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Effects of Using Project-Based Learning in Teaching Biology

Extended summary

Numerous studies indicate that traditional teaching, in which the teacher occupies a central role and students are generally not very active in class, does not produce the expected results in terms of student achievement in class. This is proved by the relatively poor results of our students on international tests such as PISA and TIMSS. One of the solutions for overcoming this problem is the wider application of the project-based learning (PBL) in schools.

Biology as a multidisciplinary natural science offers numerous opportunities for organizing teaching, both in the classroom and in the natural environment, which additionally opens up new perspectives for the application of project teaching. Project-based teaching enables students to be more active, by solving tasks within the project, in class and to acquire knowledge through practical activities and experience.

The goal of the research was to determine the effectiveness of the PBL application in terms of students' success in knowledge tests, then in terms of the durability of the acquired knowledge, and the mental effort that students invest in applying different teaching models.

The research sample included 406 students from four primary schools in Novi Sad (Republic of Serbia). A total of 202 students from two primary schools made up the experimental group (E), and 204 students from the other two primary schools made up the control group (K).

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The research instruments that were created for the purposes of the experiment include the following: initial knowledge test, final knowledge test, retest, and a scale for assessing students' mental effort. At the beginning of the pedagogical research, the students of groups E and K were equalised, based on the results of the initial knowledge test which measured the students' prior knowledge of the contents of the subject The World Around Us, which was a prerequisite for the students' successful work, understanding and adoption of the content of the teaching topic "Origin and Diversity of Life" within the school subject Biology. After the initial testing, two different teaching approaches were applied in the implementation of the biology content in the two groups of the fifth-grade students. The students of the group E implemented the teaching topic "Origin and diversity of Life" using PBL, by means of the assigned mini-projects. In the classes of the K group, teaching was carried out in accordance with the traditional model of covering the teaching topic "Origin and Diversity of Life". After the completion of the planned teaching content, the final test was conducted as a part of the pedagogical experiment, and, a month later, the retest was conducted in order to check the durability of the knowledge acquired by using different teaching models. The final test and the retest included the content from the teaching topic "Origin and Diversity of Life", which was covered during the research. Within each question, on the final test, there was also a five-point Likert scale for the self-assessment of the mental effort the student makes when solving the tasks.

Statistical data processing was done in the JASP program. The t-test was used to examine the differences in student achievement on the initial test, final test and the retest, with a significance threshold of p=.05. The data on the progress of students of the E and K groups from the initial test to the final knowledge test and the retest were processed using a combined analysis of variance (Two-Way Mixed ANOVA).

The results of the research showed that project-based teaching is more effective than traditional teaching because the students of the E group achieved a statistically significantly better result than the students of the K group, both on the final knowledge test and on the retest administered one month after the final testing. This proved that the knowledge acquired by using PBL is of a higher quality and more permanent compared to the knowledge acquired by means of traditional teaching because in this type of organisation of teaching, the student is also the bearer of teaching activities. The very process of learning using PBL is aimed at the student who goes through a meaningful experience of mastering the material. Also, the mental effort that the students of the E group put into solving the tasks on the knowledge test is statistically significantly lower compared to the students who attended the traditional lessons.

The obtained results have theoretical and practical significance. They complement the empirical findings on the effectiveness of the PBL in teaching biology in primary education and provide important guidance, not only for biology teachers, but also for all teachers for introducing PBL into the teaching process. These findings encourage a wider application of the PBL in teaching, which can be an incentive for teachers and researchers to check the effectiveness of the PBL application in other subjects or at other education levels (secondary schools and colleges) in future research.

Keywords: project-based learning, project-based teaching, teaching biology, elementary school

References

- Afriana, J., Permanasari, A., & Fitriani, A. (2016). Project-based learning integrated to stem to enhance elementary school students' scientific literacy. *Journal Pendidikan IPA Indonesia*, *5*(2), 261–267. https://doi.org/10.21831/jipi.v2i2.8561
- Al Rasyid, M., & Khoirunnisa, F. (2021). The effect of project-based learning on collaboration skills of high school students. *Jurnal Pendidikan Sains*, *9*(1), 113–119. https://doi.org/10.26714/jps.9.1.2021.113-119
- Barron, B., & Darling-Hammond, L. (2008). Teaching for meaningful learning: A review of research on inquiry-based and cooperative learning. In G. N. Cervetti, J. L. Tilson, L. Darling-Hammond, B. Barron, D. Pearson, A. H. Schoenfeld, & T. D. Zimmerman (Eds.). *Powerful learning: What we know about teaching for understanding*. Jossey-Bass.
- Brophy, J. (2004). *Motivating students to Learn*. Lawrence Erlbaum Associates.
- Corvers, R., Wiek, A., De Kraker, J., Lang, D. J., & Martens, P. (2016). Problem-based and project-based learning for sustainable development. In H. Heinrichs, P. Martens, G. Michelsen & A. Wiek (Eds.). *Sustainability Science* (349–358). Springer. https://link.springer.com/chapter/10.1007/978-94-017-7242-6_29
- Đerić, I., Malinić, D., & Đević, R. (2021). Project-based learning: challenges and implementation support. In N. Gutvajn, J. Stanišić, & V. Radović (Eds.). *Problems and perspectives of contemporary education* (52–73). Institute for Educational Research.
- Ekstedt, E., Lundin, R. A., Söderholm, A., & Wirdenius, H. (1999). *Neo-institutional organising: Renewal by action and knowledge in a project-intensive economy*. Routledge.
- Eliana, E. D. S., Senam, S., Wilujeng, I., & Jumadi, J. (2016). The effectiveness of project-based e-learning to improve ict literacy. *Jurnal Pendidikan IPA Indonesia*, *5*(1), 51–55. https://doi.org/10.15294/jpii.v5i1.5789
- Fernandes, S., Mesquita, D., Flores, M. A., & Lima, R. M. (2014). Engaging students in learning: Findings from a study of project-based education. *European Journal of Engineering Education*, *39*(1), 55–67.
- Gagić, Z., Skuban, S., Radulović, B., Stojanović, M., & Gajić, O. (2019). The implementation of mind maps in teaching physics – educational efficiency and students' involvement. *Journal of Baltic Science Education*, *18*(1), 117–131. https://doi.org/10.33225/jbse/19.18.117
- Goodman, B., & Stivers, J. (2010). Project-based learning. *Educational psychology*, 1–8.
- Herreid, C. F. (2003). The death of problem-based learning*? Journal of College Science Teaching*, *32*(6), 364–366.
- Hug, T. (2010). Radical constructivism mainstreaming: A desirable endeavor? Critical considerations using examples from educational studies and learning theory. *Constructivist Foundations*, *6*(1), 58–65.
- Kapusuz, K. J., & Can, S. (2014). A survey on lifelong learning and project-based learning among engineering students. *Procedia – Social and Behavioral Sciences*, *116*, 4187–4192. https://doi.org/10.1016/j.sbspro.2014.01.914

- Keegan, A., & Turner, J. R. (2001). Quantity versus quality in project-based learning practices. *Management Learning*, *32*(1), 77–98. https://doi.org/10.1177/1350507601321006
- Knoll, M. (2012). "I had made a mistake": William H. Kilpatrick and the project method. *Teachers College Record*, *114*(2), 1–45.
- Košir, K., Dugonik, Š., Huskić, A., Gračner, J., Kokol, Z., & Krajnc, Ž. (2020). Predictors of perceived teachers' and school counsellors' work stress in the transition period of online education in schools during the COVID-19 pandemic. *Educational Studies*, *48*(6), 1–5. https://doi.org/10.1080/03055698.2020.1833840
- Lea, S. J., Stephenson, D., & Troy, J. (2003). Higher education students' attitudes to student centered learning: beyond "educational bulimia?" *Studies in higher education*, *28*(3), 321–334. https://doi.org/10.1080/03075070309293
- Levinthal, D. A., & March, J. G. (1993). The myopia of learning. *Strategic Management Journal*, *14*(S2), 95–112. https://doi.org/10.1002/smj.4250141009
- Loyens, S. M., & Gijbels, D. (2008). Understanding the effects of constructivist learning environments: Introducing a multi-directional approach. *Instructional science*, *36*(5–6), 351–357. https://doi.org/10.1007/s11251-008-9059-4
- Lundin, R., & Midler, C. (1998). *Projects as arenas for renewal and learning processes*. Kluwer Academic.
- Maghfiroh, N., Susilo, H., & Gofur, A. (2016). Pengaruh pembelajaran berbasis proyek terhadap keterampilan proses sains peserta didik kelas x sma negeri sidoarjo. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *1*(8), 1588–1593. https://doi.org/10.17977/jp.v1i8.6673
- Markham, T., Larmer, J., & Ravitz, J. (2003). *Project based learning handbook: A guide to standards focused project-based learning for middle and high school teachers*. Buck Institute for Education.
- Matthews, M. R. (2002). Constructivism and science education: A further appraisal. *Journal of Science Education and Technology*, *11*(2), 121–134.
- Milenković, D., Jovanović, Lj., Dimitrijević, N., Milojević, T., Dragin, I., Lazić, J., i Simin, Đ. (2018). *Ceger ekoloških ideja*. Kairos.
- Mohedo, M., & Bujez, A. (2014). Project based teaching as a didactic strategy for the learning and development of basic competences in future teachers. *Procedia – Social and Behavioral Sciences*, *141*, 232–236. https://doi.org/10.1016/j.sbspro.2014.05.040
- Newell, S., Edelman, L., Scarbrough, H., Swan, J., & Bresnen, M. (2003). Best practice development and transfer in the NHS: The importance of process as well as product knowledge. *Health Services Management Research*, *16*(1), 1–12. https://doi.org/10.1258/095148403762539095
- Pecore, J. L. (2009). *A case study of secondary teachers facilitating a historical problem-based learning instructional unit*. Georgia State University.
- Pecore, J. L. (2015). From Kilpatrick's project method to project-based learning. *International handbook of progressive education*, 155–171.
- Peetsma, T., Hascher, T., Van der Veen, I., & Roede, E. (2005). Relations between adolescents' self-evaluations, time perspectives, motivation for school and their achievement in different

countries and at different ages. *European Journal of Psychology of Education*, *20*(3), 209–225. https://doi.org/10.1007/BF03173553

- Petrović, M., i Hoti, D. (2020). *Priručnik za projektnu nastavu i nastavu na daljinu*. Naled.
- Postrel, S. (2002). Islands of shared knowledge: Specialization and mutual understanding in Problem-Solving Teams. *Organization Science*, *13*(3), 303–320.
- Prtljaga, S., & Veselinov, D. (2017). The influence of the project method on the achievement of young learners in the field science and social studies. *Research in Pedagogy*, *7*(2), 254–264. https://doi.org/10.17810/2015.63
- Radulović, B., & Stojanović, M. (2019). Comparison of teaching instruction efficiency in physics through the invested self-perceived mental effort. *Voprosy Obrazovaniya*, *16*(3), 152–175. https://doi.org/10.17323/1814-9545-2019-3-152-175
- Radulović, B., Gajić, O., Španović, S., & Lungulov, B. (2019). Challenges of initial teacher education in the context of higher education reform in Serbia. *Education and Self Development*, *14*(3), 34–39. https://doi.org/10.26907/esd14.3.04
- Radulović, B. (2021). Educational efficiency and students' involvement of teaching approach based on game-based student response system. *Journal of Baltic Science Education*, *20*(3), 495–506. https://doi.org/10.33225/jbse/21.20.495
- Ristanović, D. P. (2018). Pupils' perception of cooperation in the project-based teaching of social, environmental and scientific education. *Inovacije u nastavi*, *31*(4), 60–73. https://doi.org/10.5937/inovacije1804060R
- Rofieq, A., Latifa, R., Susetyarini, E., & Purwatiningsih, P. (2019). Project-based learning: Improving students' activity and comprehension through lesson study in senior high school. *Jurnal Pendidikan Biologi Indonesia*, *5*(5), 41–50. https://doi.org/10.22219/jpbi.v5i1.7456
- Safaruddin, S., Ibrahim, N., Juhaeni, J., Harmilawati, H., & Qadrianti, L. (2020). The effect of project-based learning assisted by electronic media on learning motivation and science process skills. *Journal of Innovation in Educational and Cultural Research*, *1*(1), 22–29. https://doi.org/10.46843/jiecr.v1i1.5
- Sasson, I., & Dori, Y. J. (2015). A three-attribute transfer skills framework – part II: applying and assessing the model in science education. *Chemistry Education Research and Practice*, *16*(1), 154–167. https://doi.org/10.1039/C4RP00120F
- Singley, M. K., & Anderson, J. R. (1989). *The transfer of cognitive skills*. Harvard University Press.
- Smith, C. A., Powell, S. C., & Wood, E. J. (1995). Problem-based learning and problem-solving skills. *Biochemical Education*, *23*(3), 149–152. https://doi.org/10.1016/0307-4412(95)00019-Y
- Sonmez, D., & Lee, H. (2003). *Problem-based learning in science*. ERIC Clearinghouse for Science, Mathematics, and Environmental Education.
- Tabachnick, G. B., & Fidell S. L. (2013). *Using multivariate statistics*. Pearson Education.
- Thomas, J. W. (2000). *A review of research on project-based learning*. The Autodesk Foundation.

- Van Merriënboer, J. J. G. (1997). *Training complex cognitive skills: a four components instructional design model*. Educational Technology Publications.
- Wong, K. K. H., & Day, J. R. (2009). A comparative study of problem-based and lecture-based learning in junior secondary school science. *Research in Science Education*, *39*(5), 625–642. https://doi.org/10.1007/s11165-008-9096-7
- Yair, G. (2000). Reforming Motivation: how the structure of instruction affects students' learning experiences. *British Educational Research Journal*, *26*(2), 191–210.
- Žderić, M., i Miljanović, T. (2008). *Metodika nastave biologije*. Prirodno-matematički fakultet.
- Županec, V., Radulović, B., Pribićević, T., Miljanović, T., & Zdravković, V. (2018). Determination of instructional efficiency and learners' involvement in the flipped biology classroom in primary school. *Journal of Baltic Science Education*, *17*(1), 162–176. https://doi.org/10.33225/jbse/18.17.162