Research on the use of Digital Tools by STEM Students at the University of Rijeka

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Abstract **– The use of digital tools for learning has the potential to positively affect student motivation. While exploring the extent of use of digital tools for learning by STEM students at the University of Rijeka, it was observed that the current level of use is not at the expected level. Obtained research results have shown that surveyed STEM students are currently not encouraged nor intrinsically motivated enough to explore the possibilities of using freely available digital tools for learning. With the aim of influencing student motivation, we propose building an evaluation system in STEM education based on the principles of Educational Recommender System.**

Keywords **– digital tools, STEM, Educational Recommender System, ELARS, Design-Based Research.**

1. Introduction

Extensive research has been done in the field of educating students in the disciplines of science, technology, engineering and mathematics (STEM) with the aim of improving students' motivation. A number of different motivational strategies have been employed such as: defining learning and teaching styles that are compatible [1], formulating principles for designing materials for teaching and learning [2], [3], introducing e-tivities and using active learning approaches [4], [5], organizing blended learning courses [6], [7], using online formative assessments [8], [9] or using personalized assessment approach [10], [11].

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Along with various motivational strategies, usage of different freely available digital tools within the learning process proved to positively affect student motivation [12], [13], [14]. These digital tools foster communication among students (but also between students and their teachers) enabling them to share ideas, knowledge, content, and resources thus stimulating student's creativity during learning. Also, easy access to digital tools offers a possibility for their uninterrupted use by students whenever they need them [15], [16].

For the reasons stated above, the inclusion of digital tools in education process (either by teachers or by students themselves) can significantly contribute in increasing students' motivation for the different aspects of the teaching and learning processes [17]. At the same time, the inclusion of digital tools can improve student learning experience while simultaneously preparing them for self-regulated learning that is crucial for lifelong learning they will be facing through their future careers [18].

Research conducted at the University of Rijeka in its first phase included the design and development of ELARS (E-Learning Activities Recommender System) with the aim of incorporating Educational Recommender System (ERS) in the formal education processes. The main purpose of the developed system was to encourage personalization of collaborative learning activities that are performed using various digital tools. The system was tested in practice on several different computer science courses and it was showed that such an approach can motivate students to use digital tools to acquire knowledge [7], [14].

In the second phase of the research, the aim was to motivate not only computer science students but also STEM students to use digital tools for learning [13].

Design-Based Research methodology (DBR) was chosen because it provided the possibility of introducing appropriate modifications based on the obtained results simultaneously with the ongoing research. DBR as a repetitive model of designing and adapting the learning process through iterative refinements enables collaboration between students, teachers, and researchers as equal active participants in the overall learning process [19]. Also, a classical

experimental approach that implies setting the hypothesis and conducting research with the aim to analyze results once the research is fully completed can become ineffective in the testing of educational theories in a real educational environment [20].

With the aim to motivate STEM students to use digital tools for learning, we incorporated ELARS in their formal learning environment. Appropriate digital tools for STEM learning were promoted through the system and the students were encouraged to use them as a part of their learning activities. Initially obtained results suggested that the current use of digital tools among STEM students is not at the expected level.

The research presented in this paper explored more thoroughly the current state of use of digital tools for learning in the STEM area. The research also aims to contribute to the field by examining STEM students' attitudes toward the possibility of using digital tools as a part of the learning process. The obtained results of this first cycle of DBR are discussed and possibilities for future research that will involve the use of ERS in order to promote the use of digital tools for learning activities are identified.

2. Methodology

In order to examine the current state of use of digital tools by STEM students, the following research questions (RQ) were explored:

RQ1. What are students' attitudes towards the use of new technologies in general and their knowledge about the variety of freely available digital tools?
RQ2. How often and in what form students encounter the use of digital tools in learning activities organized by the teachers?
RQ3. What are students' attitudes towards the use of digital tools for learning?

These research questions were chosen because they are most suitable for exploring the current state of digital tools incorporation in learning activities.

A paper-based questionnaire consisting of a set of single-answer multiple choice questions (shown in Section 3) was devised and conducted. The questionnaire had three parts, each enveloping one of the RQ. Within the questionnaire, participants were presented with a list of 12 different digital tools. These tools were selected because they are freely available, they enable communication and interaction between multiple users, and can be used for joint teamwork on suitable tasks.

The participants were 347 students enrolled in six different STEM study programs at the University of Rijeka, as shown in Table 1.

Table 1. Study programs and the number of participants in the survey.

Study program	Number of participants
Undergraduate University Study of Mechanical Engineering	162
Undergraduate University Study of Naval Architecture	15
Undergraduate University Study of Electrical Engineering	74
Undergraduate University Study of Polytechnics	19
Undergraduate University Study of Computing	50
Undergraduate Vocational Study in Electrical Engineering	27

3. Research results

3.1. Students' attitude towards the use of new technologies and their knowledge about freely available digital tools

In order to find the answer to the RQ1 students were asked to express their views on the way they accept and start using new technologies in general. Obtained results showed that 64.27% of surveyed students start using new technologies at the same time as their peers, 26.22% as soon as these technologies become available, while 4.32% of them start using new technologies only when most of their peers have been using them for some time. Only 5.19% of surveyed students stated that they are not interested in the use of new technologies in general.

Figure 1. shows results regarding students' familiarity with 12 different digital tools. It shows that the two most popular (Facebook and YouTube, tools that were developed primarily for the entertainment purposes) are used by 98,27% and 97,98% respectively while two most unknown (MindMeister and Diigo, tools that were developed with the aim to be used in education) are used respectively by 0,58% and 1,44 % of surveyed students.

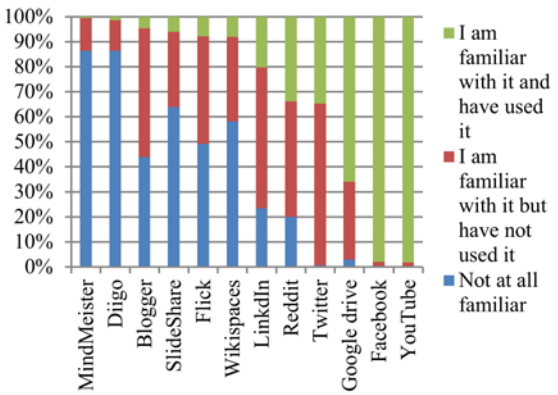

Figure 1. Students' familiarity with freely available digital tools.

3.2. The use of digital tools in the teaching process (organized by the teachers) form students' perspective

Through RQ2 of the questionnaire, the main aim was to explore how often surveyed students encounter the organized use of digital tools incorporated within learning activities. Out of the total number of 347 students included in this research, only 127 (36.60%) of them encountered the organized use of digital tools.

The ratio of courses that belong versus courses that do not belong to computer science among courses within which students have encountered the organized use of digital tools was about two to one in favor of computer science courses. Approximately half of the students that encountered organized use of digital tools for learning used them in both types of courses.

Detailed results obtained for each question in this part of the questionnaire are presented in Table 2.

Table 2. Survey results (organized use of digital tools in the teaching process).

Have you ever been encouraged to use digital tools by your teachers?	
No	38.90%
Yes, in a smaller number of courses	51.30%
Yes, in a greater number of courses	9.51%
Yes, in all courses	0.29%
Have you ever been expected to use digital tools to handle specific task within the course?	
No	63.11%
Yes, in a smaller number of courses	34.58%
Yes, in a greater number of courses	2.31%
Has the course within which you have used digital tools belonged to the computer science?	
Yes	36.22%
No	18.90%
Some belonged and some didn't belong to CS	44.88%
Did you have to learn to use digital tools on your own or have you been instructed how to use them by your teacher?	
I was instructed by my teacher	14.96%
I had to learn on my own	61.42%
I was instructed but also had to learn on my own	23.62%
Has the use of digital tools affected your overall grade in this course?	
Yes	46.46%
No	53.54%
Have you used digital tools for standalone or teamwork?	
Standalone work	54.33%
Teamwork	12.60%
Sometimes for standalone and sometimes for teamwork	33.07%
In your opinion, did the use of digital tools help you to better handle the course content?	
No	6.30%
It has helped me minimally	14.17%
It has helped me moderately	66.14%
It has helped me maximally	13.39%

3.3. Students' attitudes toward the use of digital tools for learning

The aim of the third part of the questionnaire was to find the answers to the RQ3 regarding students' attitudes toward the use of digital tools for learning. Although their attitude proved to be overall positive, surveyed STEM students emphasized that they expect to be additionally motivated and encouraged to use these tools for learning by their teachers.

Detailed results obtained for each question in this part of the questionnaire are presented in Table 3.

Table 3. Survey results (students attitude toward the use of digital tools for learning)

If you do not use digital tools for learning please select one of the offered reasons.	
Don't know how to use them	7.75%
Don't have time to learn how to use them	5.04%
I am not encouraged to use them by my teachers	71.32%
I'm not interested in using them	15.89%
Which of the following answers best describes your attitude towards using digital tools for learning?	
I do not plan to use digital tools for learning	10.66%
Sometimes I use digital tools for learning	40.35%
I would love to use them but I don't	30.55%
I use them whenever I can	18.44%
Have you used digital tools for communication and/or consultations with the course teacher?	
No	70.89%
Sometimes, only for communication	17.87%
Sometimes, only for consultations	3.17%
Yes, sometimes for communications and consultations	8.07%
Have you ever used digital tools for communication and/or teamwork with your colleagues?	
No	4.03%
Yes, for communication	17.29%
Yes, for teamwork	8.36%
Yes, for communication and teamwork	70.32%
Do you know if your colleagues use digital tools for learning?	
I don't know	27.38%
I think that some of them do	51.59%
I know that some of them do	21.04%
Do you think that knowing that your colleagues use digital tools would encourage you to start using them?	
It would not encourage me	18.44%
Maybe it would encourage me	65.42%
It would definitely encourage me	16.14%
Do you think that using digital tools could make learning more interesting?	
No, it would not	12.39%
I am not sure if it would	37.75%
I think it would	49.86%

4. Discussion of obtained results and possibilities for future research

4.1. Discussion of obtained results

Results obtained through the conducted survey clearly show that surveyed STEM students minimally use digital tools for learning. Since there is a great

body of evidence that indicates that use of different freely available digital tools within the learning process can positively affect student motivation [12], [17], this results point to the unused potential that can be utilized in order to improve the learning activities.

Surveyed students encounter organized use of digital tools only in a small number of courses, usually with computer science content. Research results also indicate that they do not necessarily try to find digital tools developed for use in education on their own. It appears that they are more oriented toward tools which they already use for entertainment purposes (i.e. YouTube and Facebook) which correspond to the other research results such as [16]. In this way, they miss the opportunity to enrich their learning experience by using tools designed for and proved to be useful for education, such as Wikispaces, Diigo, SlideShare, and MindMeister.

Majority of surveyed students use digital tools for individual work and only a small number of students for teamwork. Since these tools are primarily designed to be used by multiple users working on the same problem at the same time, it can be concluded that even when digital tools are introduced into teaching and learning process that they are used only through their basic capabilities.

Nevertheless, most of the students who have encountered the organized use of digital tools for learning believe that using digital tools moderately or maximally helped them to overcome the content of the course. These results indicate that surveyed students do find digital tools an interesting and helpful instrument for learning and that they are willing to accept their incorporation in teaching and learning processes.

Regarding students' attitude toward the use of digital tools for learning, results presented in Table 3. show that predominant feeling among students is that they are not encouraged enough by their teachers to incorporate digital tools in learning activities. From these results, it can be infered that surveyed students expect to be additionally encouraged by their teachers to use digital tools and are not proactive in incorporating digital tools into their learning practices on their own. It can be concluded that by helping students to learn about digital tools and the ways they can be utilized for learning it should be possible to additionally affect their motivation thus enabling them to achieve better overall learning results.

From the obtained results, it can also be seen that students commonly use digital tools for communication among themselves, but generally do not use them for communication with their teachers. These results point to the unused potential that teachers can use to promote the use of digital tools outside specific tasks within course content. Communication that these tools offer can be used as a starting point for encouraging students to further develop their creativity through collaboration with their teachers and colleagues while learning.

Results also show that students can encourage their colleagues to use digital tools for learning just by example. This can be related to their assessment that most of them think that with the use of digital tools, learning would become more interesting.

By reviewing all the obtained results it can be summarised that there are two fundamental problems that should be addressed in future research:

- Digital tools in teaching and learning processes among surveyed STEM students are currently minimally used,
- Surveyed students are ready to use digital tools for learning but they lack encouragement and additional motivation that they expect from their teachers.

4.2. Discussion of possibilities for future research

In order to try to address the identified problems, future research will involve the use of Educational Recommender System in order to promote the use of digital tools for learning. By recommending the use of appropriate digital tools for individual or collaborative work on a greater number of smaller assignments, STEM students should be able to accept the use of digital tools for learning more easily, thus gaining the habit of their continuous use.

By using Educational Recommender System for promoting the use of digital tools for learning, it should be easier for teachers to incorporate digital tools into their teaching. Teachers do not need to master the advanced capabilities of these tools in order to incorporate them into their classroom practices. Knowing basic capabilities should be enough to begin, and mastering advanced capabilities by teachers could be done during the same time period these tools are initially used in the education environment.

On the other hand, STEM students usually apply different forms of information and communication technologies (ICT) in their profession. Because of that, it can be expected that STEM students will be able to more easily accept and, together with basic capabilities, use the advanced options that are offered by different digital tools. If during the use of digital tools for learning, students show that they are more knowledgeable then their teacher regarding the capabilities of these tools, it should not in any way prevent their use in the educational process. On the contrary, the more knowledgable the students are the more they can get out of the use of digital tools for learning by working on the assignments prepared by their teachers in more innovative and original ways.

A positive trend that was observed from the conducted research was that the surveyed students welcome the idea of incorporating digital tools into their learning. As can be seen from their answers presented in Table 3., they would like to use them more often. Since a great deal of research suggests that digital tools can be used as motivational approach to learning [21], [22], this can be used as a starting point for incorporation of innovative motivational strategies based on them.

In the next cycle of the research, introduction of digital tools for learning through Educational Recommender System ELARS integrated with an online evaluation system for STEM education will be combined. This approach was devised with the aim of motivating STEM students to work more continuously during the semester. Previous research results also suggested that when students work continuously on their assignments that usually influence their success in learning and that they achieve better overall learning results [23].

It should be pointed out that presented research was conducted at one university, and it shows the current state at this particular university. Whether the observed results correspondent to the conditions at the other universities in Croatia or other universities in other countries is at this time unclear and should be a part of the future research activities.

5. Conclusion

The main goal of the presented research was to explore the current state of digital tools usage among STEM students at the University of Rijeka. In order to do this, students' attitudes toward the use of new technologies, their familiarity and experience together with their attitude toward using different digital tools for learning was researched through the use of a paper-based questionnaire.

According to the obtained results related to RQ1, students in general welcome new technologies and want to use them. They are familiar with the most popular digital tools but ignorant of digital tools primarily developed for the use in education. During their study, surveyed students rarely encounter organized use of digital tools for learning. When they do encounter them, they accept their incorporation in learning easily and these tools generally help them to master the course material (RQ2). Students' attitudes toward the use of digital tools for learning are overall positive but that they expect to be additionally motivated by their teachers to use them in this fashion and that they do not show proactive approach (RQ3).

Presented results indicate that there is a lot of room for improvement primarily in terms of motivating STEM students to use digital tools for learning. From the interpretation of all gained results, it can be concluded that this problem can be addressed through the use of digital tools as a part of the motivational strategies devised and implemented for STEM education.

The idea of combining standard elements of Educational Recommender Systems with an online evaluation system for STEM education emerge as a motivational strategy that can be used in the next phase of research. Also, using Design-Based Research as a basic methodology for future research should ensure an adequate starting point for the execution of planned educational research.

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