

Educational software for learning psychics - combination of simulations and formative assessment

Biljana Đorić ^{1*}, Dragan Lambić ², Željko Jovanović ¹

¹ University of Kragujevac, Faculty of Technical Sciences Čačak, Serbia

² University of Novi Sad, Faculty of Education, Sombor, Serbia

* biljana.djoric@ftn.kg.ac.rs

Abstract: *Based on results of literature review in the field of computer simulations, feedback and formative assessment, educative software which contains simulations and elements of formative assessment is presented in this paper. The software is created for the purpose of learning as well as for evaluating efficiency of this learning approach on learning process and students' achievement in field of psychics. The evaluation of usefulness of this software should be investigated in the future from different aspects.*

Keywords: *simulation; feedback; formative assessment; electrical circuit*

1. INTRODUCTION

Short theoretical bases and literature review about usefulness of computer simulations and different types of feedback in education are given in this section.

1.1. Simulation in STEM education

Computer simulations are tools for demonstrating real physical process and they enable changing parameters and measurement in interactive virtual environments. Simulations are based on constructivist learning theory and engage students in being active participants in learning process [1]. According to this, simulations are useful for developing inquiry skills. By using the simulations, students identify problem, set own hypothesis, analyses the results of observations, compare their hypothesis and make conclusions [2].

For example, teacher can require from students to decide what will happen with the value of electrical current in the electrical circuit if the parameters of voltage or resistance are changed. Firstly, students identify problem regarding to given values and parameters in circuit. In other words, they find the relationships between elements in circuit and given variables. Secondly, students set a hypothesis with own solution and then they check their understanding by using simulation. Depending on whether students set hypothesis correctly they can improve understanding and overcome misconceptions or confirm knowledge. This can enhance retention of content in long-term memory and facilitate applicability of knowledge.

Applicability of simulation in teaching is a topic investigated very often in the field of STEM

education. The large number of authors have found the positive effects of using computer simulation in different subject areas. For example, authors of numerous studies recommend using simulations for enhancing conceptual understanding of content [3], [4], [5], [6].

On the other hand, literature review suggests that there are a lot of studies which deal with comparing effects of using computer simulations to traditional approach – hand on activities with real equipment and their combined application on students' conceptual understanding. The results of these studies indicate that computer simulations are effective tools when used in combination with hand-on activities [7], [8]. Similarly, the other studies have found positive influence of using computer simulation like preparation for hand-on activity [9], [10].

However, there are studies which results indicate that there are no differences in efficiency simulations and hand-on activity [11]. According to that, it can be concluded that simulation can be at least effective as traditional activity. Nevertheless, simulations can replace the use of traditional labs and reduce costs of equipment as well as dependence on time and place.

1.2. The role of formative assessment and feedback in learning process

Formative assessment is defined as procedure which includes discovering what student know and how students achieve the set aims of learning. Based on results of formative assessment, teachers decide whether instructions were effective and develop new instructional strategies to improve students' learning [12]. On the other hand,

students receive feedback about finished task. In this way, students see where they made mistake or confirm their knowledge. This can lead to the adoption of new learning strategies [13]. Feedback which students receive need to be constructive and to help students reflect own learning process. According to this, there are two general types of feedback [14]: directive – guides students what need to be improved and facilitative feedback which contains comments and suggestions for solving problems.

Thus indirectly, feedback as key component of formative assessment can have significant influence on learning process [15].

In computer –based environment, numerous types of feedback are applicable [14]: verification feedback (knowledge of results – KR); correct response (knowledge of correct response – KCR); repeat-until-correct feedback; elaborated feedback (providing explanation why a specific task was correct or wrong). There are a few types of elaborated feedback (EF). Some of them include giving central attributes of target concept; focuses on the specific students' response; feedback with re-teaching material; feedback which requires error analysis and diagnosis; feedback which guides the students to what to do next or gives a worked example or demonstration.

Studies have shown positive effect of elaborated feedback on conceptual understanding [16]. However, the effect of elaborated feedback can vary depending on content and context of learning [17].

For example, Meyer et al. [18] found more positive effect of EF on students' reading comprehension than simple feedback. Other authors claim that EF is more useful for learning in combination with KCR feedback than KR feedback [19]. Authors of meta-analysis which investigated effect of feedback in computer-based environment found that ER is more effective from simpler form of feedback only for higher learning outcomes [15]. Because of that, there are a lot of factors which can influence feedback effectiveness. Also, depending on students' abilities to understand feedback and use it in the correct way, usefulness of feedback can vary [20]. Similarly, Timmers & Veldkamp [21] claim that attention paid to feedback by students depends on length of explanations as well as task difficulty.

The results of other study showed that EF has more positive effect on solving new tasks in comparison to repeated tasks [22]. Thus, when students once receive feedback in form of explanation, students can conclude whether they have reasoned correctly and eventually where they have made mistakes. It

can help students to solve similar task in other attempts.

Based on mentioned researches which confirm usefulness of using simulations and elements of formative assessment, particularly elaborated feedback, these approaches are integrated for creating education software in the field of physics.

The aim of this paper is to describe created software for learning physics. Nevertheless, this paper represents the opportunities for using educative software with simulation in combination with elaborated feedback in education. Mentioned educative software can be an example for using similar software solution in different subject.

2. SOFTWARE SOLUTION

Created software contains simulation of electrical circuit, instruction based on text and images, as well as elements of formative assessment. The software is intended for 8th grade primary school students. Lessons are based on curriculum content for 8th grade [23]. The software was created by the authors of this paper.

Simulations were created in LabView v12 software package [24] and an interactive web page in Java programming language and HTML. Simulations are based on measurement of the values of the total current and voltages on the end of resistors in circuit (for circuit in serial connection) or currents in branches of electrical circuit in parallel connection depending on given values of voltage and resistances (Figure 1). Simulation also contains hint for using simulation when students need to learn without teacher support (yellow field). On the right side student can see graphs which present changes in the values of voltage and current in set time.

The tests in lessons contain tasks which measure different levels of achievement according to Blooms' taxonomy [25]. In tests there are tasks which require factual knowledge (e.g. knowing the units of voltage, resistance and current); understanding (e.g. understanding the relationships between voltage, resistance and current); applying acquired knowledge (e.g. calculating the value of current); relationships analysis between elements (e.g. predicting what will be happen with total current and current in one branch if the value of resistance in other branch are changed).

Student first access web page inputting name, surname, name of school and class into log in page.

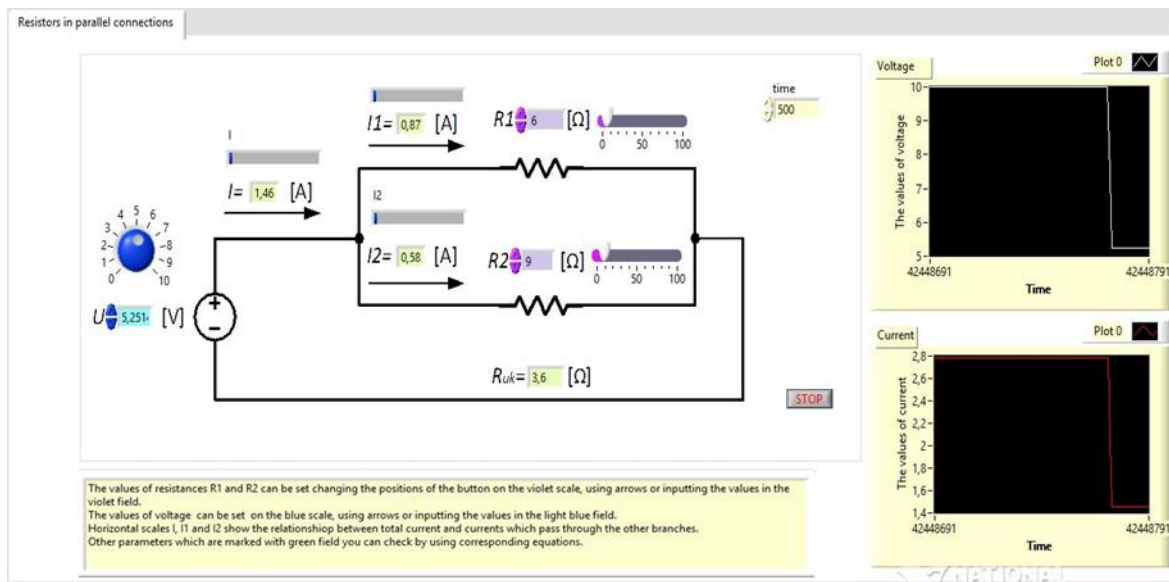
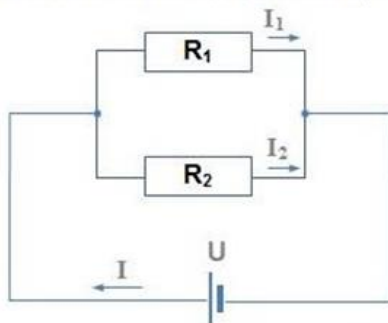


Figure 1. Simulation - parallel connection

Then, students get access to web page which contains instructions for learning Ohms' law. The aim of this page is to familiarize student with simple electrical circuit and measurement of electrical current and voltage. The web page contains link to first simulation. When students access to simulation and finish measurement, they can get test for this part of lesson. If students do not pass lesson, software will give instruction for accessing

first simulation again and elaborated feedback in forms of explanations for each task but without giving information about correct and incorrect answers. The aim of this type of feedback is to direct student how to find a solution for similar tasks. After that, student can access test again. When student passes the test, software will give elaborated feedback again for each task and KCR feedback (Figure 2).

2. For the two resistors $R_1 = 5\Omega$, $R_2 = 5\Omega$ in parallel, and $U = 10V$, as shown in Figure , the calculated values of R_e , I , I_1 , I_2 will be:



- $R_e=2,5\Omega$; $I=4A$; $I_1=2A$; $I_2=2A$ ✓
- $R_e=2,5\Omega$; $I=4A$; $I_1=0,5A$; $I_2=0,5A$
- $R_e=10\Omega$; $I=1A$; $I_1=0,5A$; $I_2=0,5A$
- I DO NOT KNOW



Since, it is $R_e = R_1 * R_2 / R_1 + R_2$. The value of the current is equal to the voltage and the equivalent resistance ratio. The value of the individual currents is equal to the total voltage and resistance value through which this current flows ratio. Check if you've used these equations to get the right solution!

Figure 2. Example of elaborated feedback + KCR feedback (passed test)

Then, students can access to second part of lesson – serial connection of resistors in electrical circuit. The procedure for testing is repeated until students pass the second test. After that, student can access the third part of lesson – parallel connection of resistors in electrical circuit (Figure 1). When students finish this part including accessing to

simulations and passing test, they receive message about whole finished lesson.

For each test, reports with information about students' achievement, percentage of correct and incorrect answers, and number of attempts to solving tests are given. Tests have dynamic form

which gives opportunities for randomly choosing the task from the date base for each new solving tests attempt. In this way teacher can track achievement for each task, analyze task and get feedback about students' misconceptions. Based on these results, teacher can conclude which types of

tasks are difficult for students and which points of content are critical.

The simplified algorithm of presented software is given (Figure 3).

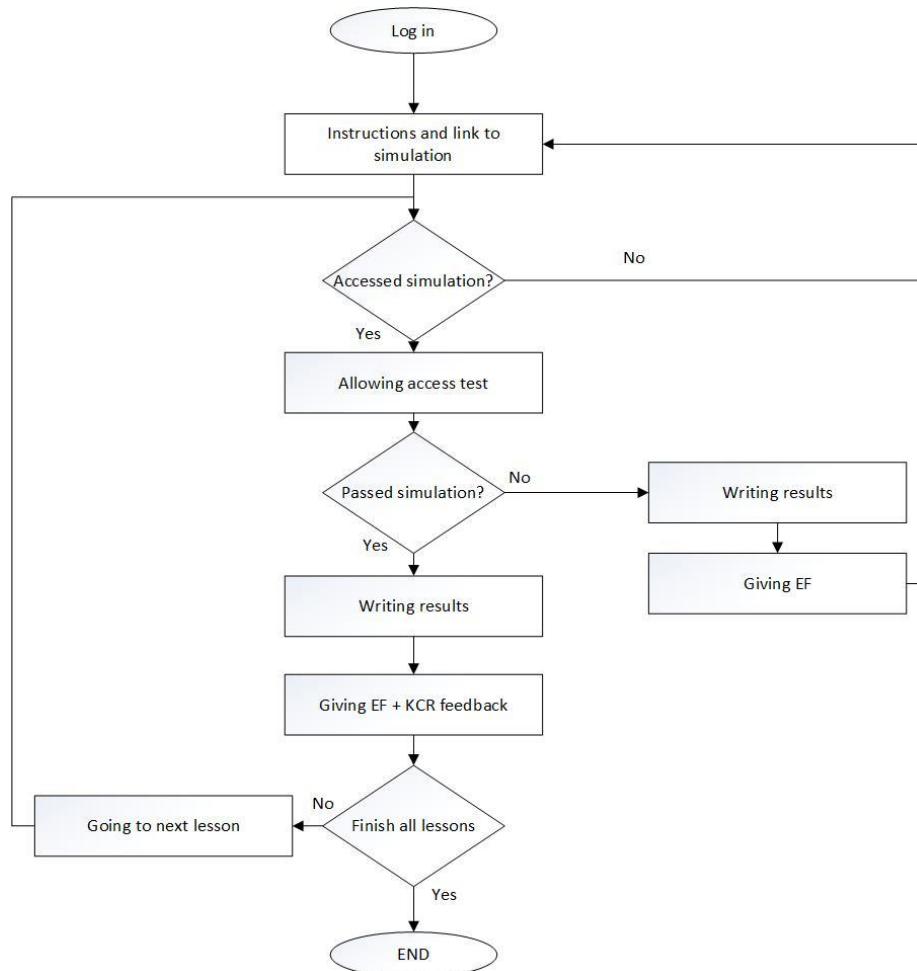


Figure 3. Algorithm scheme

3. CONCLUSION

As it has already been mentioned, efficiency of any type of feedback must not be generalized for all learning context, subject and students. Because of that, created software can be used as educative tool for learning physics as well as tool for evaluating usefulness of elaborated feedback in combination with KCR feedback in this field. Nevertheless, the created software is based on three-layer software architecture which enables students to acquire content divided in three parts (Ohms' law, serial connection and parallel connections) and can make learning less difficult and more systematic. According to this, this software should be evaluated from more aspects to determine which factors make it effective for learning. It can be influence of instructions, feedback, simulation, as well as three-layer organized lesson.

ACKNOWLEDGEMENTS

This study was supported by the Serbian Ministry of Education and Science, Project OI 179026.

REFERENCES

- [1] Faraco, G. & Gabriele, L. (2007). Using LabVIEW for applying mathematical models in representing phenomena. *Computers & Education*, 49(3), 856-872.
- [2] Zacharia, Z. C., Manoli, C., Xenofontos, N., de Jong, T., Pedaste, M., van Riesen, S. A., ...Tsourlidaki, E. (2015). Identifying potential types of guidance for supporting student inquiry when using virtual and remote labs in science: A literature review. *Educational*

- Technology Research and Development*, 63(2), 257-302.
- [3] Akpınar, E. (2014). The use of interactive computer animations based on POE as a presentation tool in primary science teaching. *Journal of Science Education and Technology*, 23(4), 527-537.
- [4] Ülen, S., Čagran, B., Slavinec, M., & Gerlič, I. (2014). Designing and evaluating the effectiveness of Physlet-based learning materials in supporting conceptual learning in secondary school physics. *Journal of Science Education and Technology*, 23(5), 658-667.
- [5] Kollöffel, B. & de Jong, T. (2013). Conceptual understanding of electrical circuits in secondary vocational engineering education: Combining traditional instruction with inquiry learning in a virtual lab. *Journal of engineering education*, 102(3), 375-393.
- [6] Chang, K. E., Chen, Y. L., Lin, H. Y., & Sung, Y. T. (2008). Effects of learning support in simulation-based physics learning. *Computers & Education*, 51(4), 1486-1498.
- [7] Zacharia, Z. C. (2007). Comparing and combining real and virtual experimentation: an effort to enhance students' conceptual understanding of electric circuits. *Journal of Computer Assisted Learning*, 23(2), 120-132.
- [8] Olympiou, G. & Zacharia, Z. C. (2012). Blending physical and virtual manipulatives: An effort to improve students' conceptual understanding through science laboratory experimentation. *Science Education*, 96(1), 21-47.
- [9] Limniou, M., Papadopoulos, N., & Whitehead, C. (2009). Integration of simulation into pre-laboratory chemical course: Computer cluster versus WebCT. *Computers & Education*, 52(1), 45-52.
- [10] Limniou, M., Papadopoulos, N., Giannakoudakis, A., Roberts, D., & Otto, O. (2007). The integration of a viscosity simulator in a chemistry laboratory. *Chemistry Education Research and Practice*, 8(2), 220-231.
- [11] Tatli, Z., & Ayas, A. (2013). Effect of a Virtual Chemistry Laboratory on Students' Achievement. *Educational Technology & Society*, 16 (1), 159-170.
- [12] Regier, N. (2012). *Book two: 60 Formative assessment strategies*. Regier Educational Resources.
- [13] Baas, D., Castelijns, J., Vermeulen, M., Martens, R., & Segers, M. (2015). The relation between Assessment for learning and elementary students' cognitive and metacognitive strategy use. *British Journal of Educational Psychology*, 85(1), 33-46.
- [14] Shute, V. (2007). *Focus on Formative Feedback*. ETS Research Reports. Available on: <https://www.ets.org/Media/Research/pdf/RR-07-11.pdf>
- [15] Maier, U., Wolf, N., & Randler, C. (2016). Effects of a computer-assisted formative assessment intervention based on multiple-tier diagnostic items and different feedback types. *Computers & Education*, 95, 85-98.
- [16] Maier, U., Randler, C., & Wolf, N. (2016). Effects of computer-based, formative tests with diverse feedback formats on student performance in science classes. *ZEITSCHRIFT FÜR PADAGOGIK*, 62(2), 241-262.
- [17] Meyer, B. J., Wijekumar, K., Middlemiss, W., Higley, K., Lei, P. W., Meier, C., & Spielvogel, J. (2010). Web-based tutoring of the structure strategy with or without elaborated feedback or choice for fifth-and seventh-grade readers. *Reading Research Quarterly*, 45(1), 62-92.
- [18] van der Kleij, F., Eggen, T. J. H. M., Timmers, C. F., & Veldkamp, B. P. (2012). Effects of feedback in a computer-based assessment for learning. *Computers & Education*, 58(1), 263-272. DOI: 10.1016/j.compedu.2011.07.020
- [19] van der Kleij, F., Feskens, R. C. W., & Eggen, T. J. H. M. (2015). Effects of feedback in a computer-based learning environment on students' learning outcomes: a meta-analysis. *Review of educational research*, 85(4), 475-511. DOI: 10.3102/
- [20] Mulliner, E., & Tucker, M. (2017). Feedback on feedback practice: Perceptions of students and academics. *Assessment & Evaluation in Higher Education*, 42(2), 266-288.
- [21] Timmers, C., & Veldkamp, B. (2011). Attention paid to feedback provided by a computer-based assessment for learning on information literacy. *Computers & Education*, 56(3), 923-930.
- [22] Butler, A. C., Godbole, N., & Marsh, E. J. (2013). Explanation feedback is better than correct answer feedback for promoting transfer of learning. *Journal of Educational Psychology*, 105(2), 290-298.
- [23] Zavod za unapređenje obrazovanja i vaspitanja, <http://zuov.gov.rs/nastavni-planovi-i-programi/>
- [24] LabView, <http://www.ni.com/download/labview-development-system-2012-sp1/3692/en/>
- [25] Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice*, 41(4), 212-218.