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Impact of long-term regular outdoor learning in mathematics – The case of John

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This paper reports on a longitudinal study investigating the impact of long-term regular outdoor learning in mathematics in the school-grounds. An interview-based case study of John, a lower secondary school student, will be analysed. The case study will describe John's perceived experience of long-term regular outdoor learning in mathematics and its impact on affective and academic factors. The findings emphasise the positive outcomes of long-term regular outdoor learning in mathematics, indicating enhanced cooperative learning, reduced mathematics-related stress and anxiety, changed self-concept, and enhanced mathematical proficiency.

Keywords: Outdoor learning, mathematics anxiety, self-regulation, mathematical proficiency.

Introduction

The constant focus on textbooks and formal mathematical practice might invoke a view among students that mathematics is abstract, distanced and only useful in a classroom context, working only in the textbook (Boaler, 1998). If students are not given the opportunity to engage with real-life problems in mathematics they will encounter problems applying their knowledge in an outside school context (Desforges, 1995). Mathematics taught in the classroom will have limited value if it is not transferable to students' everyday life and future academic and career endeavours. Current research on outdoor learning in mathematics demonstrates positive affective outcomes and possible academic benefits (Daher & Baya'a, 2012; Moffett, 2011; Noorani et al., 2010). In this paper, by analysing John's perceived experiences of long-term (3 year period) regular outdoor learning in mathematics, we explore any possible impact on both affective and academic factors. By affective factors we mean mathematics-related stress and anxiety, and motivation. With academic factors we refer to possible academic outcomes such as application and understanding of mathematical knowledge, enhancement of mathematical proficiency, learning strategies, self-regulation and self-concept.

Theoretical background

Outdoor learning

Outdoor education can be referred to as organised learning that takes place in the outdoors and is drawn up on the philosophy and theory and practises of environmental as well as experimental education. The embodied and multisensory experiences provided by well-organised outdoor learning are believed to enhance the individual's learning and understanding within a subject, in this case, mathematics. The variation of context between the indoor classroom activities and the outdoor activities enables rich opportunities for cooperative learning in real-life situations (e.g. Jordet, 2007).

Mathematical proficiency

In the present paper we use the framework of mathematical proficiency presented by Kilpatrick, Swafford, and Findell (2001). According to Kilpatrick et al. (2001), mathematical proficiency has five strands: conceptual understanding (comprehension of mathematical concepts, operations and

relations), procedural fluency (skill in carrying out procedures flexibly, accurately, efficiently, and appropriately), strategic competence (ability to formulate, represent and solve mathematical problems), adaptive reasoning (capacity for logical thought, reflection, explanation, and justification) and finally, productive disposition (habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's efficacy) (Kilpatrick et al., 2001, p. 116).

Mathematics anxiety, motivation, self-regulation and self-concept

Mathematics is highly valued by society, and proficiency in mathematics has become increasingly important in order to become a fully functioning citizen, with resulting financial empowerment, making the ability to use mathematics in an out-of-school context even more important (OECD, 2004; Peterson, Woessmann, Hanushek, & Lastra-Anadón, 2011). A variety of studies have shown that many students have negative attitudes towards mathematics, which sometimes results in mathematics-related stress and anxiety (Ashcraft, 2002; Maloney & Beilock, 2012). Within a student, engaged in a mathematical activity, an on-going unconscious evaluation of the situation with respect to the student's self-concept and personal goals is taking place. Depending on the individual's evaluation of the outcome, the student may become emotionally affected being either motivated or not for further mathematical activities (Hannula, 2002; Pintrich, 2004). According to PISA (OECD, 2013), Ryan and Deci (2009) and Wigfield, Tonks, and Klauda (2009) two forms of motivation to learn mathematics within self-regulative skills exist. The two forms are intrinsic motivation and extrinsic motivation. Intrinsic motivation is the motivation to perform mathematics merely for the joy gained from doing mathematics. While extrinsic motivation is the motivation to perform mathematics due to its importance in society, usefulness and the fact that mathematical knowledge will aid future career prospects and further academic studies. An individual with mathematics-related stress and anxiety is emotionally affected in a negative sense and tends to have a low self-concept (self-related cognitions of ability that can explain as well as predict achievement related behaviour, belief in one's abilities) as well as low levels of self-efficacy (a student's belief that he/she has the capability to perform a given mathematics task at a designated level) (Bandura, 1994; Bong & Skaalvik, 2003). Furthermore, these individuals also tend to lack the ability to self-regulate, resulting in avoidance behaviour and a decline in mathematics performance. As a consequence they are assigned lower grades and tend to have limited choices of possible future academic and non-academic career paths (Wu, Barth, Amin, Malcarne, & Menon, 2012).

One important factor to promote learning is students' capability to self-regulate (Pintrich, 2004). If students' are provided with guidance on how to self-evaluate their own learning process and how to develop suitable strategies to promote their own learning during formal schooling, such guidance will enable acquired knowledge to remain updated after leaving school and to be used in an outside school context (Pintrich, 2004; Zimmerman, 2002). Self-regulation refers to the degree in which students are active participants in their own learning. It is an individual's ability to set mastery goals, mobilizing the efforts and resources the individual will need in order to achieve these goals. To reach these mastery goals, students use a wide range of self-regulatory processes and display a number of adaptive motivational factors such as self-efficacy and self-concept, where moderate levels of mathematics-anxiety may actually facilitate learning as well as performance (Pintrich, 2004).

Cooperative learning

Procedures in cooperative learning are designed to engage students actively in the learning process through inquiry and discussion with their peers in small groups, which need to be well organised with a clear structure to promote cooperative participation and learning (Davidson & Worsham, 1992, p. xii). Cooperative learning provides students with academic factors such as positive effects in mathematics performance and student achievement (Whicker, Bol, & Nunnery, 1997). Cooperative learning is a preferable method when helping individuals with mathematics-related anxiety to reduce their stress and anxiety. Furthermore, it is also an important feature of self-regulated learning because active participation is a crucial element of the self-regulation construct (Clark, 2012; Daneshamooz & Alamolhodaie, 2012).

Focus of the study

The aim of the study was to investigate John's perceived experience of long term (three years) regular outdoor learning in mathematics in terms of possible impact of integrated outdoor mathematics activities on affective and academic factors.

Methodology

This paper is a part of a larger intervention research project aiming to explore the possible impact of outdoor teaching and learning in lower secondary school (Fägerstam, 2012). Outdoor teaching and learning was implemented on a regular basis as a complement to ordinary classroom teaching during the entire lower-secondary school period of three years. The focus of this paper is to explore the possible impact of long-term regular outdoor learning in mathematics, and the case of John is presented as an example of its possible impact. The research is exploratory to its nature because there are few longitudinal studies on outdoor learning in mathematics. John is 15 years old, attending his third and final year of lower secondary school. John is a fictitious name that has been given to ensure the individual's anonymity. John's class had one of their four weekly mathematics lessons outdoors on a regular basis during the entirety of lower secondary school. The same mathematics teacher taught John during the three years of the intervention project. The school to which John and his class belong was situated in the suburbs of a medium-sized (approx. 85000 inhabitants) municipality in Sweden. The school, grade 7 to 9, was a normal sized school with approx. 450 students in six parallel classes. John was interviewed using semi-structured interview as a method. The interview was audio-recorded and transcribed using verbatim. Data was analysed thematically to identify recurrent patterns and commonalities using thematic coding (Boyatzis, 1998). Aspects of self-regulation skills were analysed based on concepts originally used in the PISA survey (OECD, 2004), namely intrinsic and extrinsic motivation, self-concept and mathematics anxiety. Representative illustrative quotes will describe the possible impact of regular outdoor learning in mathematics on self-regulation in mathematics and mathematical proficiency as well as John's perceived experience. The ethical guidelines and directives stipulated by The Swedish Research Council regarding good research have been followed (Hermerén, Gustafsson, & Pettersson, 2011).

The case of John

John is a fifteen-year-old boy who has had severe difficulties with learning and understanding mathematics since he started school. John was selected as a case due to his low levels of mathematics

self-concept, expressed mathematics-related stress and anxiety and low levels of mathematical proficiency, which were reflected in his mathematical performance.

John's overall experience: Well-planned lessons, structure, intelligibility, and time

John emphasises the importance of well-planned lessons, structure and intelligibility. It is important, he says, that one knows what is expected and that everyone knows what to do.

It is of importance that everyone knows what he or she is supposed to do. It is important that the teacher gives a thorough briefing before the outdoor lesson. It is important that the teacher presents a well-organised picture of the task. You need to have a check before you start as well so you know what to do and that you do not just start directly and miss out on something that is of importance when solving the task that is presented to you and your group.

Through well-organised lessons and well-made tasks, it is easier to understand the mathematics and what is expected of you. John continues:

It is crucial that you understand what you are supposed to do, what kind of theory you need in order to solve the task that is presented to you. If the lessons are not well organised, the head, the brain, you get so, you disconnect, you start to think of other things.

Time is another aspect of John's experience of the long-term regular outdoor learning. He thinks that the teacher who teaches mathematics provides time to work with mathematics outdoors. However, he questions why other teachers in other subjects do not provide time and prioritise time to have some of the weekly lessons outdoors.

I think that you should have outdoor lessons in other subjects too. Take biology for example. In biology there are so many "outdoors and environmental issues" so it would be a great possibility to work more outdoors. But, we are never outdoors during our lessons in biology, which I think is strange.

According to John, outdoor learning in mathematics provides more time and space to understand what and why you do things.

Indoors you seldom receive any help from the teacher. Often you just sit there for like ten minutes waiting for the teacher to have the time to help you. This results in you not raising your hand to ask for help, because it is quite meaningless. On the contrary, during the outdoor lessons in mathematics the group could either help each other or if the group needs assistance from the teacher, the teacher helps the whole group at the same time, which is really great.

Impact on affective factors

John experienced and expressed a change in self-concept.

Outdoor lessons in mathematics make it easier for you to remember what you do and why. When you have your lesson in mathematics outdoors, the teacher explains clearly what to do. You are given a clear picture of what is expected of you and what the task at hand is about and what the aim of the lesson is. You will better understand what you do and why you do it.

Moreover, it seems like the change of learning environment reduces the mathematics related stress and anxiety.

It is relaxing to work on a regular basis with mathematics outdoors. I get really stressed during the regular indoor lessons in mathematics and suffer from mathematics-related panic attacks. However, during the outdoor lesson in mathematics I really enjoy myself, I am more relaxed and do not suffer from mathematics-related anxiety attacks.

John experiences that he is enjoying himself and feeling more relaxed during the regular outdoor lesson in mathematics.

John also indicates that his extrinsic motivation has a tendency to hamper his achievement and performance in mathematics. He brings up the pressure to perform and the stress and anxiety the national tests in mathematics cause. However he also brings up a sense of changed perception of himself and emphasises the positive outcomes of variation of context for the learning of mathematics.

It makes you understand everything much better. You become more engaged and motivated. Regular outdoor lessons in mathematics provide you with more input and understanding of mathematical concepts. In addition, you feel better and enjoy the mathematics lessons more.

John appears to address the idea of losing one's self-confidence, which will lead to low self-concept.

John emphasises the importance of feeling engaged and motivated. To be extrinsically motivated tends to have a negative impact on understanding and learning mathematics. It rather makes you give up because you feel like a loser who cannot manage mathematics. However, by working to engage with real-life problems in mathematics with regular outdoor lessons in mathematics solving these real-life problems together with others provides, according to John, the possibility to become aware of one's true mathematical proficiency and that it might be enhanced. As demonstrated, John experienced that he began to enjoy mathematics more. He changed from being extrinsically motivated to become more intrinsically motivated and was more ready to face new, more challenging tasks because he started to believe in his own abilities.

Impact on academic factors

John also stated that he had difficulties with negative numbers when using them and understanding the concept of them. During one of the outdoor lessons in mathematics they had worked with negative numbers. Before this outdoor lesson they had, during the indoor lesson, talked about negative numbers and worked with them in the textbook.

Well, we had one lesson when we worked with negative numbers, you know plus and minus and that kind of stuff. We did this exercise where you were supposed to run and put a piece of paper next to another on one of these big long things that looks like a row, and then there were also, you know, numbers in between and at the far end there was perhaps minus something and in the middle was zero. After a while you started to realise that it was kind of a huge thermometer. It was almost like the numbers became connected with each other. The visual picture and the practice of actually building the thermometer gave you a better understanding of the concept. It is strange but you actually need lots of self-confidence when it comes to learning and understanding mathematics.

As seen, working more visually and practically with negative numbers, strengthens John's conceptual understanding of negative numbers.

John emphasised the gain of cooperative learning. During the outdoor lessons in mathematics the students were supposed to collaborate when solving different problems they were given. During the outdoor lessons in mathematics, John was given a feeling of participation.

The class cooperated better when working with mathematics outdoors than indoors. Indoors the class seem to be more divided into certain groups. There is that group with the smart kids, who are good at mathematics, then the rest of us who are kind of left behind. During the outdoor lessons there tends to be more cooperative work, because all of us know that you must first begin to solve the given mathematics task on your own to begin with and then help the group by discussing the problem together. It is important that everyone can join in, participate and be given the possibility to explain how to solve the task at hand. Everyone should be given the opportunity to show his or her proficiency and share one's knowledge with others. It is a way to better understand how a given task can be solved. You become more engaged and motivated if you are allowed to participate and speak your mind regarding how you believe that the task at hand can be solved.

John emphasises that cooperative learning opens up opportunities for and development of adaptive reasoning. Through the outdoor lessons in mathematics, the students are given the possibilities to reason with each other. They have the opportunity to explain and try out their logical thoughts as well as justify their thoughts and chosen solution to the task at hand by reasoning with others.

Productive disposition

John expressed experiencing that he began, thanks to the regular outdoor lessons, to recognise and realise the importance of mathematics and that it is worthwhile to make the effort to understand the concepts of mathematics. Through cooperative learning he realised that he actually possesses a certain level of proficiency in mathematics. He realised that a task can be solved in several different ways.

You need self-confidence in mathematics and if you enjoy mathematics then you become more confident and more motivated. Indoors you just sit and understand nothing. But when you work with mathematics outdoors you understand how it all works.

Discussion

John's perceived experiences of regular outdoor learning in mathematics indicate that it is reasonable to assume that students can benefit from regular outdoor learning in mathematics. We may conclude that long-term regular outdoor learning in mathematics shows a tendency to have an impact on affective factors by altering the individual's self-concept, reducing mathematics-related stress and anxiety and resulting in a more engaged and motivated student, which is supported by the findings of previous studies (e.g. Moffett, 2011). In addition, long-term regular outdoor learning in mathematics shows a tendency to have an impact on academic factors and one major feature was the importance of variation of context. It is reasonable to assume that the possibility to work more visually and practically with real-life problems, which had first been presented theoretically during the indoor lessons, might be a key factor for enhanced conceptual understanding (Kilpatrick et al., 2001). We may conclude that engagement and motivation for learning mathematics is enhanced. Accordingly, students tend to become more engaged and motivated by regular outdoor learning in mathematics. Cooperative learning is a prominent part of outdoor learning in mathematics and is emphasised by John as a key feature for the enhancement of his adaptive reasoning (Kilpatrick et al., 2001). Previous findings have indicated that cooperative learning tends to help mathematics- anxious individuals

reduce their stress and anxiety for mathematics (Daneshamooz & Alamolhodaei, 2012). The main feature of cooperative learning is the opportunity to discuss and reason with others and justify one's mathematical thoughts on how to solve different mathematical problems. John stresses that cooperative outdoor learning in mathematics tends to make students aware of their true mathematical proficiency by being given the possibility to observe that a task at hand can be solved in more than one way and that more than one "right" solution to the problem may exist. John experienced that when mathematics became less abstract and more transferable to his everyday life, learning mathematics becomes more joyful resulting in a more positive attitude towards mathematics making him engage instead of avoid learning mathematics (e.g. Maloney & Beilock, 2012). Long-term regular outdoor learning in mathematics gave John the possibility to develop the ability to self-regulate his learning (Wu et al., 2012). Finally, it is reasonable to assume that if a student is provided with a sense of control, that student may enhance the levels of self-concept and reduce mathematics related stress and anxiety.

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