is one of the most common in teaching deaf and hard-of-hearing students. From the practical experience of teaching such students, a detailed explanation of new and abstract terms by a sign language interpreter before the lecture contributes to their successful understanding. The simple gesture explanation of the interpreter is based on the existing lexical gesture vocabulary of the students. Taking this into account, when creating electronic resources for the general technical and humanitarian courses with video materials, it is possible to propose the use of video dictionaries with abstract terms in sign language related to the topic of the lecture. Subsequent video lectures containing basic information on the topic are suggested to be duplicated with text captions, taking into account the recommendations for their adaptation (Borshhevskij, 2016).

Our experience in teaching hearing-impaired students with an online course in descriptive geometry revealed a number of difficulties that arose for these students when working independently with e-resources. First of all, students experienced difficulties when working with large texts, even with the use of adapted materials (reduced text complexity, the lecture text is limited to 4-5 pages). Taking into account these factors, the text information was reviewed later. The volume of texts was reduced, the linguistic features of this group of students were also taken into account (mainly simple sentences, preferable use of nouns and verbs), simple and understandable words were selected to explain terms and phenomena, and practical examples were given. When designing the course tasks, in order to create a situation of success, the principle of "from simple to complex" was implemented, comprehensive instructions and a well-thought-out visual design were provided.

The analysis of the experiment results allowed us to formulate some requirements for the presentation of information in the electronic resources when teaching hard of hearing students:

- it is inefficient to offer theoretical material on slides in the form of texts, the information should be simplified as much as possible and include images, symbols, tables, diagrams, etc. ;

- it is advisable to present the material for memorization (formulas, terms, rules) on separate slides;

- it is advisable to present the material for memorization (formulas, terms, rules) using short sentences, mainly using verbs and nouns;

- it is better to organize the material starting with simple concepts and ending with complex ones;

- when presenting the information containing a sequence of events or a process, it is recommended to show each stage in a single slide. This is due to the specifics of the mental reconstruction of images by deaf and hard-of-hearing students.

When presenting text materials, it should be taken into account that any submitted texts should be easy to view and read without additional visual efforts to find the key ideas, regardless of the media used.

Poor results of tests for memorizing the content of the texts (long-term memory) prove the difficulties in assimilating new information. When working with students with hearing impairments, it is necessary to consolidate new information in every possible way, starting with the provision of a printed lecture plan and highlighting basic concepts, and ending with the strengthening of logical connections with previously studied information.

As for learning English, an important factor for learning foreign vocabulary contextually is providing the e-course with adapted video materials with subtitles. In addition, in order to implement the principles of the communicative approach in the electronic environment, the authors propose a language marathon, organized in the form of a group conversation, and involving regular simple practical writing tasks.

The language marathon course created with the PBL gamification model showed good results for initiating students' self-study. For further improvement it is suggested to use such extra gamification tools as the creation of a pedagogical trajectory (the hero's journey). The most common trajectory include 3 main stages: "exodus" (from the real world) – "initiation" (passing obstacles in the mythological, virtual world) – "return" (to the real world, updated, with the experience and knowledge gained). The scheme of the hero's journey allows us to ensure the progress and development of the player, and the students better understand their capabilities.

Conclusion

It is obvious that when teaching hearing impaired students, an instructor should focus on visual information and avoid long texts. This paper provides some details for effective replacement of audio information with its visual representation, adaptation of online educational materials to deaf students' specific cognitive processes and encouraging their self-study and educational initiatives. As a result of our study, the following typical structure of a thematic sections of the e-course on technical subjects was proposed: each unit starts with the introduction of an e-vocabulary of terms (in Russian sign language), followed by a test for comprehension of the presented terms, then presents the theoretical material in the form of video lectures with subtitles, lecture notes, activity book, step-by-step instructions to perform tasks and additional materials. Gamification tools contribute to students' motivation and involvement, so it is highly recommended to use them when planning online courses for students with hearing impairment. The implementation of full online courses in English, Russian and descriptive geometry for deaf students is in the future work plans, in the framework of this research.

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