THE USAGE OF STEAM PROGRAM IN DEVELOPING AND IMPROVING OF STUDENTS' EXPERIMENTAL SKILLS

Violeta Šlekienė
Šiauliai University, Lithuania
E-mail: violeta@fm.su.lt

Abstract

The research analyzes the usage of STEAM program "Cognition of Energy and Thermal Processes" for students of ninth (1st Gymnasium) classes in order to deepen and broaden the knowledge of natural science education, develop practical abilities of students and their scientific researcher's competence. Students were advised to do five experimental works in this field. The program engages a basic educational strategy – inquiry based learning. The results of the pedagogical experiment and the questionnaire survey are discussed. Summarizing the results of the research, it can be stated that educational experimental activities are necessary and useful for students. By using the experiment, students can be provided with educational material in an attractive form, which stimulates the interest in the subject. Program participants have deepened and expanded their knowledge of energy and thermal processes in nature. Students improved their competence in natural science research. They learned how to plan and perform experiments, acquired the ability to formulate hypotheses, to make assumptions, to analyze and explain results, and to formulate reasoned conclusions. Students acquired practical skills to work properly and safely with devices and tools (computer systems Nova 5000 and Xplorer GLX, temperature, humidity sensors, caliper, scales, etc.) Students liked to be young researchers; they felt the joy of discovery by practically experimenting and independently exploring natural phenomena.
Keywords: *inquiry-based learning, experimental skills, science learning, STEAM education.*

Introduction

Most educational strategists, scientists, and practitioners in advanced countries keep up-to-date STEM subjects and their teaching, taking into account the rapid change in the field of science and technology and the rise of interdisciplinary integration. Fan and Yu (2016) pointed out that STEM education was focused on curriculum reform in many countries. This is because a number of advanced countries have fully realized that students' academic performance in science, technology, engineering and mathematics determines the country's economic development and competitiveness. Emphasis is placed on student-centred, constructivist education responding abilities of each student and suitable for all students. Worldwide practice uses various methods for updating and promoting STEM subjects. Many scientists suggested that inquiry-based learning strategy should be used to promote technology exploration, to practice teaching at a higher level, and strengthen the effect of STEM. According to many scientists, inquiry-based learning approach should be applied in schools (Abdi, 2014; Connor, Karmokar, &

Whittington, 2015; DeJarnette, 2012; English, 2016; Erickson, 2013; Filippi & Agarwal, 2017; Gormally, Brickman, Hallar, & Armstrong, 2009; Kelley & Knowles, 2016; Kennedy & Odell, 2014; Krajcik & Delen, 2017; Lai, 2018; Lee, 2011; Stohlmann, Moore, & Roehrig, 2012; Yakman & Lee, 2012).

Inquiry-based learning strategy can help to deliver a deep and meaningful science education, increasing the interaction between the student and the concepts under investigation. Interactive, multimedia experience cannot replace the real laboratory work but can enhance the learning process of many students, help them find the relation between the theoretical principles and the observed behaviour in an easy and intuitive way (Avouris, Tselios, & Tatakis, 2001). Since science is an experimental science, the role of lab-work in science education has been often paid attention by research studies (Bernhard, 2003; Harms, 2000; Sassi, 2001).

In order to make students more interested in natural sciences and to motivate them to relate their life to STEAM activities, it is appropriate to encourage students to engage in independent research and to discover the joy of discovery. One of the ways to solve this problem is the students' practical experimental activity in the laboratories of University. Since Science is an experimental subject, the role of practical activities in science education is very important. Experimental activities are one of the main science teaching/learning methods. This research analyzes the usage of STEAM program "Cognition of Energy and Thermal Processes" for students of ninth (1st Gymnasium) classes in order to deepen and broaden the knowledge of natural science education, develop practical abilities of students and their scientific researcher's competence. The main goal - to disclose the effectiveness of practical experimental work in science teaching at a high school.

Research Methodology

70 students of ninth (1st Gymnasium) classes from Šiauliai Adult School, S. Sondeckis Art Gymnasium, Romuva Gymnasium, S. Daukantas Gymnasium and S. Šalkauskis Gymnasium were involved in the experiment in 2018-2019. Analyzing the results of the real education process was revealed the effectiveness of practical experimental work. The educational process was based on the STEAM program *Cognition of Energy and Thermal Process*, which was based on inquiry-based learning. Students were advised to do five experimental works at the level II, as structured exploration, and level III, as guided exploration. Experimental works were used an inquiry-based approach, based on a small-scale research activity. Students were asked to do five experimental works for 2 hours each. Works were done in groups of two. Experimental works were carried out at Šiauliai University laboratory using the available equipment and tools. Some works have been done using computer-based training systems *Xplorer GLX* and *Nova 5000*. In order to evaluate the students' opinion on this program a survey has been carried out. Data were processed using the SPSS (Statistical Package for Social Sciences) software. Methods of descriptive statistical analysis were used for the analysis of the research data. For each statement of the questionnaire Positive Attitude Index (*PA*) was calculated. The Positive Attitude index may vary from 0 to 1.

Research Results

It can be stated that experimental activity is a necessary and currently integral part of the educational process. By using the experiment, students can be provided with educational material in an attractive form, which stimulates the interest in the subject. All students were satisfied and interested in all the experimental work (*PA* = .96), there were no unresolved difficulties for them (*PA* = .66), they easily understood the experimental methods and workflow (*PA* = .73). Less than a third of students have done similar work at school during school hours (*PA* = .28) and a little over a third were familiar with tools and devices (*PA* = .30). The students indicated that the experimental activities are interesting and engaging; they would like to continue such activities in the future (*PA* = .87). Following a t-test analysis, no statistically significant difference on these issues between the groups (students of different schools) was obtained (null hypothesis H_0 on average equality cannot be rejected; $p > .41$).

Although the students felt that they were doing well in experimenting, they thought they could easily understand the methods and workflow of the experiment, but monitoring and evaluating the activities made it possible to identify the typical difficulties that students encounter in practical work. Most of the students were hurried to do one or the other measurement, not fully understanding the meaning of the whole experiment. The lack of experimental skills was also evidenced by the difficulty for students to organize the work desk properly, to put tools and devices in a convenient and functional way. In most cases, students wanted to do everything while sitting, although this is sometimes very uncomfortable. There was a lack of basic skills to work with small auxiliary tools such as tweezers, tongs, flasks, tubes and so on.

The inquiry steps of experimental work, i.e. how students are able to formulate research problem, hypothesis, how to plan workflow, define variables, how to work with equipment and measuring devices, how to capture, process and analyze experimental data, formulate conclusions was analysed. 76 % of the students successfully formulated a hypothesis and only 12 % of the students, who have worked at inquiry level III, understood and planned the workflow correctly. 65 %t of the students properly processed the results, filled in the tables, drew up the graphs, performed the mathematical calculations, although only 34 % were succeeded in formulation of the conclusions.

Students' attitudes towards experimental equipment and tools used at work, their complexity and expediency were explored. Most students' preferred electronic measuring devices. Students enjoyed working with Science Learning Systems *Xplorer GLX* and *Nova 5000*. Comparing the advantages and disadvantages of the *Xplorer GLX* and *Nova 5000*, *Xplorer GLX* was relatively better (*PA* = 0.91) than *Nova 5000* (*PA* = 0.78). They emphasized that *Xplorer GLX* is easier to manage and the *Nova 5000* is quite inert and slow to operate, often malfunctioning.

Conclusions

It can be stated that in order to strengthen the interest of students in science and to achieve better learning outcomes, it is necessary to organize the education process so that it would be interesting for students. By applying inquiry based learning, students' experimental abilities and skills are developed, curiosity of students is stimulated, and interest in the subject is encouraged. The new, favourite activity of the students is of great importance for better learning outcomes.

It can be stated that the experimental training activity is a necessary and currently integral part of the educational process. By using the experiment, students can be provided with educational material in an attractive form, which stimulates the interest in the subject.

Positive attitudes of students towards STEAM training programs suggest that it is appropriate to use such programs when teaching science.

The typical difficulties that students encounter in practical work were identifying. Most of the students hurry to do measurement, not fully understanding the meaning of the whole experiment. The lack of experimental skills is also evidenced by the difficulty for students to organize the work desk properly. There is a lack of basic skills to work with small auxiliary tools such as tweezers, tongs, flasks, tubes and so on.

The research showed that students formulate the research hypothesis well enough, process data properly, but find it harder to plan workflow and formulate conclusions.

Program participants have deepened and expanded their knowledge of energy and thermal processes in nature. They understood the thermal expansion of the solid bodies, the concept of the specific heat of the material, the properties of the phase transformations of the material, the specific heat of evaporation of the water, the process of heat transfer of the human body and the environment.

Students deepened their competence in natural science research, learned how to plan and perform experiments, acquired the ability to formulate hypotheses, to make assumptions, to analyze and explain results, and to formulate reasoned conclusions.

Acquired practical skills to work properly and safely with devices and tools (computer systems *Nova 5000* and *Xplorer GLX*, temperature, humidity sensors, caliper, scales, etc.)

Students felt the joy of discovery by practically experimenting and independently exploring energy and thermal phenomena. They enjoyed being young researchers.

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