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 outcomes and academic benefits. The findings emphasise the positive outcomes of a 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

This paper reports on a longitudinal study, investigating one student's, John's, perceived experience of long-term regular outdoor learning in mathematics and its impact on affective and academic factors. With affective factors we refer to mathematics related stress, mathematics anxiety and motivation. With academic factors we refer to possible academic outcomes such as application of mathematical knowledge and understanding, enhancement of mathematical proficiency, strategies/ways for learning mathematics, self-regulation and self-concept. The study is a part of a larger intervention research project aiming to explore the possible impact of outdoor teaching and learning in lower secondary school. The project took place over a three years time period. Mathematics taught in the classroom will have limited value if it is not transferable to students' everyday life and future academic and career endeavours. 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 in 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 have problems applying their knowledge in an outside school context (Desforges, 1995). Existing research on outdoor learning in mathematics indicates positive affective outcomes and possible academic benefits from outdoor learning in mathematics (Daher & Baya'a, 2012; Moffett, 2011; Noorani et al., 2010). In this paper, by analysing John's perceived experiences the aim is to explore possible affective outcomes and possible academic benefits from a long-term (3 year period) regular outdoor learning in mathematics.

Theoretical background

Outdoor learning

Outdoor education can be referred as organised learning that take 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 individuals 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 this study we use the framework of mathematical proficiency presented by Kilpatrick, Swafford, and Findell (2001). According to Kilpatrick et al. (2001) mathematical proficiency is conceptualised of five aspects: conceptual understanding, which is comprehension of mathematical concepts, operations and relations; procedural fluency, which is skill in carrying out procedures flexibly, accurately, efficiently, and appropriately; strategic competence, which is ability to formulate, represent and solve mathematical problems; adaptive reasoning, which is capacity for logical thought, reflection, explanation, and justification and finally productive disposition, which is 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

Society values mathematics highly and proficiency in mathematics has become increasingly important to gain full citizenship with economic access 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 manifests itself as mathematics related fear or mathematics anxiety (Ashcraft, 2002; Hembree, 1990; Maloney & Beilock, 2012). A student that is engaged in a mathematical activity there is an on-going unconscious evaluation of the situation with respect to the student's self-concept and personal goals. Depending on the outcome the student becomes affected emotionally and are 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) there are two forms of motivation to learn mathematics within self-regulative skills, intrinsic motivation and extrinsic motivation. Intrinsic motivation regards the motivation to perform mathematics merely for the joy gained from doing mathematics. Extrinsic motivation is the motivation to perform mathematics because mathematics is important and useful and will aid future career prospects and further academic studies. An individual with mathematics anxiety tends to suffer from low self-concept and low levels of self-efficacy. Self-concept is self-related cognitions of ability that can explain as well as predict achievement related behaviour, belief in one's abilities; while self-efficacy is a student's belief that he/she has the capability to perform a given mathematics task at designated level (Bandura, 1994; Bong & Skaalvik, 2003). Furthermore, these individuals lack the ability to self-regulate one's learning, which leads to avoidance behaviour, a decline in mathematics performance, is assigned lower grades, and finally, have limited choices of possible future academic and non-academic career paths (Wu, Barth, Amin, Malcarne, & Menon, 2012).

Students' capability to self-regulate is an important factor to promote learning (Pintrich, 2004). By providing students guidance about how to self-evaluate one's own learning process and how to develop suitable strategies to promote one's own learning during formal schooling it enables acquired knowledge to remain updated after leaving school and can be used in an outside school context (Pintrich, 2004; Zimmerman, 2002). Self-regulation concerns the degree to which students are active participants in their own learning. It is an individuals' ability to set mastery goals, mobilizing one's efforts and resources the individual will need in order to reach 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, self-concept and where moderate levels of mathematics anxiety actually may 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 needs to be well organised with a clear structure to promote a cooperative participation and learning (Davidson & Worsham, 1992, p. xii). Cooperative learning provides students with academic benefits 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 an important feature of self-regulated learning because active participation is a crucial element of the self-regulation construct (Clark, 2012; Daneshamooz & Alamolhodaei, 2012).

Focus of the study

The aim of the study was to investigate John's perceived experience of long-term regular outdoor learning in mathematics in the school grounds, and its possible impact on affective factors and academic benefits. We sought to identify and explore following objectives: What are John's perceived experience of integrated outdoor mathematics activities during a period of three years in lower secondary school? What possible impact does long-term regular outdoor learning in mathematics has on affective factors? What possible impact does long-term regular outdoor learning in mathematics has on 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 entirety 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 the 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 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. 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 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 has been followed (Hermerén, Gustafsson, & Pettersson, 2011).

The case of John

John is a boy that has had severe difficulties with learning and understanding mathematics since he started school. He often feels stressed and anxious about mathematics.

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

John emphasise 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 thoroughly briefing before the outdoor lesson. It is important that the teacher present a well-organised picture of the task. You need to have a check before you start as well so you now 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 for 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 to solve the task that is presented for you. If the lessons is not well organised then, the head, the brain, you get so, you disconnect, you start to think of other things and as a result you end up with not understanding a thing of what you are supposed to. The teacher could speak for an hour and afterwards you have not understood a thing of what you were supposed to.

Time is another aspect of John's experience of long-term regular outdoor learning in mathematics that he brings forward throughout the whole interview. He thinks that the teacher that teach mathematics provide time to work with mathematics outdoors. However, he is questioning why other teachers in other subjects do not provide time and priorities time to have some of the weekly lessons outdoors. John brings forward that he believes that all subjects in school would gain plenty by working with a variation of context and with regular outdoor learning.

> I think that you should have outdoor lessons in other subjects too. Take biology for example. In biology there is so much of "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 are doing things. There is more time to explain how it all works and more time to discuss, reflect, justify and analyse solutions made on task at hand. You are given more time during the outdoor lessons to develop your conceptual understanding in comparison to the indoor lessons.

> 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 asking 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 seem to express an experienced change in self-concept

> Outdoor lessons in mathematics makes that you easier will remember what you do and why. When you have your lesson in mathematics outdoor, 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. This makes you better understand what you are doing and what is required of you. When you understand you become more secure and calm and begin to be more aware of your mathematical abilities. 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. John says:

> 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 my self, I am more relaxed and do not suffer from the mathematics related anxiety attacks.

John experience that he is enjoying him self and feeling more relaxed during the regular outdoor lesson in mathematics.

John is also indicating that John's extrinsic motivation has a tendency to hamper his achievement and performance in mathematics. He brings forward the pressure to perform and the stress and anxiety the national tests in mathematics causes. An interpretation is that John has a very low self-concept and do not trust his abilities in mathematics and are not sure about his level of mathematical proficiency. However he brings forward a sense of changed perspective of himself and emphasises the positive outcomes of variation of context for the learning of mathematics. John says:

> It is good when you are given the possibility to work with mathematics outdoors and work together with others. By working together solving and reflecting, discussing and justifying your thoughts of how to best solve the task at hand together with others aid your understanding of mathematics concepts you are working with. 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. The indoor lessons makes you indifferent and uninterested, because, it is the same all the time and when you can not solve the task at hand then you need help from your teacher. But the teacher will not have enough time to help you resulting in that you are just sitting there doing nothing and becomes totally unengaged. Hence, if you do not understand then you kind of feel like you are "a problem". You believe that the teacher and your classmates think you are useless and stupid.

John seem to address when one loose one's self-confidence which will lead to low self-concept.

John emphasise the importance to feel engaged and motivated. To be extrinsically motivated tend to have a negative impact on understanding and learning mathematics. It rather makes you give up because you feel like a looser that 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 that one's mathematical proficiency can be enhanced. John experienced that he began to enjoy mathematics more and changed from being extrinsically motivated to become more intrinsically motivated and was more ready to face new more challenging tasks because you start to believe in your own abilities.

Impact on academic factors

John told that he have had difficulties with negative numbers. He said that he had struggled with how to think when using and understanding the concept of negative numbers. 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. John said:

> Well, we had one lesson when we worked with negative numbers, you know plus (addition) and minus (subtraction) 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 it also was, you know, numbers in between and at the far end it were perhaps minus something and in the middle it was zero. Well, you were supposed to run and leave the number you thought it was beside. 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. Afterwards you had a better understanding, so to day, I really master negative numbers and that stuff, because I understand the concept of negative numbers now. We did this exercise in year eight, so I still remember it well. When you enjoy what you are doing you will better remember and understand the concept. It is strange but you actually need lots of self-confidence when it comes to learning and understanding mathematics. Honestly, I am not that confidence in mathematics, but, hey! I do as best I can!

The enhanced conceptual understanding by working more visually and practically with the negative numbers strengthens John's self-confidence and self-concept and the understanding of the concept.

John emphasised the gain of cooperative learning. During the outdoor lessons in mathematics they were supposed to collaborate when solving different problems they were given. During the outdoor lessons in mathematics John experienced that one was given a feeling of participation when working on a regular basis with mathematics outdoors.

> Well it feels like you are building a better fellowship together with your classmates when working with mathematics outdoors. 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 ones, that are good at mathematics then the rest of us that is kind of left behind. During the outdoor lessons it 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. You cannot act like a diva, because if you are, then you will destroy for the entire group. You know you cannot destroy for others just because you think that you are the only one that understand and can solve the problem. 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 possibility to show his or her proficiency and share one's knowledge with others. It is a way to better understand how a task at hand can be solved. You become more engaged and motivated if you are allowed to participate and speak your mind of how you believe that the task at hand can be solved.

John emphasise that cooperative learning open 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 that he experienced that he began, thanks to the regular outdoor lessons, to recognise and realise the importance of mathematics and that it is worthwhile to make effort to understand the concepts of mathematics. Through cooperative learning he realised that he actually possesses lots 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 waiting for the teacher to help you and then mathematics feels pointless and not meaningful at all. But when you work with mathematics outdoors then you understand how it all works and you enjoy mathematics and become aware that a mathematical problem can be solved in more than one way. There are so many more possibilities outdoors than in the classroom.

Interpretation of John's story

Learning tends to become visualized. Conceptual understanding is developed because the student knows what to expect and what he/she is supposed to work with. The student is given the opportunity to see and experience that a problem can be solved in more than one way and to be given the opportunity to together with others discuss possible solutions providing opportunities for

adaptive reasoning resulting in a better self-concept. If the student is provided with a sense of control the student gain better self-concept and mathematics related stress and anxiety becomes reduced. Cooperative learning seems to enhance the individual's adaptive reasoning for a student with low self-concept and who is struggling with learning mathematics.

Conclusion

The case of John indicates that students can benefit from regular outdoor learning in mathematics. Even though we report on only one student's, John's, perceived experience we can draw some rather important conclusions. Long-term regular outdoor learning in mathematics show a tendency to have an impact on affective factors by altering individual's self-concept, reducing mathematics related stress and anxiety and resulting in a more engaged and motivated student which is supported by previous studies (e.g. Moffett, 2011). In addition long-term regular outdoor learning in mathematics show a tendency to have an impact on academic factors and one important feature was the importance of variation of context. The possibility to work with more real-life problems and more visual and practical tasks, which had first been presented theoretically during the indoor lessons, might be a key factor to improve the individual's conceptual understanding (Kilpatrick et al., 2001) foremost within an individual that is experiencing difficulties in mathematics. Accordingly, students tend to become more engaged and motivated by regular outdoor learning in mathematics. Cooperative learning is a prominently part of outdoor learning in mathematics and is emphasised by John to be a key feature for enhancement of his adaptive reasoning (Kilpatrick et al., 2001). Previous findings have indicated that cooperative learning tend to help mathematics anxious individuals to 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 stress that cooperative outdoor learning in mathematics tend 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 one's everyday life, learning mathematics become more joyful resulting in a more positive attitude towards mathematics making one 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).

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