Comparison of the Inquiry, Project-Based and Conventional Approach in Teaching - Botanical Case Study

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Abstract

This contribution brings the results of the survey done to find the most suitable method for teaching the topic of cooling effect of vegetation. The ninth-grade basic school pupils were taught through different approaches – inquiry-based teaching, project-based teaching and conventional, teacher-centred teaching. An improvement of pupils' knowledge, their attitudes to vegetation and teachers' opinion on focused approaches were investigated. Despite the fact that all approaches led to the particular improvement of pupils' knowledge, project and inquiry-based groups showed increase of positive attitudes to vegetation. Ambiguous teachers' opinion on different teaching approaches are discussed.

Key words

Project-based education; Inquiry-based education; Botany education; Teacher centred education

INTRODUCTION

Recent international studies reported decreasing interest of young generation in botany (Balas & Momsen, 2014) related to overall plant blindness of public (Wandersee & Schussler, 1999). Plant blindness is supposed to be a reason for plant illiteracy (Uno, 2009) of general public, a dangerous phenomenon for the future of human-being, because ignorance of plant physiological processes could have serious consequences for sustainable development (Amprazis & Papadopoulou, 2020). Therefore, botany educators focus their effort to increase the attractiveness of botany education for young generation. To reach this goal, activating strategies based on problem-solving approaches, hands-on activities etc. are used. Among modern didactic approaches especially inquiry-based education (Janstova et al., 2013) as well as project-based education (Rusek & Becker, 2011; Rusek & Dlabola, 2013; Lindner, 2014) are frequently used in teaching science to enhance students' engagement and motivation for learning.

Our previous papers have brought evidences for the low level of pupils understanding of air-conditioning function of vegetation (Ryplova & Pokorny, 2020a; 2020b). From this reason, new teaching activities were developed on this topic to be implemented into biology education at basic schools (Ryplova & Pokorny, 2020a; 2020b). Understanding of air-conditioning function of vegetation

is important, because via the air-conditioning vegetation helps to retain water in the landscape. Solar energy is converted into the latent heat by water vapour from vegetation and due to later condensation in cold places the water is returned back into the landscape in a form of precipitation (for detail description of the air-conditioning function of vegetation see Ryplova & Pokorny, 2018; 2019).

During the development of the new teaching activities, three different teaching approaches were tested to find the most efficient and suitable one. This contribution brings results of a didactic survey focused on the comparison of inquiry approach, project-based approach and traditional teacher-centred approach used for teaching the topic of air-conditioning function of vegetation. The aim of the survey was to find an answer on the research question: Which one of these three different teaching approaches is the most efficient for pupils and the most suitable from the teachers' point of view?

METHODS

A teaching activity on air-conditioning function of vegetation was developed in three variants providing the same information to the pupils but using three different didactic approaches:

1. Inquiry approach (for detail design of the inquiry teaching activity see Ryplova & Pokorny, 2020b). The teaching activity was based on the 5E-model of inquiry (Engagement, Exploration, Explanation, Elaboration and Evaluation, Carin, Bass & Contant, 2005). The aim of this activity was to answer a question 'Why is the shadow under the tree cooler than the shadow under an umbrella?' (90 minutes lesson).
2. Project based approach. The participants worked according to the project-based instruction in team format activities in order to solve the problem how to cool down the town square. The activity was divided into two parts. In the first part, the participants were motivated by using the thermovision pictures, obtained a short explanation from teacher and absolved an outdoor activity including measurement of the cooling effect of vegetation. During home activity, they should prepare proposals for cooling the town square by vegetation. The whole activity was finalized in second part via introduction of individual proposals and discussion with a peers and teacher (2x 45 minutes + homework).
3. Traditional teacher-centred approach combined with students' outdoor activity. After initial motivation via the thermovision pictures, the participants obtained the teacher's explanation and in the second part of the activity, they proved the cooling function of vegetation via their own field measurement (45 minutes lesson).

Each variant of the activity was introduced by the same motivation accompanied by the thermovision picture of cooling effect of vegetation; each variant included also hands-on activity – field measurement of solar radiation and surface temperatures of different surfaces in the close surrounding of the school (or school garden). Each variant of teaching activity was tested with one group of nine grade students (15 years old), number of respondents in one group varied among 24 – 30. The same teacher taught all three variants of the activity.

During the didactic survey three different aspect were investigated: Pupils knowledge and its' improvement, pupils' attitudes and engagement and teachers' opinion. The participants faced to pre-tests a day before teaching, post-tests immediately after the intervention and follow- up tests a week after the intervention. The aim of the didactic survey was to test:

A) The knowledge:

- an improvement of pupils' understanding of the cooling function of the vegetation was tested via the questionnaire consisting of nine questions (max. total test score = 9 points, pre-test /post-test experimental design, the differences in a total score among pre-test and post-test were analysed using Wilcoxon test (The STATISTICA 12 PC package, StatSoft Inc., for the detail description of the questionnaire see Ryplova & Pokorny, 2020b).
- Deeper understanding was tested via one question in follow-up test one week after the absolved education. The pupils were asked to draw the scheme of solar energy distribution in the landscape – max. amount of 6 point.

B) The pupils' attitudes to vegetation and botany education:

- The change in pupils' attitudes to vegetation and botany education was tested in pre- and post-test together with the test of knowledge via 3 questions:
    a. Do you think learning about plants is amazing?
    b. Do you think understanding of plant life is important for human?
    c. Do you think it is necessary to have trees in the city?

C) Teachers' attitudes to the use of this topic in the education

Twenty basic school teachers of biology got familiar with written form of teaching methodology of prepared activities and were asked to fill short questionnaire consisting of two semi-opened questions:

a. Do you think, the teaching about air-conditioning function of vegetation is reasonable? (Why yes or why not?)

b. Would you choose any of prepared activity for your practise? Which one and why?

RESULTS AND DISCUSSION

There is a clear evidence that all three didactic approaches lead to the significant improvement of participants' knowledge, which was very low before the teaching. Participants of all three courses reached significant improvement of their knowledge (Tab.1). The biggest improvement showed participants of inquiry learning (277 %), followed by participants of project-based learning (216 %) and traditionally taught pupils (204 %). Different situation was observed in the case of drawing scheme of solar energy distribution. In this question the participants taught by traditional way were the most successful (mean score 3.5 from 6 possible) on the contrary to participants of inquiry (mean score 1.5 from 6 possible) as well as project-based teaching (mean score 1.8 from 6 possible), showing low ability of drawing scheme of solar energy distribution. The scheme of solar energy distribution describes conceptual understanding of cooling function of vegetation. This question seemed to be too much difficult for participants of inquiry as well as project-based activity. The participants of these two groups have not seen the scheme before; they should conclude it from their knowledge obtained during the teaching activity. The respondents taught by traditional approach were faced to this scheme already before during the teachers' explanation. From the findings we can conclude, that although inquiry or project-based approach improve significantly students' knowledge, in case of biology principles, which are quite difficult to be understand (solar energy distribution in the landscape), the conventional approach could be more efficient. According to the Kirschner, Sweller & Clark (2014), there are cases, when minimally guided approaches are less effective than strongly guided approaches, because of low pupils' prior knowledge, which is in agreement with our pre-test results.

Tab. 1 Analysis of the improvement of pupils' knowledge. Mean test score reached by students in pre-test/post-test and percentage change between pre- and post-test mean score (* = statistically significant difference)

APPROACH VARIANT	PRE-TEST MEAN SCORE	POST-TEST MEAN SCORE	% CHANGE	WILCOXON TEST	EFFECT SIZE	SOLAR ENERGY DISTRIBUTION SCHEME SCORE
INQUIRY BASED	2.6	7.2*	277 %	z=-4.828, p=0.0001	r=0.61	1.5
PROJECT BASED	3.1	6.7*	216 %	z=-2.829 p=0,005	r=0.46	1.8
TRADITIONAL	2.8	5.7*	204 %	z=-2,741 p=0,005	r=0.37	3.5

On the other hand, both inquiry as well as project-based approach, lead to higher engagement of pupils and positive change in their attitudes to plants and botany. During the pre-tests similarly, low amount of respondents in all three groups (from 16 % to 38 % - Fig.1), consider learning about plants as amazing, understanding of plant life as important and trees in the city as necessary. The most positive change in attitudes showed participants of project-based learning (increase 44 %, 52 %, 47 % of respondents who consider learning about plants as amazing, understanding of plant life as important and trees in the city as necessary), followed by participants of inquiry-based learning (increase 35 %, 40 %, 38 %) and finally participants of conventional learning showing just a low increase (11 %, 15 %, 30 %). These results are in agreement with previous works documenting high motivation for education due to project-based (Ilter, 2014) or inquiry-based education (Ryplova, 2017).

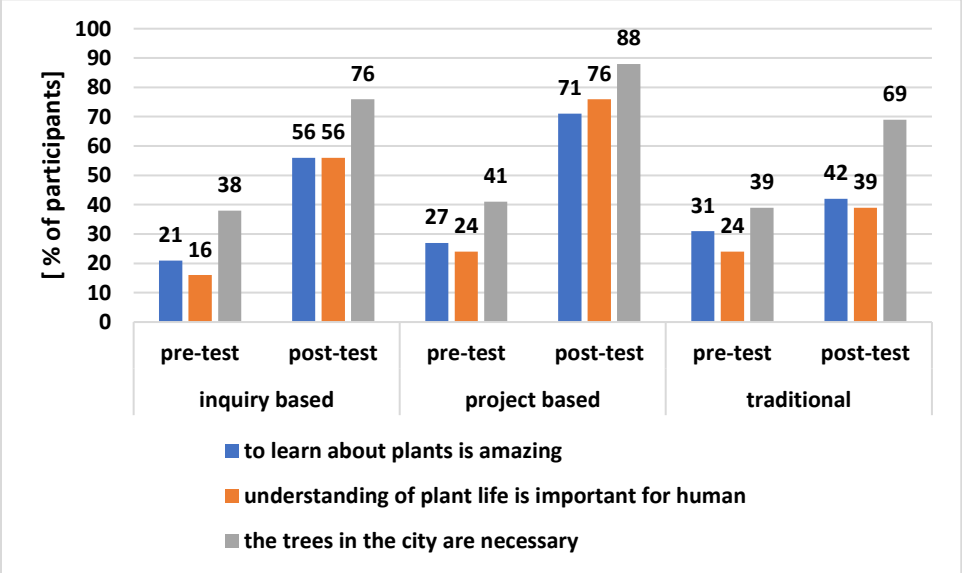

Fig. 1 Analysis of the change in pupils' attitudes to plants and botany education

A positive effect of all kinds of learning could be caused also by interdisciplinarity of the air conditioning function of vegetation combining physical sciences and botany. According to Lehmann, (2008), interdisciplinarity is one of the key features of project-based learning, thus this kind of approach seems to be suitable.

The teachers assessed the teaching of air-conditioning function of vegetation as reasonable, all twenty basic school teachers answered 'yes' to first question. As the reason they mentioned mostly the importance of vegetation for human environment, increasing drought or the pupils experience of air-conditioning principles from their everyday life (everybody knows, that the air in the forest is much cooler than in the city). Nine of the teachers would use traditional approach for teaching of this topic

in their practise. As the reason they mostly mentioned time and school schedule (biology lesson is once a week in duration 45 minutes). Six teachers would prefer inquiry–based approach (the reasons mentioned were: the pupils have the possibility to earn the experience with the cooling function of vegetation on their own; 90 minutes lesson is better because pupils need more time for the outside measurement; it is a topic, pupils know from their life and this is the good reason to use inquiry learning). Five teachers choose project–based learning, the reasons were similar like for inquiry-based learning (pupils need more time than 45 minutes; this is a good way to use school knowledge in relation with everyday life).

CONCLUSIONS

All three activities using different didactic approaches led to significant increase of pupils' knowledge. For the complex understanding of solar energy, distribution in the landscape a direct explanation by the teacher seems to be more appropriate than less guided inquiry or project-based approach. Participants of project-based activities showed the most positive change in their attitudes to plants and botany. The majority of the teachers would prefer traditional teaching approach for the topic of air-conditioning function of vegetation, prevailingly from the reason of time and organization of school hours.

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LITERATURE

Amprazis, A. & Papadopoulou, P. (2020). Plant blindness: a faddish research interest or a substantive impediment to achieve sustainable development goals? Environmental Education Research, https://doi.org/10.1080/13504622.2020.1768225

Balas, B. & Momsen, J. (2014). Attention "Blinks" Differently for Plants and Animals. *CBE-Life Science Education,* 13, 437–443. https://doi.org/10.1187/cbe.14-05-0080

Carin, A. A., Bass, J. E. & Contant, T. L. (2005). Methods for teaching science as inquiry. 9th ed., Pearson Prentice Hall.

Ilter, İ. (2014). A study on the efficacy of project-based learning approach on Social Studies Education: Conceptual achievement and academic motivation 9, 487–97. https://doi.org/10.5897/ERR2014.1777

Janstova V., Pavlasova, L. & Cerny, J. (2013). Inquiry based laboratory exercise focused on proteins. In M. Rusek & V. Kohlerova (Eds.), *Project-Based Education in Chemistry and Related Fields X*. (48-55). Charles University in Prague, Faculty of Education.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. Educational Psychologist, 41,75–86. https://doi.org/10.1207/s15326985ep4102_1.

Lehmann, M., Christensen, P., Du, X. & Thrane, M. (2008). 'Problem-oriented and project-based learning (POPBL) as an innovative learning strategy for sustainable development in engineering education'. European Journal of Engineering Education, 33 (3). 283-295. https://doi.org/10.1080/03043790802088566

Lindner, M. (2014). Outdoor Projects in STEM: Results of a Research on Students'Learning and Motivation. In M. Rusek, D. Starkova & I. Metelkova (Eds.), *Project-Based Education in Science Education XII.* (pp. 21-27). Prague: Charles University, Faculty of Education.

Pokorny, J. (2019) Evapotranspiration. In: Fath, B.D. (editor in chief) Encyclopedia of Ecology, 2nd edition, vol. 2, 292–303. Elsevier.

Ryplova R. (2017) Inquiry education in botany – a way to cope with plant blindness? In M. Rusek, Vojir K.(Eds.), Project-based Education in Science Education: Empirical texts XV, Prague: Charles University, Faculty of Education, 120 – 128.

Ryplova R. &Pokorny, J. (2018). Using project-based education to develop pre-service biology teachers' knowledge of the cooling effect of vegetation. In: M. Rusek, K. Vojir (Eds.), Project-based Education and other activating strategies in Science Education XVI, 105 – 113.

Ryplova R. & Pokorny, J. (2019). Opomíjená úloha vegetace v distribuci sluneční energie a utváření klimatu – sonda znalostí začínajících studentů učitelství přírodopisu. [Ignored Role of Vegetation in Solar Energy Distribution and Formation of Climate – Survey of the Knowledge of Novice Pre-service Science Teachers];. Envigogika, 14 (1), 1 – 19. https://doi.org/10.14712/18023061.586

Ryplova, R. & Pokorny, J. (2020 a). Fostering interdisciplinarity through technology enhanced learning of transpiration. In M. Rusek, M. Tothova & K. Vojir (Eds.), Project-based Education and Other Activating Strategies in Science Education XVII. (pp. 245-252). Prague: Charles University, Faculty of Education.

Ryplova R. & Pokorny J. (2020 b)**.** Saving Water for the Future Via Increasing Plant Literacy of Pupils. *European Journal of Sustainable Development* (2020), **9**, 3, 313-323. https://doi.org/10.14207/ejsd.2020.v9n3p313

Rusek, M. & Becker, N. (2011). "Projectivity" of Projects and Ways of its Achievement. In M. Rusek (Ed.) *Project-Based Education in Chemistry and Related Fields IX* (pp. 12-23), Charles University in Prague, Faculty of Education.

Rusek, M. & Dlabola, Z. (2013). What is and what is not a project? In M. Rusek & V. Kohlerova (Eds.), *Project-Based Education in Chemistry and Related Fields X*. (pp. 14-19). Charles University in Prague, Faculty of Education.

Uno, G. E. (2009). Botanical literacy: How and what students should learn about plants. *American Journal of Botany,* 96, 1753-1759. https://doi.org/10.3732/ajb.0900025

Wandersee, J. H. & Schussler, E. E. (1999). Preventing Plant Blindness. *The American Biology Teacher,* 61(2), 82-86.

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