

Possibilities for Motivation in Hard Sciences Teaching

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KEYWORDS Creativity. Didactic Games. Lifelong Education. Pedagogical Constructivism. Psychology

ABSTRACT This paper focuses on the relevance and importance of motivation in one of the subject of hard sciences namely mathematics in the context of lifelong learning. The introduction identifies and summarises basic theoretical issues of motivation: a definition from the perspective of psychology and education, the basic divisions and different approaches used to motivate children and adults. There is a description of the pitfalls and difficulties in motivating students in mathematics, as encountered by teachers in educational practice. Paper presents the results of undertaken research at elementary school. Finally it also explores possible solutions in teaching methods which use pedagogical constructivism, a tool used to increase students' attention and to provide motivation within mathematics teaching.

INTRODUCTION

The paper's objective is to highlight the importance of motivation in mathematics teaching. The purpose of it is to introduce some ways and possibilities on how to increase pupils' interest in learning mathematics as a subject.

In educational practice, motivation plays one of the major roles and can considerably increase the effectiveness of the educational process. Motivation is one of the basic conditions of good performance of people, as it can concurrently influence several factors: concentration, storing and keeping pieces of knowledge in one's memory, and the quality of activities (endurance, quickness, depth etc.)

The extensive scope and depth of the issue of motivation are evidenced by various approaches to its definition. In psychology, motivation in the broadest sense is understood as a set of factors which encourage, direct and maintain one's actions (Decker 2015). The researcher believes that it is important to emphasise the plural at the beginning of the definition, that is, that there are several factors that work concurrently.

A rather different view of the definition of motivation based on the emphasis on its procedural aspect can be seen in Nakonečný (1997: 27), according to whom *"it may be said that motivation is a postulated process that establishes the orientation (aim), duration and intensity of one's actions (conduct). Motivation is a process initiated by a default motivational state whose content reflects a deficit in the physical*

or social existence of an individual and that aims at the removal of the deficit, which is experienced as a certain kind of satisfaction."

As is the case with psychology, there is no uniform definition of motivation in pedagogy or didactics of mathematics. The common focal point should be sought in psychological definitions; nevertheless, it is shifted in a more specific direction towards the educational process and the interaction of its two subjects: the teacher and the pupil.

Kalhous and Obst (2009: 367) view motivation as a process and say that *"motivation is the result of the interaction among the pupil, the teacher, classmates, the curriculum etc."* They also state that *"the motivation to learn is in itself a subject of learning, and its formation is most influenced by the imitation of patterns, a clear expression of requirements and expectations, and direct instructions of persons perceived as important."*

Slovak authors Fulier and Šedivý (2001: 367) say that *"motivation (from the Latin word movere = move) in didactics is viewed as an activity through which we excite the interest of pupils (individuals) in learning, concentrate their attention and actuate them."* With respect to the didactics of mathematics, they further state that *"in mathematics teaching, we must use the motivation provided by mathematics itself. The exciting heuristic activity forms one's psyche so that the desire for powerful intellectual experiences is firmly established in one's mind; such*

intellectual experiences can be gained through the discovery of the laws of mathematics. This fact helps one to grow fond of mathematics" (Fulier and Šedivý 2001: 367).

In conclusion, the researcher would like to mention a pedagogical definition based on the constructivistic principles upon which is based this paper: "Motivation is a prerequisite for the commencement of the learning process and constitutes its successful start. It can take various forms: a suitably conducted discussion about an interesting issue, a well-placed question, good problem formulation, discussion about life strategies, an interesting task or a challenging game. Motivation causes a tension between 'I do not have' and 'I would like to have', 'I am not able to' and 'I would like to be able to', and 'I do not know' and 'I need to know'" (Hejny and Kurina 2001: 105).

In general, it may be said that the motivation for one's actions has two sources: internal and external. The internal motivational disposition of an individual is primarily formed of the individual's needs, whereas the external motivational sources are incentives. In a broader sense, internal motivation includes the so-called flow motivation that is characterised by a deep concentration, hard work and attachment to the tasks at hand. It is a state where the individual is deeply interested in his/her work despite the fact that there is no external support.

Needs and incentives are very closely related. On the basis of the mutual interaction of needs and respective incentives, a motive is established and developed; such a motive is then closely related to one's actions. Behaviour is perceived as an instrumental activity mediating the relation between a need and its satisfaction; a motive then expresses the content of such satisfaction (Decker 2015).

In summary, it may be said with respect to needs and motives as the two key concepts of motivation that needs express the default motivational state that is concretised through development, and motives express the content of the reaction (satisfaction), and as such should be understood as further unanalysable psychological causes of one's behaviour.

METHODOLOGY

A concrete opportunity for the application of effective instruments on motivation in mathe-

matics teaching where the basic constructivistic principles are respected was provided by the Ministry of Education Youth and Sports (MEYS) National Research Programme II project entitled "*The research of new creativity competition methods for young people aimed at motivation for research activity in hard sciences, especially mathematics, physics and chemistry*" (No. 2E06029). As part of the resolution of one of the sub-tasks of the S 006 project with the working title of "Plays with Mathematics", the researchers was inspired by the above constructivistic ideas and tried to confront them with concrete practice at elementary schools. Therefore, the researchers' experiment was focused on the establishment, support and research of educational efficiency of various mathematical activities: school mathematics competitions, projects and events for parents and the public. The experiment was oriented at various target groups of elementary-school pupils: pupils gifted in mathematics, "average" pupils in order to increase their interest in mathematics, and pupils with special educational needs.

The above theoretical starting points provided the basic orientation and framework for our research, leading to the establishment of mathematics competitions and projects at the class or school level at elementary schools (children aged 6-15 years) with the possibility of involvement of pupils with special educational needs. The specific continuous outcomes consisted in the preparation and implementation of events such as the "Day with Unconventional Mathematics" (open mathematics lessons, projects, competitions etc.) as exemplary activities focused on changing the methods and forms of teaching. The primary objective was to contribute to the popularisation of mathematics, to make mathematics more attractive in the eyes of elementary-school pupils, and to enable pupils to perceive mathematics lessons not as a "training ground" for the acquisition of difficult and unnecessary rules, theorems and algorithms, but rather as an environment intended for the performance of interesting activities and experiments. It was the pupils' task to complete a certain number of "stations" with various forms of unconventional activities, the purpose of which was in particular the motivation of pupils to want to learn mathematics, the development of a positive perception of mathematics as a school subject against the background of subject integration, and the

possibility of making pupils learn mathematics in an entertaining and spontaneous form (sudoku, tangrams, matchstick puzzles, quantity estimates, tasks with detective stories, logic board games, manipulation with geometric models, computer games etc.)

The experiment was based on mere intuitive experience gained by the team of authors in the implementation of new or innovated activities at eleven elementary. The researchers consider the application of projects, competitions, non-standard tasks and didactic games to be an important part of the constructivist-oriented teaching of mathematics in terms of the motivation of both pupils and teachers. According to Spilková (2004), the interaction of knowledge formation is accentuated in this respect, as knowledge is always formed in the social context, in particular in the communication and interaction with the classmates and the teacher. What is also important is the authenticity of knowledge – “I” as the subject of the original formation of knowledge (the importance of seeking, discovery and construction of knowledge on the basis of one’s own activities and experience).

The ability of pupils to work independently with data and to use mathematical tools to address real situations in practical life is seen as an important manifestation of mathematical literacy in the outcomes of the OECD PISA study (Hejný 2012). As Boero (2006) emphasises, the estimation, verification and modelling – intended for the purposes of interpreting natural phenomena and anticipating their development – should become the core of mathematics education as early as elementary school as an important component of the development of mathematical thinking. The reflection of teaching activities is very important to teachers, in order for them to be able to retroactively analyse and evaluate their performance and subsequently modify and innovate their teaching methods. This considerably influences the quality of the teacher’s work and may significantly develop his/her didactic thinking and conduct (Capek 2015).

RESULTS

In order to assess to what extent the authors of the project were successful in achieving or at least coming close to the set objective, several research tools were used:

1. A questionnaire survey on the basis of a sample of elementary-school pupils participating in the research;
2. Authentic opinions of pupils (written and verbal) upon the completion of the individual events in the schools;
3. The reflection of the opinions and experience of teachers, gained in the preparation and implementation of the individual activities.

The data for the quantitative survey were obtained by means of a questionnaire. In order to preserve the authenticity and obtain reliable data if possible, the questionnaire survey was conducted immediately upon the completion of each particular event in the relevant school. The data were obtained from 340 respondents, of which 153 were girls (45 %) and 165 were boys (49 %). 22 of the questionnaires did not indicate the sex. The respondents were chosen from six elementary schools and one grammar school. Out of the total number, 119 were elementary-school pupils aged 6-10 years (35 %) and 216 were elementary-school pupils and grammar-school students aged 11-15 years (64 %); 5 of the questionnaires were returned with no indication of the grade attended. Pearson’s chi-squared test for cross tabulation was used to process the survey results. In each area, the researcher examined the differences in the respondents’ replies depending on the sex (boys and girls) in order to take into account the gender differences, and depending on the age (children aged 6-10 years or children aged 11-15 years).

The pupils mostly chose logic games (such as Reversi and Blokus etc.) as the most popular methods. The researcher believes that this is mainly because such games are collective and are associated with the feeling of joy and healthy competition. Matchstick puzzles, sudoku and tangrams were also popular thanks to the simplicity of their assignment and the fact that they constituted an adequately difficult challenge in the field of logical thinking and spatial imagination.

DISCUSSION

Considerable attention was paid to teachers’ reflections in this research. Positive evaluations of the teachers who had participated in the individual events under the project clearly illustrated a positive shift in the quality of the prepara-

tion and implementation of curricular and extra-curricular mathematical activities, and became a source of mutual inspiration.

The elementary-school teachers had the opportunity to individually or collectively (in co-operation) reflect upon their own activities. They also had the opportunity to ask themselves questions such as:

- ♦ What did I do and how did I do it?
- ♦ What were my intentions, expectations and results?
- ♦ In what did I succeed and why?
- ♦ Were there any problems or critical points?
- ♦ What were the problems in understanding the pupil products?
- ♦ What interpretations of pupils' performances are possible?

At the same time, the teachers could think over and analyse the background of their activities – their opinions, attitudes, beliefs and experience. This active, practical knowledge, which is mostly intuitive, sensational and subconscious, becomes part of the consciousness through reflection and self-reflection, is the key to the understanding of one's own activity and connections, causes and consequences, and may result in a desirable change in the teaching methods and the approach to the teaching of mathematics.

It is therefore obvious that there is a reciprocal relation between the degree of the teacher's motivation to teach and the pupils' motivation to learn. If the mathematics teacher is adequately motivated to perform his/her job, he/she will try to draw the attention of the pupils and familiarise them with mathematics in a suitable manner. It is mostly up to the teacher which methods he/she will use and apply in practice, to what extent and in what way. The teaching methods are generally designated as actuating and comprehensive methods in classifications. Their successful application in lessons directly influences the internal motivation of teachers to teach mathematics. Such methods include in particular didactic games, competitions, interesting tasks, projects, cooperative teaching and learning, e-learning and outdoor lessons.

CONCLUSION

In the critical assessment and evaluation of the achieved results, it will be necessary to expand the framework of new activities focused on the change of the methods and forms of mathe-

matics teaching at various school levels (elementary and secondary), and to sufficiently promote such new activities among teachers as well as parents.

Researcher may say that motivation is not the only thing which strongly influences the educational process of pupils and their performance; a teacher who applies adequate methods of motivation bestows a subjective meaning upon the taught activities and assigned tasks, thus immediately influencing the efforts made by the pupils in the completion of the assigned tasks. In relation to the above, there is the issue of suitable motivation of teachers, who may be viewed from two perspectives: the teacher as an employee of the school and the teacher as the creator and organiser of the educational process.

The objective was not to establish a uniform and universal template of similar events but rather to make the school subject of mathematics as diverse and pleasant as possible so that it is familiar to the broadest possible spectrum of pupils, thus contributing to a change in the climate associated with constructivist-oriented mathematics lessons. The positive reactions of the participants – both pupils and the teachers – have convinced us that ... “to learn means to discover what you already know. To act means to demonstrate that you know it. To teach others means to remind them that they know it as well as you do. We are all pupils, trainees and teachers at the same time”.

RECOMMENDATIONS

The fact that a pupil's behaviour may stem from both needs and an external incentive is very important to teachers, as they work with pupils with needs developed to different extents, who have to be motivated in suitable ways. For instance, a pupil with strongly developed cognitive needs can be interested in any part of the lesson which satisfies his/her need for knowledge or problem resolution. On the other hand, in the case of a pupil with underdeveloped cognitive needs, the teacher has to work carefully with external incentives and gradually develop the cognitive needs in such a pupil. In concrete terms, a pupil may get down to solve a mathematical problem because of his/her inherent need for achieving the desired result, because the problem interests him/her with its content or pictures, or because the pupil's teacher (friend, parent)

presents the problem to him/her in an engaging way.

In line with the introduced general division in motivational theories, the researcher could recommend to focus on internal motivators that are part of the teacher's work and that appear in the course of the teacher's work. The possibility of doing one's job with an internal motivational potential is motivating because the work itself constitutes the reward. External motivators constitute an external reward which has significance or value upon the completion of the work or outside one's workplace. They provide only a little (if any) satisfaction after the work has been completed.

LIMITATIONS

In all stages, all the projects mentioned above may be characterised by activity – apparent manipulative or latent intellectual activity – accompanied by mutual communication and the seeking and defending of one's own solution processes. The purpose is primarily to motivate pupils to want to learn mathematics, to develop a positive perception of mathematics against the background of subject integration, to make pupils learn mathematics in an entertaining and spontaneous form, and to motivate teachers to seek new teaching methods. Nevertheless, the researcher is aware of the restrictions and limits in the use of unconventional activities in real mathematics teaching. The researcher also respects and takes into account the opinions of those who note that *“the most beautiful school, the best teacher, excellent textbooks and activating teaching methods are useless if a pupil is unwilling to learn”*.

FOR FUTURE STUDIES

The facts ascertained in the questionnaire have led to some findings which have become the starting points for further activities intended to increase the pupils' interest in mathematics. The researcher belief that mathematics was unpopular among pupils was not confirmed. The achieved results, however, clearly reflect the fact that the questionnaire survey was conducted immediately upon the completion of the events which had shown mathematics in a different light. The researcher sees this as a confirmation of the meaningfulness of our project, aiming at the popularisation and promotion of mathematics among

the general public and mathematics teachers alike. The researcher also considers these findings to be a certain challenge presented to teachers and an opportunity for changing the concept, forms and methods of mathematics teaching, so that teachers are able to teach mathematics in a creative and engaging way, and to allow their pupils to experience the feeling of joy and success in the resolution of interesting and unconventional tasks that are popular among pupils, in working with computers and in the use of interactive instruments.

A specific outcome following the above results is a specialised publication which is being completed at the Department of Mathematics of the Faculty of Education of Palacky University in Olomouc at the moment; the publication has a working title of “Motivation and Creativity in Mathematics Teaching”, and should provide teachers with theoretical starting points as well as practical suggestions of activating teaching methods as a motivational instrument for pupils and teachers. The monograph contains a total of 13 chapters arranged according to their topics. The first (and introductory) chapter defines the theoretical starting points of motivation that are fundamental in all the other chapters in the publication. The following chapters focus on the following fields: research-oriented teaching as one of the tools (not only) in mathematics teaching, the resolution of competition tasks as a way towards increasing the popularity of mathematics among pupils, motivational activities in the education of pupils gifted in mathematics, outdoor teaching of mathematics, manipulative activities as a means of motivation and development of spatial imagination in elementary schools, origami models as a means of forming spatial imagination in geometry, e-learning support of mathematics education, information and communication technology as a motivational element in mathematics teaching, digital educational objects in mathematics education, financial literacy as part of mathematics education, CLIL (Content and Language Integrated Learning) in theory and practice, and functions and functional equations.

NOTE

*This article was presented at The International Conference on Lifelong Learning and Leadership for All (ICLEL-15), in Olomouc on October 29-31, 2015.

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