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DIGITAL TEXTBOOK DESIGN FOR DIFFERENT AGE GROUPS: ADVANTAGES AND LIMITATIONS

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Abstract

The active spread of animation technologies (2D, 3D), augmented reality (AR), software for their development, and means of viewing them has led to the introduction of these technologies into the educational process. The focus of modern developments in digital manuals is the substantial saturation of educational content with game-based multimedia elements. The article discusses current trends in the development of electronic editions, in particular the design of digital textbooks.

An analysis of previous studies aimed at comparing the acquisition of educational material using a printed edition or an electronic analogue for users of a certain age was performed. The results of these studies raise a number of questions that are relevant both for authors/developers of electronic textbooks and for those who are directly involved in the design of electronic textbooks and their multimedia components, such as video, animation, augmented reality, etc.

The authors set the goal of conducting research on the perception of the multimedia component of the digital textbooks (DT) by a wide age group, as well as establishing their perception of information. A section of the DT was developed for the 1st, 8th, and 11th grades of school and higher education institutions. Each of them is presented in three design formats: a PDF format, a version with animated illustrations, and a version with augmented reality.

According to the results of respondent surveys, it was established that the audience considers the use of animated illustrations to be appropriate primarily for primary school and to facilitate the perception of complex material in publications for higher education institutions. A similar distribution of opinions exists regarding the use of augmented reality elements.

A separate question was asked about the difficulties of working with publications containing augmented reality elements. The results of the research show that today's users still need additional knowledge and explanations about the specifics of using technologies for working with files that contain elements of augmented reality. Some respondents simply do not

want to perform any auxiliary actions, which causes many inconveniences in use: from the audience's simple ignorance of the algorithm for interacting with a new type of resource to technical problems that can be solved through in-depth testing.

Based on the results of the research, it can be noted that it is not appropriate for all age groups of users to develop DT with a large number of built-in interactive multimedia components. Their presence does not always improve the assimilation of material. At the same time, it has been established that the audience is interested in such technologies. It is important to further study this issue: to determine the optimal format (type) of interactive multimedia elements for each age group, taking into account the specifics of the academic discipline. It is equally important to conduct research not remotely, but directly with content users. This will allow for adjustments to be made to the research that has already been conducted.
Keywords: *e-textbook design, digital textbooks, electronic editions, multimedia content, animation in e-textbooks, augmented reality.*

Itroduction

The creation, design, implementation and use of digital textbooks (DT) are being actively studied by researchers around the world [1–3]. The introduction of DT into the educational process was a logical next step after the emergence of electronic editions of fiction and the active use of this form of presenting information. Important issues include both the perception of information and the cost of these publications. The use of electronic editions of an entertaining nature or publications for leisure is not usually accompanied by a requirement to assess the memorability of the information content. Users of such content are of completely different age categories, and the vast majority already have the minimum knowledge necessary to search for the required publication and then open files, use devices and the appropriate software.

Practical experience shows that the introduction of DT into the everyday life of schoolchildren and students is also growing rapidly. The main limitations are caused by the lack of DT, taking into account the correct presentation of multimedia content and the characteristics of devices that reproduce this content. Many studies are still focused on comparing the perception and assimilation of information between printed textbooks and their electronic counterparts [4–8]. However, trends in the development of electronic multimedia publications raise the question of finding and researching effective forms of implementation of relevant products and using them to create electronic textbooks.

In recent years, research has mainly focused on comparing printed textbooks and DT for a single age group. A number of researchers [9] raise the issue of learning material assimilation in DT with multimedia elements or the quality of different DT, namely the use of AR. However, there are no studies focused on the perception of information by users of different age groups. After all, the material and time costs of preparing DT saturated with a large amount of multimedia content are significantly higher than those of publications containing only static text and images.

Publication [10] provided a summary of the results of research conducted by scientists collaborating with UNESCO on DT and their implementation in educational institutions. The advantages and disadvantages of using different types of materials in the classroom are presented. Researchers provide arguments in favour of DT from the perspective of students, parents and teachers.

At the same time, it is quite difficult to find high-quality DT with built-in multimedia elements. Developing such a learning resource is a complex process: it requires more time, significant financial costs, and the involvement of specialists who are proficient in specialised software.

But the question still arises: is it worth spending time and resources on developing and creating editions with a large number of multimedia elements? Is there a need for this? Is a static PDF textbook with a minimum amount of interactive content sufficient? Where is the line beyond which students no longer take learning seriously, and where textbooks that present information in a playful manner fail to foster a responsible attitude towards learning? What type of multimedia content is appropriate for which age group?

This, in turn, raises a number of questions: is it always appropriate to fill DT with multimedia resources? What is the optimal amount of such elements? For which age group are they most effective? And most importantly, how does the format of educational content affect its perception?

Developing an electronic textbook with a design that includes high-quality integrated multimedia elements is a complex task. Unlike the PDF version of a printed edition, it takes longer to produce and is more expensive. It requires developers to have knowledge of a considerable amount of specialised software. This raises a number of questions: is it appropriate to include multimedia elements in DT; for which age group is their inclusion appropriate; what is the optimal number of multimedia elements; how exactly does the way information is presented affect its perception by consumers?

Methodology and equipment

The research was based on digital textbooks with different multimedia designs. Specifically, basic pages were created for textbooks on technical subjects, such as mathematics and drawing. The educational publications were developed for four age categories (approximately): 1st grade, 8th grade, 11th grade, and higher education institutions, i.e., primary, secondary, and high schools, and first-year university students. Thus, the main age categories actively involved in the educational process are covered. Three types of DT have been developed for each of the selected age categories: PDF format, DT with animated illustrations, and DT with augmented reality. Screenshots of the appearance of some of them and the work of animated illustrations are presented in Figs. 1–3. Adobe InDesign was used as the basis for developing the pages of the publications.

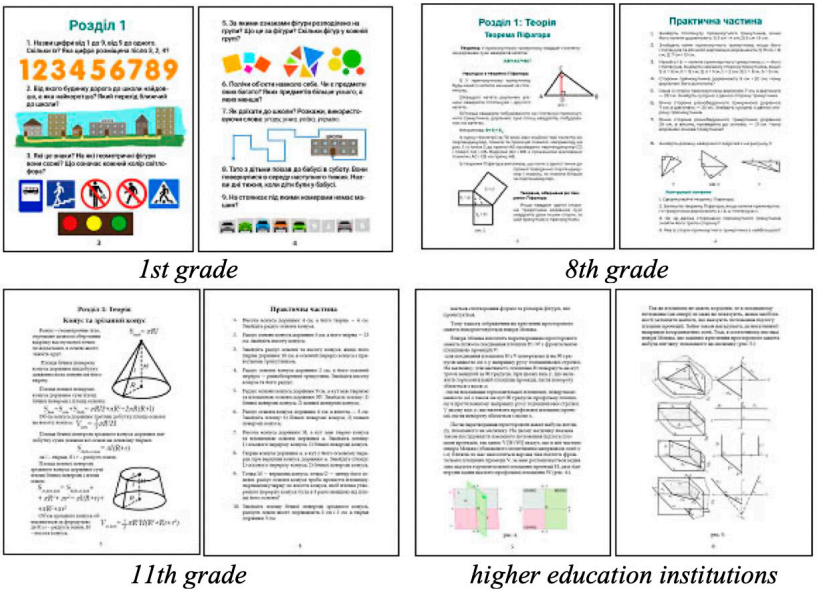


Fig. 1. Page layout of PDF format editions

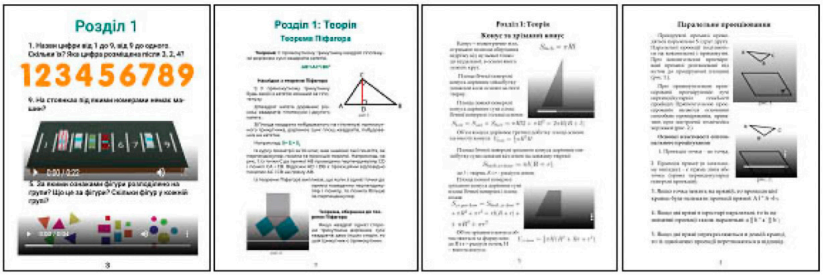


Fig. 2. Examples of page layouts from editions with animated illustrations

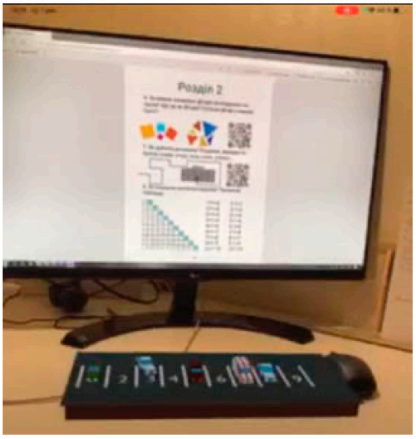


Fig. 3. AR in an edition (the image shows a 1st grade textbook)

The files of the developed pages of educational editions were stored in a Telegram channel created specifically for conducting the respondent survey. A total of 12 small-volume editions (three for each age category) were posted in the created channel "Editions", most of which covered a single topic.

Since the experimental part of the research required a transition to web publications, this service also successfully implemented the ability to directly follow links and save all developed editions and AR files. Another advantage was the convenient opening of AR files *.usdz, compared to Google Drive. This is ensured by the ability to download files to the device cache with the ability to play them directly after downloading. Therefore, there is no need to download AR files to the phone's memory and then open them with third-party programs.

Special attention was paid to the audience of respondents. The developed elements of educational publications have a wide age range of users. Therefore, the research needs to be tested by users of different ages and with different skills in using the devices on which the editions can be viewed. The age category of respondents is defined as over 18 years old, studying in higher education institutions or having children of primary school age and older. It is desirable for this audience to have children in order to see changes in interest in learning from a third party and to determine whether auxiliary (multimedia) elements interfere with learning.

A questionnaire was created using Google Forms to survey respondents. The questionnaire contains open-ended and closed-ended questions. Questions were grouped to assess the feasibility using a particular technology, ease of use, usefulness of a particular technology in the learning process, choice between electronic and printed versions, and suggestions for using electronic textbooks.

To find potential respondents, we used channels that mainly focus on electronic editions and related topics, where it is permitted to publish the results of one's own research and where surveys are periodically conducted on the preparation of editions, their components, and related topics. This method of collecting information was dictated by the spread of distance learning in Ukraine.

Presentation of research results (Analysis)

The analysis was conducted based on the responses of 1000 respondents, 94% of whom had school-age children (brothers/sisters). The answers to the following questions were intended to determine the ease of use of the proposed DT types and the appropriateness of using animated illustrations and AR (Figs. 4–6). A score of 1 to 5 was accepted as the least and most convenient option for use, respectively.

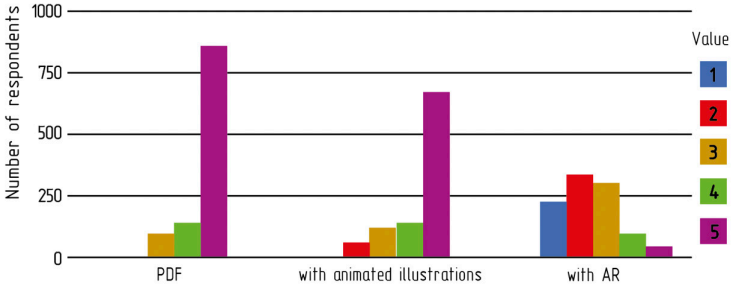


Fig. 4. To what extent are the proposed types of DT convenient to use?

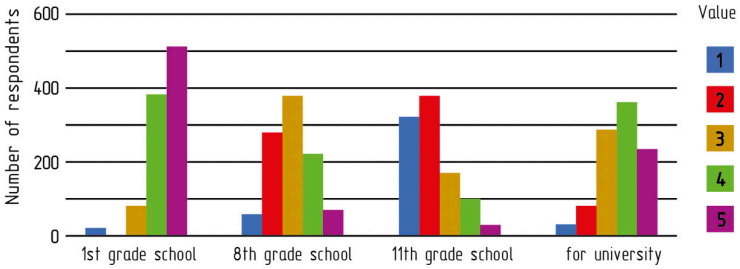


Fig. 5. The expediency of using animated illustrations in the DT

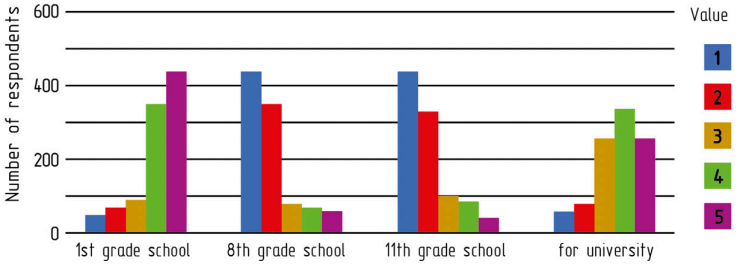


Fig. 6. The expediency of using in AR the DT

Analysis of the responses showed that the familiar PDF format of educational editions received the highest score for ease of use. The options presented with animated illustrations also received positive reviews, while editions with AR were considered by respondents to be the least convenient to use.

Regarding the appropriateness of using animated illustrations in DT design, the audience considers them appropriate primarily for primary school editions and for explaining complex material in editions for higher education institutions. Editions for secondary and especially senior schools received the most negative feedback regarding the use of animated illustrations in their structure. A similar distribution of opinions was observed regarding the use of AR elements.

The next set of questions was devoted to the correctness of file opening and user actions in case of failure to open/incorrect opening (Figs. 7–9). To identify inconveniences in using a particular type of edition, an open-ended question was also used, allowing respondents to describe the problem. The most common responses were: ‘AR is too unusual, it is very difficult to adapt to this format’, ‘there were difficulties when using the AR textbook’, ‘it is a little unclear how to use it,’ ‘there were difficulties using the AR

textbook,' 'sometimes it is not entirely clear how to use it,' 'it is unclear how to use AR,' 'AR is difficult to understand,' 'the videos in the textbook with video illustrations take a long time to load,' 'the illustrations sometimes disappear in the textbook with animated illustrations,' 'there were problems opening the PDF file, it displayed an error.

A total of 670 responses were received to this question, 490 of which were about the AR textbook, 140 responses were about problems using the DT with animated illustrations, and 13 respondents had problems opening the PDF file.

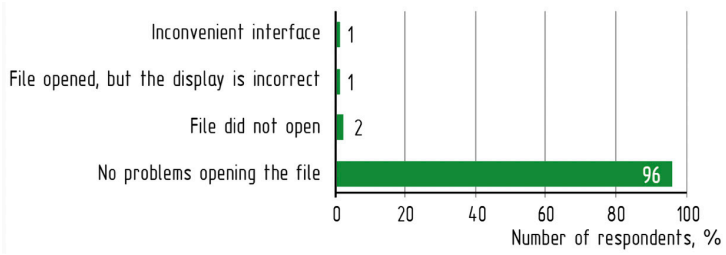


Fig. 7. Did you encounter any difficulties opening the PDF file?

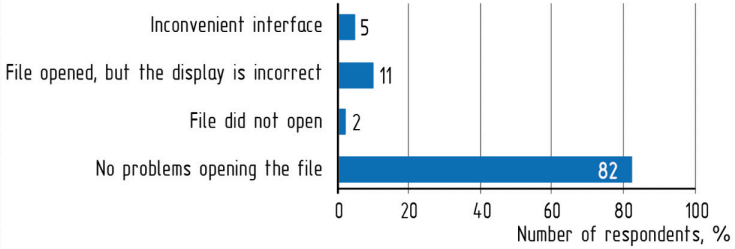


Fig. 8. Did you encounter any difficulties when opening the DT with animated illustrations?

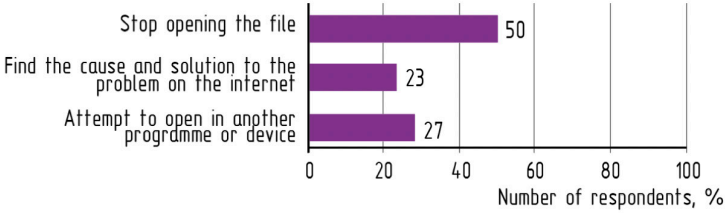


Fig. 9. If the file with animated illustrations and AR elements did not open, what did you do?

A separate issue addressed the difficulties of working with editions that contain AR elements. The results are presented in Fig. 10. It can be concluded that users still need additional knowledge and explanations about the specifics of using technologies and working with files that contain AR elements; some respondents simply do not want to perform any auxiliary actions.

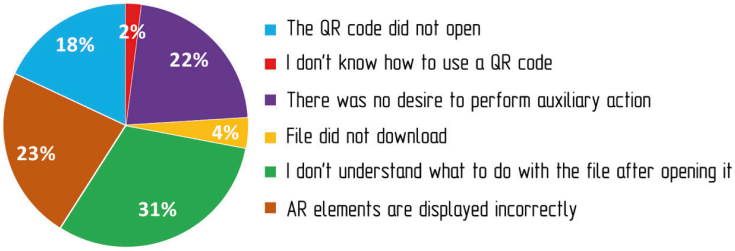


Fig. 10. Did you have any difficulties in opening AR?

After analysing the responses, we can conclude that AR has many inconveniences in use: from the audience's lack of knowledge of the algorithm for interacting with a new type of resource to technical problems that can be solved through in-depth testing. Most users did not encounter any difficulties with textbooks that were easier to interact with. However, based on the answers to the question 'Do you consider the use of AR in educational literature useful?' (Fig. 11), we conclude that users are interested in this technology and see its potential, but only if the interaction algorithm is simplified.

Respondents also expressed interest in animated illustrations in educational editions (Fig. 12), but believe that this is not appropriate for all age groups. The authors highlighted the issue of the impact of multimedia elements on the interest of primary school children in learning new material and completing tasks. This is precisely why an audience of primary school children was needed. There were assumptions that these elements might interest them. However, could they distract children from learning, leaving them interested only in the animation or AR itself? Would this facilitate the learning of the material? The answers (Fig. 13) showed that the children were primarily interested in the textbook with animated illustrations. Only 8% were interested in the textbook with AR elements, while 6% of respondents did not show any additional interest compared to the textbook in PDF format.

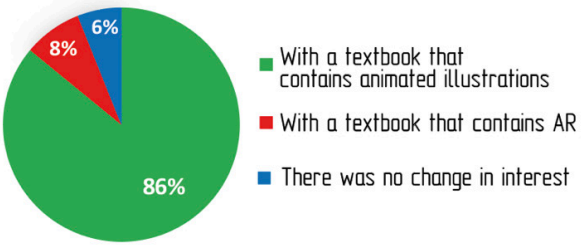


Fig. 13. Was the child more interested in performing tasks with…

The user's choice is influenced not only by the interactivity of the publication, but also by its cost. Therefore, the questionnaire included the question 'When choosing between analogue and digital versions of a textbook, which would you choose?' (Fig. 14). The following answer options were offered: a) both are free; b) both have the same cost; c) the electronic textbook is cheaper. The survey results showed that electronic textbooks are inferior to printed ones only if both formats are available free of charge.

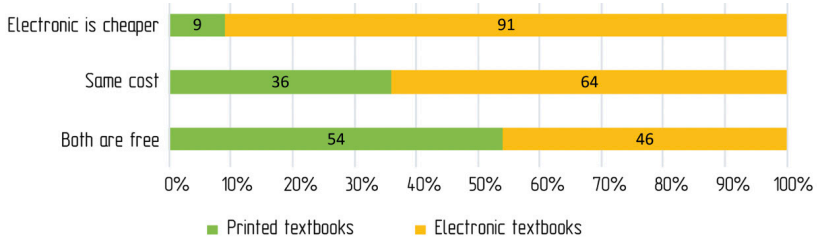


Fig. 14. When choosing between analogue and digital versions of a textbook, which would you choose?

Conclusions

According to research, the use of electronic textbooks in the everyday life of schoolchildren and students is growing rapidly. It has been established that the main limitations are caused by the lack of electronic textbooks that take into account the correct presentation of multimedia content and the characteristics of the devices that reproduce this content.

Much research is still focused on comparing the perception and assimilation of information between printed textbooks and their electronic counterparts. However, trends in the development of electronic multimedia editions

raise questions about finding and researching effective forms of implementation for relevant products and using them to create digital textbooks.

Based on the developed versions of digital textbooks for different age groups, the perception of the content of these editions by users was studied. Studies comparing the PDF version, with integrated animation and AR in digital textbooks, showed that the audience was most interested in the animation component. However, it should be noted that in terms of ease of use, the familiar PDF format of educational editions still receives the highest score.

The audience considers the use of animated illustrations to be appropriate primarily for primary school editions and for explaining complex material in editions for higher education institutions. Editions for secondary and especially senior schools received the most negative feedback regarding the use of animated illustrations in their content. There is a similar distribution of opinions regarding the use of AR elements. According to respondents, AR has many inconveniences in use: from the audience's lack of knowledge of the algorithm for interacting with a new type of resource to technical problems that can be solved by developers through in-depth testing.

The results obtained will enable developers to consider the feasibility of using multimedia content when creating digital textbooks for a specific age group. Further research should focus on identifying the topics of electronic editions, as users' perceptions of 'technical' disciplines and the humanities may differ significantly. Another important issue is conducting further research in a face-to-face format rather than remotely, which may lead to adjustments in the research results already obtained.

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