POSSIBILITIES OF PROMOTING STUDENTS' COGNITIVE INTEREST IN SCIENCE SUBJECTS

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Abstract. Insufficient knowledge and skill level in science subjects is one of the most serious problems of this century that hinders the advance of many branches of national economy. Academic achievements at school are closely connected with the students' learning interest. The teacher's style of work and the choice of the teaching/learning methods determine to a great extent the fact whether students will learn with interest the science subjects that for many of them seem difficult and boring. The aim of the study is to find out the students' opinion about the teaching/learning methods that help students most learn the sciences. The survey of Grade 9 students was performed. The answers are ranged on the Likert scale of four points using SPSS program for data processing. The study findings show that diversity of the methods used in schools is great and they are based on the constructivism approach. The majority of students value the highest the experiment demonstrations and laboratory works; these methods raise interest and help gaining understanding about the nature of the science. However, on the whole, the tendency to learn without putting effort in the process is observed. Approximately one fifth of the surveyed students consider that the active methods applied in science subjects do not help them in learning. The importance of textbooks has received rather low assessment while the teacher's narration is valued a bit higher. In general, it is possible to conclude that the teacher's personality and professional mastery has a great importance on promoting students' cognitive interest. Interactive teaching/learning methods developing analytical thinking and practical skills promote the acquisition of the science subjects.

Keywords: cognitive interest, constructivism, science education, teaching/learning methods.

Introduction

Nowadays it is expected that the education system will prepare students, who not only have good knowledge and skills in the science subjects, but especially the knowledge and skills that are vital for successful everyday life and future career. These are essential skills that often are denoted as "learning for life and work" – to learn to think critically, to analyse and synthesize the information, to solve problems in different contexts, to work effectively in a team and to self-educate oneself [1]. In order for students to achieve these learning outcomes the teachers have to use respective teaching methods. Firstly, it is necessary to increase the students' motivation. It has to be taken into consideration that students in the classroom come with different levels of motivation. It is important to achieve that every student who learns science subjects and technologies should be motivated that is a very challenging task for the teacher.

As the analysis of theoretical and research literature published in the world in the last 30 years proves many researchers consider constructivism as the learning approach the most corresponding to the demands of the society in the context of general education already since the end of the 20th century. The introduction of the constructivism learning approach transforms radically the acquisition process of science subjects relating it to everyday life not just teaching abstract statements but using a creative approach in the solution of tasks set in the science subjects. The student becomes an active participant of the teaching/learning process and the teacher turns into his/her assistant. One of the didactic requirements is to ensure the teaching/learning process, which would promote students' cognitive activity, creativity, flexibility in thinking, would facilitate the solution of problem-oriented tasks and cooperation, including the exchange of opinions, accumulation of experience, formation of attitudes, reflection and self-activity. Exactly such teaching/learning process ensures the formation of students' cognitive interest [2-4].

The success of the teaching/learning process, firstly, depends on the student's active and interested activity during the learning [5]. The satisfaction about the activity completed and the achieved, the joy of discovery and creation, self-actualization are the positive experiences that are both an integral part of active learning and the internal driving forces or motives of active learning. Therefore, the teacher with his/her personal experience, knowledge, attitude to work and students, methodological mastery in organizing an active teaching/learning process has to ensure such a teaching/learning environment in which such students' positive emotional experiences are possible.

The previously performed studies show that students' interest in science subjects is still rather low [6-8] and the question – how to organize the teaching/learning process so that science subjects become closer and more understandable to students – is still very topical. The diverse teaching/learning methods applied in the science lessons give teachers the possibility of choice; however, there are few studies on how successfully one or another method promotes the cognitive interest. One of the most essential provisions of a successful teaching/learning process is learning with interest. Do students gain satisfaction in science lessons? Does the teaching/learning process promote understanding about the nature of science? The present study put forward the following research questions.

- Which teaching/learning methods used in science subjects do students value the highest?
- How do the applied teaching/learning methods promote students' cognitive interest?

The study is based on ideas developed in pedagogy and psychology about the constructivism approach in the teaching/learning process at school [9-13]. The constructivism approach in the promotion of the student's cognitive interest is connected with several key statements [14; 15].

- Learning is a self-regulated, active and constructive process; cooperation and communication have a special importance and the student's previous experience is being connected with the new one in it. Learning depends on the teaching and learning methods, the context of the teaching/learning content that encourages students to communicate and cooperate with each other in order to identify the problem and to receive new learning experience in the solution of the problem.
- The teacher's role changes. The teacher becomes not only the organized of the study process but also the observed, adviser; he/she learns him/herself in the search for invariative answers and gains new information, new ideas in the dialogue with students and develops his/her competences.
- The student as a subject more and more takes the responsibility about his/her learning and organizes it.
- The provision of a respective environment offering the diversity of methods of obtaining, applying, evaluating the information and solving problems thus ensuring the choice of freedom to the student is important.

The constructivism approach in teaching/learning encourages the students' cognitive interest and creative thinking, therefore, the teaching and learning methods that ensure cooperation between students and the teacher are topical because incomplete or even erroneous suppositions that have developed in social interaction are replaced by more precise students' knowledge [16]. Meaningful, inquiry-based learning takes place in such a context [17].

According to the constructivism approach, which is based on the individual's activity in the process of knowledge creation and constructing, the learning is directed towards development of mind including four mutually linked elements: 1) acquisition of knowledge and understanding; 2) discovery of new knowledge as a result of student's independent activity; 3) application of new knowledge in new situations, i.e. broadening of boundaries; 4) inventions – alternative, diverse problem solutions [2]. One of the ways how to achieve this is to ensure such learning environment in which student's active learning is encouraged that is manifested as participation in problem solving, construction of new knowledge, application of the existent knowledge in practice, active participation in the thinking process and the process of making connections [18].

Materials and methods

The present study is the continuation of the previously performed study [7]. It is based on the students' survey in order to find out their opinion about the methods used in the acquisition of science subjects and it allows judging, which methods develop students' attitude to sciences.

The questionnaire of the survey is based on the studies performed earlier [7] and documents regulating education in Latvia [19]. The questionnaire was made on the internet using Google disc, and students answered the questions online. Additionally, the students were given a possibility to comment their answers. The questionnaire comprises questions where the answer variants correspond to the four value Likert scale and are coded: 1 – no, 2 – rather no, 3 – rather yes, 4 – yes. The reliability (inter-item consistency) of the questionnaire according to Cronbach alpha coefficient was 0.822.

Grade 9 students from 15 schools in different regions of Latvia were invited to participate in the survey. In all schools the students learn according to a common Latvian national education standard. The total number of the respondents is 271; 62 % of them are girls and 38 % boys. The average age of the respondents is 15.3 years according to the class records. Thus, according to the gender and the teaching/ learning environment this group can be described as evenly distributed.

Five criteria that describe students' active learning activity in a modern science teaching/learning process were used for grouping the teaching/learning methods: 1) independence, 2) activity, 3) practical action, 4) research action, 5) creativity. Depending on the intensity the correspondence of the teaching/learning method to each criterion was assessed on the four point scale: 0 – does not correspond, 1 – corresponds a little, 2 – corresponds, 3 – corresponds fully.

The data analysis was performed using the statistical software SPSS 23 program. The mean values of the answers M ($1 \leq M \leq 4$) were used to describe the respondents' opinions. In order to assess the credibility of the differences of mean values in two reciprocally independent groups the t-test analysis of the independent samples was used. Correlation analysis was used for comparison of the methods. Cronbach alpha was used for stating the reliability of the questionnaire.

Results and discussion

The teaching/learning methods included in the study correspond to the principles of constructivism and are directed to make the students' cognitive process diverse, developing the skills that correspond to sciences and matching up the students' interests and needs. The findings of the survey allow concluding which teaching/leanring methods help students acquire science subjects better and create interest about them.

The mean values of the answers ($1 \leq M \leq 4$) that are relatively high ($1.94 \leq M \leq 3.58$) testify that the diversity of methods is needed and that all methods have been useful. The comments provided by the respondents show that such methods as "role plays", "brainstorm", "essays", preparation of visual aids and didactic games in science subjects are seldom used. In order to obtain more objective indicators the methods that were seldom used were excluded from the total array of methods in further analysis of findings.

The more frequently used teaching/learning methods according to the above described criteria were divided in five groups in a reducing in size order (Table 1). The correspondence of Group 1 methods to the criteria is the highest – these methods from the student require independence, active practical and research activity as well as creativity. Respectively, the Group 5 method (teacher's narrative) according to all criteria has the lowest intensity of student's activity. The most important teaching/learning methods used in sciences are presented in Table 1.

As it is seen in Table 1, the students in general are satisfied with organization of the study process in the sciennce subjects and it is confirmed by relatively high mean values of the answers ($2.82 \leq M \leq 3.58$). The students consider that demonstrations ($M = 3.58$), laboratory works ($M = 3.52$), discussions and the questions/answers methods (in both positions $M = 3.36$) have helped the most to acquire the science subjects. Using the t-test, it was stated that there were no statistically significant differences between the boys and girls' assessments, except the question about the use of visual aids $t(259) = 2.95$, $p = 0.02$, where the boys have given higher assessment.

The grouping of methods according to the type of students' learning activity and intensity shows, which kinds of methods and to what extent help students acquire the sciences (Table 1). Ranging the methods in accordance with the mean vaules of the respondents' answers indicates that the students have put those methods that do not require effort and do not ask for practical work in the first place: observation of demonstrations and verbal methods – discussion and the questions/answers method ($M_{aver} = 3.43$). The least important methods, especially according to the girls' opinion, are the application of different visual aids and work with the text in the classroom ($M_{aver} = 3.01$). Such an opinion serves as evidence to rather superficial and shallow attitude studies, thus confirming once more the students' unwillingness to put effort into learning more and better. It can be judged that many students cope with these subjects actually without having fully got to know them. Thus, the requirements in these subjects at school are rather modest and many students most likely could use the time allotted to studies more usefully. Actually it is impossible to acquire science without analytical reading skills that have to be taught to students as well as acquisition of biology, chemistry and physics is unthinkable wthout the use of tables, schemes and models.

The teacher's narrative has received high assessment (M = 3.28) which, on the one hand, could be indicative of the teachers' high professionalism; however, on the other hand, it allows thinking that the teacher's narrative in lessons is dominant and that active methods directed towards students' independence and creative thinking are used rather seldom. Yet, these active methods most strongly promote students' learning and cognitive interest.

Table 1

Students' assessment of teaching/learning methods in science subjects

Groups	Teaching/Learning	M	SD	M_{aver}	Ranging according to students' assessment
1	• Research laboratory work • Problem solving	3.32 3.05	0.912 0.962	3.19	**3**
2	• Laboratory work • Case studies (situation analysis) • Solution of tasks	3.52 3.00 3.00	0.770 0.982 1.027	3.17	**4**
3	• Application of visual aids (schemes, tables, drawings, models, etc.) • Work with the text (during the lesson)	3.19 2.82	0.988 0.976	3.01	**5**
4	• Demonstrations • Discussion • Questions and answers	3.58 3.36 3.36	0.765 0.888 0.817	3.43	**1**
5	• Teacher's narrative	3.28	0.916	3.28	**2**

The mean values of the respondents' answers also prove that science experiments seem interesting to students because they assess them high on the whole. However, it is better if they are performed by the teacher as a demonstration (M = 3.58) or if it is a simple laboratory work (M = 3.52) not the research one (M = 3.32). Significantly, that a strong correlation exists among the three above mentioned types of using the experiments. The same students like both the laboratory works and demonstrations, $r(256) = 0.32$, $p < 0.1$. The untipically high correlation between the assessment of the ordinary and research laboratory works, $r(264) = .67$, $p < 0.1$, indicates that the students actually do not see the difference between them.

Fig. 1 presents the assessment of the methods on the scale: no – rather no – rather yes – yes. It is seen that the students' opinions about the methods are rather different. Despite the fact that mean indicators are satisfacory it is seen that a considerable part of the students consider that such methods characteristic to science subjects as, for example, problem solving, case studies and solution of tasks are poor methods (9 %, 10 % and 11 %, respectively). It is possible because such tasks have caused difficulties.

The usefulness of visual aids is completely denied by 10 %, partly denied by 11 % of respondents, partly accepted by 29 %, and the majority of respondents (50 %) fully recognizes their usefulness. The opinions divide also as regards the work with the text, where 12 % have given a negative answer, a partly negative stand was given by 22 %, a partly confirming – 38 %, but fully confirming answer by 28 % of respondents. Such results serve as evidence for students' strongly different understanding about the nature of science.

Summarising the respondents who have answered with "no" or "rather no" and calculating the mean indicator of all the methods it is possible to conclude that learning of sciences has been unsuccessful to 20 % of the students on average. The obtained findings agree with the previously performed study, which shows that 15 % of Grade 9 students have a low cognitive level and that a great part of students are more interested in general issues and simply formulated tasks that do not require effort and delving into the nature of things and processes [7].

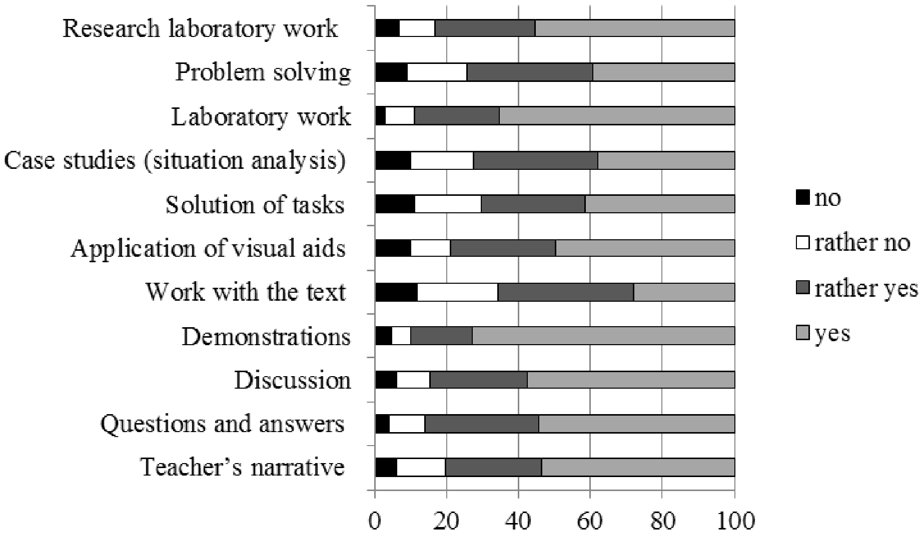

Fig. 1. **Distribution of respondents' opinions on the most frequently used teaching/learning methods (number of respondents, %)**

The results of the survey encourage looking for reasons why students have assessed some methods so low as well as seek the explanations why some method does not facilitate students' cognitive interest and why students do not to participate actively in the lesson. One of the explanations could be found in the fact that students lack good experience how the above mentioned methods can improve both learning and the interest in sciences.

Conclusions

The leading role in the teaching/learning process that promotes the cognitive interest belongs to the student, the self-development of his/her personality. This is possible if the teacher performs the functions of the adviser, the promoter of cognitive interest, the encourager and supporter of action, the discussion partner as well as the provider of a cooperation-based social environment. The promotion of the self-activity and self-development of the person is the key aim and prerequisite of education because a person obtains education, including new knowledge as a result of his own diverse activities. Students in the learning process that is based on the constructivism theory are given a possibility through discovery and in cooperation with others construct their knowledge.

A methodologically diverse teaching/learning process develops students' skills and promotes the cognitive interest. However, students prefer such methods that do not require effort – the teacher's narrative, discussion, questions/answers method. Solution of tasks, analysis of case studies, work with the text and other methods asking for active thinking and practical action seem of little importance for students in the acquisition of sciences.

Approximately one fifth of Grade 9 students consider that the methods used in science subjects have little promoted their cognitive interest. These students have not understood the nature of science; they learn formally and without putting effort in their learning. This causes worries about the quality of science education in Latvia.

The teacher's skill to form a creative teaching/learning environment suitable for solving science problems and related to socio-scientific issues; the teaching/learning environment that promotes the students' internal motivation to acquire science subjects and strengthens each student's individual key skills, especially research skills, is important. Inquiry-based methods that promote the higher order cognitive skills – the skill to express oneself, to give arguments, to explore and think analytically, to make logical judgements should be used more in science subjects.

References

1. Pellegrino J.W., Hilton M.L. Education for life and work: developing transferable knowledge and skills in the 21st century. Washington, DC: The National Academies Press, 2012. 242 p.
2. Brooks J.G., Brooks M.G. In search of understanding: the case for constructivist classrooms. Alexandria, VA: Association for Supervision and Curriculum Development, 1993. 136 p.
3. Kirschner P. A., Sweller J., Clark R.E. 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, vol. 41(2), 2006, pp. 75–86.
4. Garbett D. Constructivism deconstructed in science teacher education. Australian Journal of Teacher Education, vol. 36(6), 2011, pp. 36-49. [online] [10.03.2016]. Available at: http://dx.doi.org/10.14221/ajte.2011v36n6.5.
5. Meyer H. Was ist ein guter Unterricht? (What is a good lessons?). Berlin: Cornelsen Scriptor, 2008. 192 S. (In German).
6. Cedere D., Jurgena I., Gedrovics J. (2015). Longitudinal research on the change of Grade 9 pupils' cognitive interests in sciences (2003 -2013). Proceedings of the 14th International scientific conference „Engineering for Rural Development", May 20-22.05, 2015, Jelgava, Latvia University of Agriculture, pp. 742-747.
7. Cēdere D., Jurgena I., Helmane I., Tiltiņa-Kapele I., Praulīte G. Cognitive interest: problems and solutions in the acquisition of science and mathematics in schools of Latvia. Journal of Baltic Science Education, vol. 14(4), 2015, pp. 424–434.
8. Potvin P., Hasni A. Interest, motivation and attitude towards science and technology at K-12 levels: a systematic review of 12 years of educational research. Studies in Science Education, vol. 50(1), 2014, pp. 85-129. [online] [10.02.2016]. Available at: http://dx.doi.org/10.1080/03057267.2014.881626.
9. Piaget J. Psychoanalysis in its relations with child psychology. Gruber Jahoda H.E., Vonche J.J. (Eds.). The essential Piaget. London: Routledge & Kegan Paul, 1977, pp. 55-59.
10. Cuseo J. Active learning: definition, justification, and facilitation. 2010. [online] [10.02.2016], Available at: http://uwc.edu/sites/uwc.edu/files/imce-uploads/employees/academic-resources/esfy/_files/active_learning-definition_justification_and_facilitation.pdf.
11. Jonassen D.H. Objectivism vs. constructivism. Educational Technology Research and Development, vol. 39(3), 1991, pp. 5-14.
12. Gance S. Are constructivism and computer-based learning environments incompatible? The Journal of Education, Community and Values, vol. 2(3), 2002, pp. 1-6. [online] [12.02.2016]. Available at: http://bcis.pacificu.edu/journal/2002/03/gance.php.
13. Prince M. Does active learning work? A review of the research. Journal of Engineering Education, 93(3), 2004, pp. 223-231.
14. Katane I., Kalniņa I. Skolēnu konkurētspējas attīstība neformālās komercizglītības vidē (Development of pupils' competitiveness in the environment of non-formal commercial education). Jelgava: LLU TF IMI, 2010. 331 lpp. (In Latvian).
15. Tiļļa I. Socālkultūras mācīšanās organizācijas sistēma (The system of socio-cultural learning organisation). Rīga: RaKa, 2005. 294 lpp. (In Latvian).
16. Bereiter C. Implications of postmodernism for science, or, science as progressive discourse. Educational Psychologist, vol. 29(1), 1994, pp. 3-12.
17. Hmelo-Silver C.E., Duncan R.G., Chinn C.A. Scaffolding and achievement in problem-based and inquiry learning: a response to Kirschner, Sweller, and Clark. Educational Psychologist, vol. 42(2), 2007, pp. 99-107.
18. Osborne J., Simon S., Collins S. Attitudes towards science: a review of the literature and its implications. International Journal of Science Education, vol. 25(9), 2003, pp. 1049-1079.
19. Noteikumi par valsts pamatizglītības standartu, pamatizglītības mācību priekšmetu standartiem un pamatizglītības programmu paraugiem (Regulations on national standard of basic education, subject standards of basic education and sample basic education curricula). 2013. [online] [10.03.2016]. Available at: http://likumi.lv/doc.php?id=259125 (In Latvian).