

Z generation students' learning mathematics with e-resources

Alenka Lipovec, Jan Zmazek, Vid Lah, Eva Zmazek, Blaž Zmazek

Abstract. User experience is a key element in information and communication technology. In the presented paper, Z generation representatives argue about the most common causes of mathematics learning difficulties when using technology. They discuss the benefits and downsides of using interactive resources in learning mathematics and the ideas for the development of new applications that would help to overcome presented learning problems. Reflection is based on learning mathematics via Slovenian e-textbooks, called i-textbooks (www.iucbeniki.si or <https://eucbeniki.sio.si/>). An i-textbook is an e-textbook with a high number of interactive elements with a high level of interactivity. Students suggest that an i-textbook is an effective learning resource that motivates and encourages in-depth learning of mathematics and present continuous identification of opportunities for improvement. We argue that including student's user opinion is a key element in designing e-learning materials.

Keywords: user experience, i-textbook, secondary school pupil, active learning, ict

I. INTRODUCTION

Z generation represents teenagers born after 1990. They were born into the era of computer technology. Constantly being in constructive technological stress, we could say that they have "split personalities" because part of them lives in a virtual world through online profiles. They are the first generation in which we detect nonlinear methods of thinking in a majority, which is seen through "connect-the-dots-however-you-choose" principle (Barna, 2001). They are capable of multitasking; talking, searching for information online and doing homework (Palfrey and Gasser, 2008), therefore changes are necessary also for the field of education (Jones and Shao, 2011). Z generation presents a major problem from the consumer perspective because they have a higher level of decision power at parents; what to buy and what is wise to use (Anupriya Kaur, Medury, 2011). They are strongly connected through various online interest groups, usually with mobile connections channels (Kaplan, 2012).

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I-textbooks are more than classic textbooks in digital form, they introduce new media to enhance user's interaction with i-textbooks (Pesek and co., 2014). The basic outline of standard ISO 9241-210 is to include users in the early development phase of the final product. Nevertheless, this step is commonly ignored in education despite the fact that students in secondary schools can argue and realize their views on the development of new contents and technologies. Identification of their needs and wishes is essential.

The aim of the presented paper is therefore to list some advantages, disadvantages and recommendations for the further development of Slovenian i-textbooks available at www.iucbeniki.si (<https://eucbeniki.sio.si/>)__from users' perspective (Z generation students).

II. I-TEXTBOOK AS A RESOURCE FOR LEARNING MATHEMATICS

The essential difference between e-textbook, as a type of e-learning material, and i-textbook is in the level interactivity. The key advantage of i-textbook is its direct integration of interactive examples, structures and functions in its content. The quality of feedback is better, it enables storage of responses and monitoring of the user. I-textbooks, described in this paper, were developed in the framework of the project *E-textbooks for science classes in elementary and secondary school* and are available on www.iucbeniki.si (<https://eucbeniki.sio.si/>). The project was launched in 2011 and has ended in 2014. It was co-financed by the Ministry of Education and Sports (MoES) and the European Social Fund. The results are freely accessible without required registration. The content can be simply modified and adjusted. Slovenian i-textbooks offer a lot of options for the use of inside and outside of a classroom, is easily accessible and can function with or without internet connection. Those materials brought a new experience in the Slovenian school environment for a teacher and a student.

We define i-textbook as an e-textbook, which is dominated by (reasonably included) i-learning building blocks with a high degree of interactivity. The prevalence means that the core concepts are mainly introduced by highly interactive learning building blocks. As an example of such interactive widget, interactive conceptual applets are proposed. The applet is a relatively small software application that is built around pre-designed graphic representation. Conceptual applets are applets that allow the detection of relationships of the key concept or relations between several concepts of the

topic (Lipovec and co., 2015). The ability of visualization mathematical concepts and processes and interactive nature of the interactive applet can be a powerful conceptual teaching tool.

In the preparation stage of i-textbook and confirmation of its suitability, the following basic axioms content-didactical requirements: axiom of curriculum coverage, axiom of interactivity, axiom of multimedia, axiom of inductive approach, axiom of fill rouge, axiom of developing profound knowledge, axiom of developmental suitability (for more details see Zmazek and co., 2012). I-textbooks encourage students to be more active and discourage from learning without understanding the topic. In the i-textbook, the content is presented with audio-visual and interactive elements, which enable impressive acquisition of knowledge. It is recommended that each unit contains a summary that allows the user to repeat the acquired knowledge with its integrated content. The content is split into content sections and is accessible in a tree structure of menu. Basic elements present closed learning units, combined in chapters and content sections. Each web page (screen image) includes closed activity, acquisition or repetition of knowledge without the need to navigate between other web pages and may contain content in whole or just a part of it.

The purpose of application dictates the manner of i-textbook use. Each next class builds new content based on known topics from previous classes. Students revise and consolidate known facts, concepts, properties and procedures and then upgrade the existing knowledge network with new experiences and new knowledge. The basic elements of an i-textbook are student-centred activities. Students implement these activities directly with an i-textbook (applets, demonstrations, spreadsheets, images) or in their own environment (working with material, pictures and sketches in a notebook, observing phenomena, monitoring of events, browsing the Internet, etc.) These activities are in the function of acquiring and expanding knowledge of a known concept. Mathematical terms are rarely presented through prototypes; they are mostly presented through several well-chosen examples and counterexamples. A student learns and forms a mathematical concept in his own mental scheme through a specific activity. With examples that support the scope of a concept, students integrate knowledge from various areas of mathematics and build familiarity and understanding of a concept. I-textbooks also encourage students to work with classmates and compare the results. Students with problems are not alone; they will exchange mathematical insights with their classmates. Social constructivism is manifested through technology.

III. OBSTACLES IN LEARNING MATHEMATICS

Mathematics is a discipline that is either loved or hated. Ways of efficient learning and teaching mathematics is a huge research area, even if we restrict ourselves to learning with technology (Lesgold, 2013). A few years ago, classic home learning of the students took place mainly by means of printed textbooks and exercise books. Math textbooks were correct content-wise, but without much additional explanation and therefore difficult to understand for weaker students. If the

previous generations' textbooks are used by the students of Z generation, they quickly lose motivation as concentration decreases rapidly. Therefore, the modern printed books have already been adapted to the new needs and expectations of children.

Below we will describe students' perspective on specific learning obstacles when learning secondary school mathematics. User point view will be accompanied by students' proposals of how to overcome obstacles by using i-textbook as a learning resource. Additionally, the Z generation students give some ideas about the new development of e-learning resources.

A. Lack of motivation

Z-generation is challenging, but a lot more to the others than to themselves. Work habits and persistence in work are the weak points of the new generation students. The problem exists in motivation. Technologically advanced young people are emotionally drained. They often do not find the real meaning in the transition from the virtual to the real world. They would like to achieve everything without real effort. For motivation, i-textbooks are aligned on Keller ARCS (Attention-Relevance Confidence-Satisfaction) model (Keller, 2009).

I-text books are designed in a way that each content includes the motivational example or contextualization of the problem (Figure 1, left); it is assumed that this will attract the attention of the students. At the end of introduction page, the objectives of the units are set to highlight the importance of the content. In the design of new i-textbooks, we follow the guidelines that require the content (explanation, activities, examples and tasks) to be associated with the real-life challenges. Students will find additional motivation and this will improve the understanding of the learned content (relevance). As already mentioned, real-time feedback reinforces the belief in their own abilities (confidence). Differentiation of task ensures that students resolving the suitable task experience a sense of satisfaction.

B. Learning bulimia

So-called "learning bulimia" of modern Z generation (Zorek, Sprague, and Popovich, 2010) could be described as follows: a few days before written or oral evaluation students quickly absorb a high amount of knowledge; immediately after exams, this knowledge is quickly forgotten as students start to prepare for the next "learning bulimia". The knowledge that is gained so quickly will certainly not become permanent and useful.

With questions and invitations to rethinking on the topics, a reader is invited to take an active role in understanding the content that often involves humour. However, compared to the i-textbooks, traditional printed textbooks cannot provide the feedback on the student's task. I-textbooks have opportunities to offer much more friendly content for young people than printed textbooks. The technology not only enables asking various or dynamic questions but according to the different responses, i-textbooks can offer different feedback based on their relevance and correctness.

Users are invited to read the content, locate or search for additional information online, discuss with classmates, etc. For information found in other sources (internet), students must provide the answers, analyse them together with their classmates so that the computer can check whether the task was actually performed. I-textbooks promote active learning, where students are asked to do something and after that think about the results. I-textbooks also invite to an acquisition of problem knowledge and useful skills. We believe that i-textbooks also reduce the degree of “learning bulimia” of Z generation.

C. Low (mathematical) student self-esteem

Many students encounter fear of failing after the transition from elementary school to secondary school. The strongest is a fear of mathematics and/or foreign language, which can lead to anxiety. Because many students with low self-esteem depend on learning procedure of solving problems rather than understanding the topics (Pintrich, 2002), they should be guided to in-depth learning.

The layout of i-textbooks is in support for students with low self-esteem. Realistic mathematical education has positive effects on students with low achievements (Barnes, 2004), the students that usually have low mathematical self-esteem. New lessons in i-textbooks are therefore presented gradually, at the start of every unit; users are presented with a contextualized motivational problem. On Figure 1, an example of such contextualization is presented on the left side. Tales theorem is contextualized via designing stage lights in the theatre.

For students with low self-esteem, which often believe that they would not understand new content, additional detailed explanations behind the buttons are of the great help.

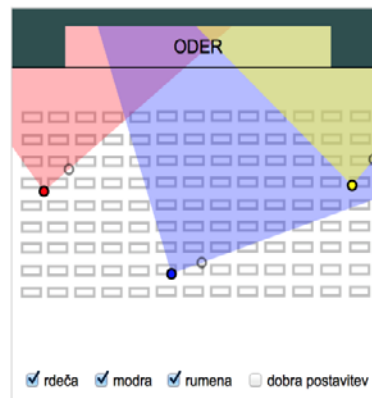
However, there is also a hidden trap, since those buttons sometimes also hide the solutions of the problem. We suggest two types of buttons or clearer labels on them. Students would better orientate if they knew what is hidden behind the buttons, e.g. additional knowledge or necessary explanations. Therefore, we propose several types of buttons or buttons with different colours.

Evklidska geometrija | Konstrukcije s Talesovim izrekom | Konstrukcije s Talesovim izrekom

KONSTRUKCIJE S TALESOVIM IZREKOM

Osvetlitev odra je v gledališču zelo pomembna. Pomagaj postaviti tri odrske luči tako, da bodo osvetljevale celoten oder, vendar ne okolice. Vse luči imajo ob straneh lopute, ki omejujejo snop svetlobe na 90° . Spodaj je tloris gledališke dvorane.

Prizigaj luči in jih postavi na pravo mesto. Rešitev se pokaže, če pritisneš na 'dobro postavitev'.



Luči moramo postaviti na:

- ☐ polkrožnico, ki sega od enega do drugega konca odra.
- ☐ poljuben krožni lok med krajščema odra.

Kvadratna funkcija | Definicija kvadratne funkcije | Teme parabole

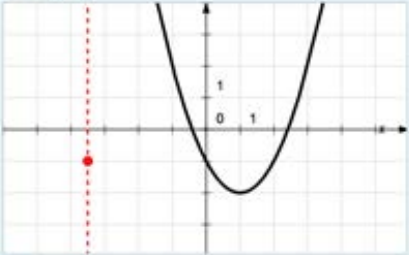
TEME PARABOLE



Metka ima čop na temenu glave.

Kje pa je **TEME PARABOLE**? Določi s premikom dane premice.

S priklicem novih in novih primerov razišči, kako se teme parabole razlikuje od vseh drugih točk na njej.



Nov primer

Presečišče parabole in njene simetrale je **TEME PARABOLE**.

Parabola $y = ax^2 + bx + c$ doseže najmanjšo oziroma največjo vrednost v temenu.

Če ima parabola teme v točki $T(p, q)$ je enačba simetrale $x = p$.

Fig. 1. Contextualization and highlighting key concepts.

D. Weak understanding of the contents in school

There are many reasons for the students' lack of understanding of the content that they discuss with the teacher

in the classroom. Let's mention three most common problems. Sometimes, a student has less knowledge and can no longer keep with the pace of the class during the interpretation. Sometimes, weaker students do not understand because of very theoretical interpretation, which is not supported by sufficient number of examples. Also, the teacher with in-depth explanation with many examples of the problem can cause the weaker students to lose the threat and therefore the motivation to follow the classes.

Students who do not follow the interpretation in the classroom will find a virtual instructor in i-textbooks. When working at home, the content and the design of i-textbooks will be helpful since the key facts are highlighted as seen in figure 1, where definitions and key information about vertex of a parabola are put on a pink or blue background.

At the end of each lesson, teacher summarizes what has been learned. The same is done in i-textbooks, as core knowledge is always followed by a brief summary page.

E. Students' low concentration

I-textbooks are prepared for students with concentration problems. Units are designed so that students actively cooperate with i-textbooks and its features. I-textbooks are not only designed to be read, but to also be cooperated with. It is important that units are not too long for students with concentration problems. Each unit starts with one page of the introduction, continues through one, two or three pages of core content. It is worth mentioning that for the students with poor concentration, a six-page long unit can cause problems. These units should contain even more interactive animations and other activities, which is currently not yet achieved in i-textbooks.

One of the advantages of i-textbooks is the use of applets with high intensity of interactivity. In applets with low interactivity, in which the student only observes an explanation, concentration can drop quickly. At applets with a high level of interactivity, the student repeats an activity, possibly with generated starting data. This type of applets is suitable for students with poor concentration. Additionally, there are "true-false" tasks (middle intensity of interactivity) with a disadvantage of students potentially clicking on the answer without thinking.

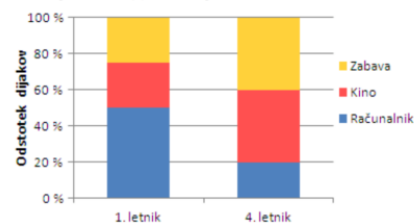
F. Homework

The optimal model for learning mathematics is continuous learning and committed work at home and in school. Regular (but not excessive) math homework has a positive effect on mathematics achievement. However, monitoring homework does not mean significantly higher achievement (Troutwein, Koller Schmitz, and Baumert, 2002). The new i-textbooks are an extensive source of differentiated homework task examples. Examples follow from the easiest, marked with a green, to a little bit difficult, marked with blue, and up to the most complex challenges, marked with red (figure 2).

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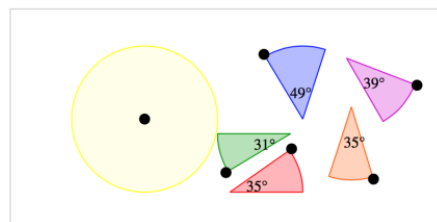
will be helpful since the key facts are highlighted as seen in figure 1, where definitions and key information about vertex of a parabola are put on a pink or blue background.

3. Na šoli so izvedli raziskavo o preživljanju prostega časa. Rezultati so prikazani na diagramu. Kaj pove diagram?



Rešitev

4. Jan ima v škatli 6 rdečih, 9 modrih, 6 zelenih, 4 oranžne in 5 vijoličnih barvic. Na stopinjo natančno izračunaj velikosti kotov, ki pripadajo posameznemu izseku, in prikaži strukturo barvic s tortnim diagramom.



Rešitev

Statistika | Prikaz podatkov | Naloge

NALOGE

1. Za katere od spodnjih spremenljivk bi bil ustrezen prikaz s tortnim in stolpcnim diagramom?
- ☐ Barva avtomobila.
 - ☐ Število potnikov.
 - ☐ Kraj rojstva.
 - ☐ Dolžina poti.
- Prikaži odzive
2. Miha je posadil sadovnjak s 25 drevesi. Tortni diagram prikazuje strukturo dreves. Izračunaj število posameznih vrst dreves in jih prikaži stolpcnim diagramom. Povleci modre točke do ustrezne višine. Ob pravilni rešitvi se bo izpisalo PRAVILNO.

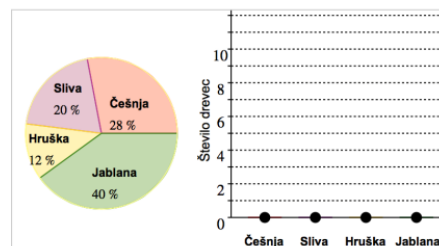


Fig. 2. Differentiated tasks as examples of homework

Tasks also include generated data. A lot of generated tasks are equipped with a changing graphic image, based on the changing of initial data.

When students are preparing at home for a written assessment, it is important to revise the previous knowledge.

However, in Slovenia students often don't have textbooks from the previous year (printed textbooks are borrowed from borrow funds and returned to them at the end of the school year). The i-textbooks from this point of view offer a better solution since they cover the whole vertical (currently it is available in mathematics from 4th grade elementary school until the 3rd grade of the gymnasium).

IV. USERS' VIEW ON FURTHER DEVELOPMENT OF I-TEXTBOOKS

Presented paper was co-authored by three students of the Z generation, who were also actively engaged in the design of i-textbooks. Nevertheless, we believe that the students of Z generation would additionally appreciate adding some functionalities to the existing Slovenian i-textbooks. One of them are tutorials, which include extracts of all the units classified by chapter. A special application could allow students to independently produce a set of tasks to be solved. The selection criteria could be for example severity, content, etc. This would provide an excellent opportunity for students with low self-esteem to choose appropriate "Add to Cart" tasks and be more successful in the early stages of assessment. Consequently, for students with difficulties in understanding, learning could consist of solving the whole range of problems; from simple to more difficult ones. An example of simple selection tasks in the form of a generated tests was contained on "E-um portal" (www.e-um.si), a predecessor of Slovenian i-textbooks.

A collection of all applets, which are not connected with the position inside the learning unit and can be used independently could be created. Students could use the same applets on smartphones and could practice everywhere, e.g. while waiting for the bus at the bus station. This is a good opportunity for the unmotivated students and those students from Z generation that are using the technology for fun. The example of such collection can also be seen on the "E-um portal".

A network diagram of all units that would show all applicable units with the pre-knowledge necessary for the new content could also be helpful. This would be a good opportunity for the students with difficulties in understanding to better connect the known principles that they already forgot with the new knowledge.

We believe that protecting access to the i-textbooks with username and password could enable efficient tracking of the work of the students. An application could be developed that would enable students' insight into their own activities and also trigger the alarm and send the notification to students through e-mail or mobile application. Perhaps this would trigger more responsible home learning.

With real-time analysis, the application could prepare the appropriate set of tasks with less or more difficulties for the specific student and therefore allow him/her (and demand from him/her) learning at the individual pace and difficulty level. Such application could also analyse such student's habits and help him/her to define the root cause for bad results. In the next generation of the students, the application could search for patterns and send early warnings to students with the same bad habits in learning mathematics.

V. CONCLUSION

The use of i-textbooks in Slovenian school environment has become a reality in the present and most probably also in the future of education. Fear, mistrust, concerns and doubts are a natural response of a teacher, who is faced with new forms and methods of teaching. Sometimes these novelties are in a virtual or actual conflict with the traditional notions of teaching and learning, and often - quite the opposite - open new opportunities. We believe that each novelty, that withstands fundamental professional judgment, is worth introducing, testing and being offered to students as an option for a different method of knowledge construction.

We were focused on students with difficulties due to low self-esteem, students with problems in understanding the content, poorly motivated students, and students with disabilities in concentration. All of these groups of students with the same types of problems are typical of the Z generation we were talking about.

The "E-textbooks" project brought a fresh perspective on the preparation and use of e-textbooks in Slovenia and other countries. It has enabled an introduction of the currently most feasible pedagogical paradigms, such as class free schools, and any other new educational approaches in the future. However, the Z-generation is sometimes very demanding and critical. We believe that professional bodies that work on the development of i-textbooks should also include Z generation students to help in development. Professional bodies that are working on development should at least hear students' opinions about the content and discuss the ideas how to improve i-textbooks.

References

- [1] Anupriya Kaur, Medury, Y. (2011). Impact of the internet on teenagers influence on family purchases, *Young Consumers: Insight and Ideas for Responsible Marketers*, 12(1), 27-38.
- [2] Barna, G. (2001). *Real Teens*. Regal Books, Ventura.
- [3] Barnes, H. (2004). Realistic mathematics education: Eliciting alternative mathematical conceptions of learners. *African Journal of Research in Mathematics, Science and Technology Education*, 8(1), 53-64.
- [4] Kaplan, A. (2012). If you love something, let it go mobile: Mobile marketing and social media 4x4, *Business Horizons*, 55(2), 129-139.
- [5] Jones, C. and Shao, B. (2011). *The net generation and digital natives: implications for higher education*. Higher Education Academy, New York.
- [6] Keller, J. M. (2009). *Motivational design for learning and performance: The ARCS model approach*. Springer Science & Business Media.
- [7] Lesgold, A. (2013). Information Technology and the Future of Education. V Lajoie, S.P. and Derry, S.S. (Ur.) *Computers as cognitive tools*. London: Routledge.
- [8] Lipovec, A. and Antolin, D. (2013). Slovenian pre-service teachers' prototype biography. *Teaching in higher education*, 19(2). 1-11.
- [9] Lipovec, A., Pesek, I., Zmazek, B. and Antolin Drešar, D. (2015). Interaktivni konceptualni apleti v i-učbeniku kot mediatorji problemskih znanj. [= Interactive conceptual applets in i-textbook as a mediator of problem knowledge.] *Uporabna informatika*, 23(1), 52-62.
- [10] Palfrey, J. in Gasser, U. (2008). *Born Digital: Understanding the First Generation of Digital Natives*. Basic Books.
- [11] Pesek, I., Zmazek B. and Milekšič V. (2014). Slovenian i-textbooks, <http://www.zrss.si/digitalnknjiznica/slovenian-i-textbooks/>.

- [12] Pintrich, P. R. (2002). The Role of Metacognitive Knowledge in Learning, Teaching, and Assessing. *Theory Into Practice*, 41(4), 219-225.
- [13] Troutwein, U., Köller, O., Schmitz, B. In Baumert, J. (2002). Do Homework Assignments Enhance Achievement? A Multilevel Analysis in 7th-Grade Mathematics. *Contemporary Educational Psychology*, 27(1), 26–50.
- [14] Zmazek, B., Lipovec, A., Pesek, I., Zmazek, V., Šenveter, S., Regvat, J., Prnaver, K. (2012) What is an e-textbook?. *Metodički obzori*, 7 (15), 127-139
- [15] Zorek, J. A., Sprague, J.E. and Popovich, N.G. (2010). Bulimic Learning. *Americal Journal of Pharmaceutical Education*, 74(8), 157-165