

Inquiry-Based Approach to Education

Mária Kožuchová - Silvia Barnová - Ján Stebila - Slávka Krásna*

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Abstract:

Introduction: In the proposed study, the authors focus on the effectiveness of the application of inquiry-based approach in Slovak schools and present the results of an original research study focused on the impact of inquiry-based teaching on students' knowledge acquisition.

Methods: For the purposes of the research study, a pedagogical experiment was carried out on the sample of 150 6th-grade students and didactic tests (a pre-test and a post-test) were used to examine students' knowledge on the three levels of Niemierko's taxonomy.

Results: The results of the t-test confirmed the significance of differences between the experimental group's and the control group's cognitive performance.

Discussion: The obtained results indicate that inquiry-based teaching can lead to better knowledge acquisition in students than traditional methods of teaching and so, it appears to be an efficient alternative.

Limitations: The limits of the research study are given by the size and the composition of the research sample. The obtained results cannot be generalized to the entire population.

Conclusions: The research findings can contribute to improving the quality of the educational process and increasing students' motivation by using activating methods of teaching.

Key words: inquiry-based approach, technical education, experiment.

* Mária Kožuchová, Comenius University Bratislava, Faculty of Education, Bratislava, Slovakia; kozuchova@fedu.uniba.sk
Silvia Barnová, DTI University, Department of School Pedagogy and Psychology, Dubnica nad Váhom, Slovakia; barnova@dti.sk
Ján Stebila, Matej Bel University, Faculty of Natural Sciences, Banská Bystrica, Slovakia; jan.stebila@umb.sk
Slávka Krásna, DTI University, Department of School Pedagogy and Psychology, Dubnica nad Váhom, Slovakia; krasna@dti.sk

Introduction

For the current society, rapid technological development is characteristic, which has both its positive and negative aspects. Undoubtedly, new technologies make people's lives easier, but on the other hand, a significant decrease in the quality of relationships and interactions can be observed. The undergoing changes have a significant impact on people's lifestyle, as well as their overall personal development. Emotional experiencing has weakened and in schools, it has come to a decrease in students' participation and passivity has penetrated the educational process.

As emphasized by experts, experiencing - i.e. experiential learning - can contribute to activating students. Inquiry-based teaching is a relatively new approach, which is - from the aspect of science - associated with a range of procedures, which researchers use for examining the world surrounding them and presenting their findings supported by scientific evidence. From the aspect of students, inquiry is based on activities helping them develop knowledge, understand scientific ideas, principles, etc., and it shows them the ways researchers work. It provides students with unique opportunities to discover the world around them, to solve problems, and to learn through experiencing.

In the framework of the inquiry-based approach, problem-solving competencies have a crucial role to play as they help students to find answers to their questions, to explore, and to discover. They are multidisciplinary and are not tied to individual school subjects and so, their development should be implemented in the curriculum for all subjects, i.e. in maths, technical subjects, science, humanities, language teaching, and in other subjects, but also in the realization of activities within cross-cutting themes, such as environmental education.

As pointed out by e.g. Li and Yuan (2022), Orosz et al. (2022), Al-Githami, Solangi, and Esmail (2022) and Mariegaard, Seidelin, and Bruun (2022) - inquiry-based education has shown to be a promising method of education. Therefore, it can be considered the basis for education in the future.

1 The need for a new paradigm in technical education

At the end of the 20th century, a need for changing the existing systems of education emerged as traditional schools were not able to prepare students for the new requirements related to social changes and technological development. A deep crisis in technical education was observed (Kožuchová, Barnová, & Stebila, 2022), which was the consequence of several factors, including the undergoing transition from the existing technological and technical society to an information and learning society. The applied transmissive approach to technical education, within the framework of which information is presented to students as definitive, infallible, and clearly proven, showed to be unsatisfactory as the

priority of developing craft skill was replaced by the need for developing skills in the field of working with information, searching, sorting, and critical evaluation. In the described context, Turek (2003) pointed out that it is not possible to prepare youth for the future by using the methods of the past and also Blaško (2011) emphasized the necessity of changing the culture of education and making a shift towards participative and interactive models of teaching providing space for students' activity and experiencing. So, it can be assumed that the new activating teaching methods are among the consequences of the rapid development of information and communication technologies, which have had a significant impact on education.

Another factor leading to searching for a new paradigm was students' decreasing interest in technical education, but also in science as such (Held et al., 2019), which can be considered an issue even currently. It has had a strong impact on the number of application forms submitted to technically oriented vocational schools and universities providing technically oriented study programmes, but also on the number of students who entered these schools and those who completed their technically oriented studies.

From the aspect of a modern society's needs and requirements, the above described situation represents a problem to be solved and so, decisive and critical spheres have introduced certain measures to improve the situation in the field and introduced programmes promoting technically oriented study programmes (Kožuchová, Barnová, & Stebila, 2022).

2 Experiential learning as a new approach

As it can be observed already at a very early age, experiencing is a natural and effective way of learning. Recently, experiential pedagogy has become popular and found its application in various learning contexts. Orosová (2020) accentuates that the principles of experiential education are applied in working with students, teachers, managers, etc., and there is a broad scale of organizations working with experiences and providing experience-based activities for diverse target groups.

Experiencing is a factor having a significant impact on individuals' development. Hlásna et al. (2013); Krásna and Svetlíková (2013); Hlásna (2012); Hlásna et al. (2012); and Hlásna and Dohnanská (2012a,b) point out the associations between experiencing and individuals' intellectual development (memory, attention, perception, logical thinking, tactical thinking, strategic thinking, combinatory skills, etc.), creativity (imagination, originality, innovative practices and approaches, etc.), social-emotional skills (communication, cooperation, teamwork, taking over responsibility, empathy, assertiveness, argumentation, reasoning, problem solving, etc.), motor skills and mobility (speed, strength,

endurance, agility, etc.), and personality development (patience, persistence, courage, self-control, self-confidence, autonomy, etc.).

Kapšová (2008) describes experiential education as based on the implementation of activities focused on gaining experiences. It leads to knowledge acquisition through integrating physical, cognitive, and emotional experiences into the existing system of knowledge. On the other hand, it must be pointed out that carrying out activities is not enough as learning is a process within which experience must be transformed into knowledge (Kolb, 1984).

From the aspect of learners, experiential learning brings several benefits. In the process of knowledge acquisition and developing learners' skills and competencies, activating methods are applied and learners are provided with opportunities for developing cooperative and communication skills as teamwork is frequently used. As emphasized by Gyurák-Babeľová and Vaňová (2008), methods of experiential education are based on interaction in groups and the focus is on group dynamics. Learners learn to adapt to various situations and learning environments, build social relationships, develop their problem solving skills, and can also try out a range of roles within their teams - including the role of a leader. By respecting diversity in groups, experiential education promotes creating inclusive school environments.

Based on the above, it can be assumed that experiential learning appears to be a suitable alternative for all age-groups both from teachers' and students' perspectives as it integrates sensory perception, cognitive processes, subjective experiencing, emotions, and actions. It changes the role of a learner from a passive recipient of knowledge who memorizes new information to its active creator.

3 Experiential learning in Slovakia

Although there are several historically determined similarities between the Slovak and the Czech systems of education, in the field of experiential pedagogy, its development and application, significant differences can be observed. While in the Czech Republic, experiential pedagogy as a discipline of science started to develop as early as in the 1970s, in the Slovak republic, experiential education is still typically applied in the framework of informal learning (Orosová, 2020) and its implementation is a much slower process. On the other hand, the field of experiential learning cannot be considered a neglected field of research in the country. Since the method of experiential learning can be well applied in various learning contexts and with learners of all age-groups, it has been investigated into from various aspects and there is a relatively broad scale of research activities carried out in the Slovak educational environment. Ondrušek and Labát (2007) examined the role of experiential education in andragogy, Zahatňanská and Hudáková (2021) - as well as Vanková and Rác

(2021) - accentuated the importance of learning by experiencing in the educational process, and Švamberk Šauerová (2015) claims that experiential education is an efficient model to be applied in the educational process. Jirásek (2006, 2019) accentuates the importance of integrating experiences into existing structures as having an experience is not enough. Greksáková (2010) points out that experiential learning is based on the principle of lived experience and clearly is in contrast with the traditional methods of knowledge acquisition and memorizing facts.

The methods of experiential education are not only suitable for all age groups but also can be well applied in various school subjects, e.g. Uhrinová and Prachárová (2020) see their potentials in developing natural literacy, Rochovská and Křížová (2007) find experiential education an effective method to be applied in teaching Biology and also point out its positive effect on the quality of classroom climate. The quality of classroom climate was also dealt with by Orosová (2011), but in this case, from the aspect of using experiential pedagogy in the educational practice of class teachers. Fedorko (2019) deals with implementing the methods of experiential learning in environmental education and in co-authorship with Dzurilla (Fedorko & Dzurilla, 2018), they focused on its application in the context of teaching Ethics. Experiential education and its impact on social relationships and aggression in schools were investigated into by Kováčová (2020); and Bratková and Maková (2017) dealt with the opportunities for implementing experiential learning in health education.

4 Inquiry based education

Inquiry based education can be considered a method of experiential education. This approach represents a shift from traditional formal education and is in compliance with the constructivist theory of learning in the sense that the outputs of the educational process are diverse, often unpredictable, and the learners are in the centre of all educational activities.

The concept of inquiry-based teaching was developed as a reaction to the criticism regarding the situation in technical education and a number of unsuccessful reforms introduced earlier. This paradigm of education makes schools more open, accessible and liberal institutions providing students with opportunities for developing their personality and individuality. It represents a shift from memorizing mediated facts to developing competencies in various spheres.

Dostál and Kožuchová (2016) define inquiry as a teaching procedure based on one's own research, within which several activating methods are applied. As pointed out by Gunčaga, Koreňová and Hvorecký (2019), the purpose of inquiry-based teaching is to develop students' general ability to carry out scientific research. Inquiry-based education is targeted on questioning existing theories

and presumptions and their subsequent experimental verification, the results of which may lead to proposing new concepts. In the process of inquiry-based education, students become researchers and try to find meaningful alternatives. Since students learn through trials and errors, they do not achieve goals straightforwardly.

Inquiry-based teaching is more than a teaching method, it should be perceived as a teaching concept including inquiry in all its components. Stuchlíková (2010) describes the notion of “inquiry” as a target-oriented process of formulating problems, evaluating alternatives, planning research, its realization, formulating conclusions, but also searching information, developing models, leading discussions with others, and formulating coherent arguments. Inquiry-based teaching is a strategy of managing students’ learning activities leading to active construction of knowledge by means of inquiry-based activities facilitated by teachers. Inquiry based activities allow students’ active participation and provide them with opportunities to create their knowledge instead of memorizing information.

When an inquiry-based approach is applied, students also learn to collaborate, as they are usually divided into groups, which can be either mixed-ability groups or groups selected based on students’ interests or abilities.

Undoubtedly, the most significant theoretical paradigm represented by the concept of inquiry-based teaching is pedagogical constructivism. Constructivism was founded on the work of Vygotsky (2004) and Piaget (1997). The concept of inquiry-based teaching attempts to apply the elements of spontaneous learning - especially ego-engagement in learning individuals - and other processes of building their knowledge (Hanushek & Woessmann, 2015). Newly gained information is actively integrated into students’ cognitive structures and is interpreted through these cognitive schemas already constituted by individuals, but it must be noted that they can also be changed or modified. In the process of inquiry, the main activity is transferred to students, the teaching process is more student-centred, and the teacher has the role of a facilitator. Students do not passively accepted knowledge presented by the teacher, they are led to apply a critical approach and so, the focus is on the applied methods, procedures, processes, and understanding associations.

In the European environment, the concept of inquiry-based teaching is primarily applied in science education, but recently, it is becoming more and more popular also in technical education. Several Czech and Slovak authors have been carrying out research activities focusing on inquiry-based teaching for a long time, e.g. Dostál (2015), Kožuchová (2015), Dostál and Kožuchová (2016), Stebila (2016), Dostál, Nuangchalerm, Stebila, and Bal (2016), Stebila and Žáčok (2019), Stebila and Hatvanyi (2022) and others.

5 Opportunities for inquiry-based learning

Even though experiential learning is not a novelty in Slovakia (Orosová, 2011, 2020), it does not receive as much attention in schools as it deserves. One of the reasons is that even though teachers' professional preparedness has a significant impact on the quality of education, they do not receive sufficient training in the field during their undergraduate studies and there are not many opportunities for in-service training focusing on the application of the inquiry based approach. This has been confirmed by Darling-Hammond's (2015), Rivkin, Hanushek, and Kain's (2005), Osborne and Dillon's (2008), and Orosz et al.'s (2022) research findings, which indicate that teachers lack competencies for implementing inquiry-based activities. As found out by Orosz et al. (2022), teachers also complain about a limited access to verified, easy to apply inquiry-based procedures that they could use in the classroom. The everyday educational practice shows that the inquiry based approach is mainly used by highly engaged and motivated teachers.

In general, it can be observed that in spite of the benefits that inquiry-based teaching brings, students lack space for inquiry, they are not provided with opportunities to carry out experiments or other inquiry-based activities. Although modern textbooks contain examples of problem-solving tasks and instructions for experiments and there are also other teaching materials at teachers' disposal, they find them insufficient. They call for more detailed instructions, step-by-step guides on using the activities in real classrooms but they often forget about the fact that their professional and classroom management skills, and ability to ask appropriate questions are among the determinants of the success or failure of inquiry-based activities and their impact on the outputs of the educational process.

6 Efficiency of inquiry-based teaching – students' cognitive performance

For the purposes of the presented research study, the experimental method was applied and 12 modules consisting of inquiry-based activities to be used in technical subjects were developed. The main goal of the study was to verify the developed modules and to compare the efficiency of the inquiry-based approach applied with the experimental group with the efficiency of the traditional approach used in the control group. Based on the main goal of the study, the following hypothesis was formulated:

H: The students in the experimental group will achieve statistically significantly higher scores in didactic tests than the students in the control group.

6.1 Methods

To examine student s' knowledge on the three levels of Niemierko's taxonomy (remembering, understanding, specific transfer) (Niemierko, 1979; Lapitka, 1996; Lavický, 2014), didactic tests were used and the participating students' cognitive performance was measured - a pre-test was administered to the participants both in the experimental group and the control group prior to the realization of the designed research activities and a post-test was administered following them. Both tests consisted of 16 items. The maximum score in both tests was 40. Satisfactory psychometric properties were earlier confirmed in a research conducted by Dostál and Kožuchová (2016).

Inquiry-based activities were only applied in the four experimental groups; in the control groups, traditional methods of teaching were used. In the experimental groups, students worked in teams of four. They were introduced to inquiry-based tasks from the thematic fields Electromagnetism and Electronics in the developed modules and, subsequently, were asked to propose various ways of solving task, including school experiments. They carried out experiments, evaluated their results, discussed occurring issues within and between groups, compared their results, and formulated conclusions.

6.2 Research sample

150 (67 male and 83 female) 6th-grade students from four schools providing primary and lower secondary education in the Slovak Republic participated in the research study. Students in each of the four schools were divided into two groups according to alphabetical order, and so, four experimental and four control groups were created.

6.3 Results

In the presented part of the research study, the input-output results of students in the experimental group and the control group were examined to find out about students' progress in the cognitive field (gained knowledge) in selected thematic units.

Table 1

<i>Two-sample t-test for hypothesis H1</i>									
	<i>Levene's Test for Equality of Variances</i>				<i>t-Test for Equity of Means</i>				
	<i>F</i>	<i>P – value</i>	<i>T</i>	<i>df</i>	<i>P - value two-sided alternative</i>	<i>Difference of mean values</i>	<i>Mean value error</i>	<i>95 % confidence interval for variance</i>	
		<i>F test</i>							
Equality of variance	32.662	0.000	24.39	75	148	15.7066	0.64378	-1.72731	0.03272
Inequality of variance	0	0	24.39	205.41	105.44	15.7066	0.64378	-1.72745	0.03285

By means of t-test, the existence of statistically significant differences between the experimental groups' and the control groups' performance was confirmed - the differences were statistically significant on the significance level $\alpha = 0.05$. It can be assumed that it is the result of using inquiry-based activities in experimental groups as a part of the experiment and these results suggest that using inquiry-based activities in the classroom influences students' overall performance in the cognitive field. For final analysis, the homogeneity of variance was examined, which was calculated using Barlett's and Cochran's tests for homogeneity (see Table 2).

Table 2

<i>Test of variance homogeneity</i>					
	<i>Cochran T.</i>	<i>Hartley T.</i>	<i>Bartlett T.</i>	<i>P</i>	<i>Degrees of freedom</i>
Score	0.69874	1.367117	0.026354	0.948322	1

Based on the above results, it can be stated that the hypothesis was confirmed as the students in experimental groups achieved statistically significantly higher scores in didactic tests than the students in the control groups.

Conclusions

Inquiry-based teaching can be included in the category of experiential methods of teaching and appears to be an effective method of education, which is based on students' activity, their curiosity and their desire to explore and discover. One of the advantages of inquiry-based education is that it creates links between theory and practice as it allows students - regardless their age - to learn through experiencing, which makes it an attractive option. Another among its benefits is

that it can be easily implemented in teaching any school subject and no special equipment is required.

The main goal of the presented part of the research study focused on the application of inquiry based activities in the classroom was to examine whether implementing elements of inquiry-based teaching can lead to better outcomes in students and better knowledge. Since the obtained results indicate that the applied approach and methods of teaching have a significant impact on students' cognitive performance, for ensuring high-quality education, it is necessary to pay sufficient attention to selecting appropriate methods to be used in the classroom. Even though activating methods - including inquiry-based teaching - appear to be an effective option, in this context, teachers' preparedness, their pre-service training, in-service training opportunities and their professional skills are decisive. However, as experience shows, there is a lack of teacher training programmes focused on the application of innovative strategies and methods and their implementation into the teaching process, and as a consequence, teachers lack confidence in using them.

Although, given by the size and the composition of the research sample, the results of the study cannot be generalized to the entire population; we believe that they are significant from the aspect of increasing the efficiency of the educational process by using activating methods of teaching. The study also offers implications for the further direction of research activities in the field.

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