EXAMINING MATHEMATICS-RELATED AFFECT AND ITS DEVELOPMENT DURING COMPREHENSIVE SCHOOL YEARS IN FINLAND

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Mathematics-related affect is told to predict choices concerning future studies, to correlate with performance, and to be of importance per se. Unfortunately, the affect towards mathematics is frequently reported to be low in several countries, and this contradiction cannot be solved before knowing more about its development. The objective of this study is to increase our knowledge about the timing of the affective factors getting worse, which is crucial for implementing interventions at a correct phase. We investigated a longitudinal data covering Finnish students' affect during comprehensive school years (n=3502). As a result, it was found that enjoyment of mathematics is most likely to decrease during primary school years, whereas self-efficacy is most likely to decrease during lower secondary school years.

INTRODUCTION

Mathematics-related affect proves to be of importance for a number of reasons. It is told to predict choices concerning future studies, to correlate with performance, and to be of importance per se (Evans, 2006). Unfortunately, the affect towards mathematics is in many studies reported to become low during comprehensive school years in several countries (Lee, 2009). The international trend of decreasing affect is visible as well in Finland in spite of the country's high performance level in recent PISA studies (e.g. OECD, 2010).

Finnish education system is fairly non-authoritarian and non-competitive, and either in spite or because of that in international studies such as TIMMS 2011 and Pisa 2009, Finnish pupils' learning achievements in mathematics have been very good (Mullis, Martin, Foy & Arora, 2012; OECD 2010). Still, regardless of the lack of strictness and the high performance level, in TIMMS 2011 study only one third of Finnish 4th graders' (compared to the international mean of 48%) and one tenth of 8th graders' (compared to international mean 26 %) emotions toward mathematics were positive. In order to understand such a contradiction, we need to acquire more knowledge about the development of affect during comprehensive school years. In other words, though affect is repeatedly reported not to be positive enough, we have not learned what the development that leads into that situation is.

In general, the affect is high when we consider young pupils (Metsämuuronen, Svedlin, & Ilic, 2012; Tuohilampi, Hannula, &Varas, 2013). Yet, this cannot be seen only as a sign of success of the early years of schooling, as the affect is high among young pupils anyway because of the developmental stage they are living through.

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According to Harter (1999), the general view of self is typically unrealistically positive in childhood. Interacting with peers, children start to evaluate their skills and appearance according to the reactions of others; this developmental phase places itself into early school years. Harter's view is in line with Op 't Eynde, de Corte, and Verschaffel (2002), who argue that affect becomes from what is "first told". This means that if there is nothing that contradicts with given information (true or false), children tend to take it as true. Only when a contradiction appears, children have a reason to evaluate former affect, as well as given information in the light of former affect. Thus, as children get older, it is normal for the affect to become lower over time (i.e. more realistic) because of the development. Still, when it comes to mathematics, the affect becomes unnecessarily negative nearly worldwide (e.g. Hirvonen, 2012; Lee, 2009).

Chapman (2002) has shown that making changes in affect structure can be hard work. The previous situation needs to be conflicted in a way that is noticeable for the individual before new information can change it. Further, Hannula (2006) argues that the beliefs (i.e. thoughts and conceptions that are true at least for the individual her/himself, but not necessarily logically justified) are more likely to change from positive to negative than vice versa, at least when it comes to mathematics-related beliefs. Thus, it is wiser to concentrate on keeping the affect on a reasonable level in the first place instead of trying to change the situation after letting it get worse. To be able to do that, it is important to be aware of the development of affect that happens accordingly when pupils construct their affect through social responses by significant others during primary school years. In particular, we need to know the separate affective factors, like self-related beliefs (cognitive dimension of affect, see Hannula, 2011), or emotions (emotive dimension of affect, ibid.), distinctive development. So far we lack this information, because though being actively studied, mathematics-related affect has rarely been examined with a help of effective longitudinal data. Thus the dynamics of affect and its components have remained under examined. Yet, earlier studies in Finland have shown that grade 5 students have higher mathematical self-confidence than grade 8 students [n=3057] (Hannula, Maijala, Pehkonen, & Nurmi, 2005) and a longitudinal study indicates a decline in self-confidence from grade 5 to grade 6 and from grade 7 to grade 8 [n=191] (Hannula, Maijala, & Pehkonen, 2004).

When it comes to gender differences regarding mathematics related affect, studies have produced very consistent results that indicate that across age and performance levels, female students tend to have lower self-confidence in mathematics than male students (e.g. Hannula, Maijala, Pehkonen & Nurmi, 2005; Leder, 1995). In Finland, the biggest difference between girls and boys appears regarding self-efficacy feelings despite no differences in achievement: independent of the performance level, girls experienced poorer self-efficacy than boys (Hirvonen, 2012). As this is the case, it seems likely that in Finland girls receive less positive or more negative feedback for

their mathematical skills from their social surroundings than boys, independent on their actual capability.

For increasing our knowledge about the development of affect, this study aims to give answers to the following research questions: *1. How do mathematics-related cognitive and emotional affective factors develop from 3rd to 9th grade among Finnish students? 2. Are there differences between girls and boys when it comes to mathematics-related affective components' development?* Carrying out this research will give us crucial information about the dynamics of mathematics-related affect. With that information we will be more capable to address the interventions at a correct phase.

METHOD

Mathematics-related affect can be defined in different ways. In this research we will use a model of Hannula (2011), wherein affect is separated into cognitive, emotional, and motivational dimensions of affect. In particular, we are interested in pupils' beliefs of self-efficacy (cognitive dimension of affect) and enjoyment (emotional dimension of affect) with respect to mathematics.

The data used in this study consists of 3 502 Finnish students (1 702 girls, 1 800 boys) who were followed throughout comprehensive school in its entirety regarding mathematics achievement and mathematics-related affect. The measurements were done at the beginning of third, sixth, and at the end of ninth grade (years 2005, 2008, and 2012, respectively). All students were selected by using the stratified sampling of the comprehensive schools, with a representation of different instruction languages (Finnish/Swedish), provinces and municipal groups (Cities/Population density areas/Rural areas). Not all the students could be followed during the whole data collection process, and the students that dropped out from the study were more commonly weak than high achieving. Thus the data, though being representative of all students in Finland, is slightly biased. This means that the results might be little bit more *positive* than what they would be having included all the weaker students in the following process.

The attitude scale used in the different datasets is a modified version of Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976; Metsämuuronen, 2012). In this study, we discuss two factors of the used instrument, i.e. self-efficacy regarding mathematics and enjoyment of mathematics. With respect to different measurements, the wording of the items was slightly modified to fit to the examinees' developmental stage. Spice items were as follows: "*Mathematics is easy*" (self-efficacy, first measurement), "*Mathematics is an easy subject*" (self-efficacy, second and third measurement), "*I like to learn Mathematics*" (enjoyment, first measurement), "*I like to study Mathematics*" (enjoyment, second and third measurement). A 5-point Likert scale was in use, but for the analyses the attitude scores were changed into percentages of maximum score. Hence, as the most positive case, the student would get 100 which is strictly 100% of the maximum score. As the most negative case, the students would get zero which corresponds with 0% of the

maximum score. The reliabilities of the attitude scores were high enough for accurate inferences (see Table 1).

α reliability	Grade 3	Grade 6	Grade 9
Overall affect	0.86	0.88	0.92
Self-Efficacy	0.79	0.82	0.88
Enjoyment	0.88	0.89	0.90

Table 1: The reliabilities of the affect scales in the three measurements.

The analyses were done by calculating distributions of overall affect (self-efficacy + enjoyment) and its components (self-efficacy / enjoyment) with respect to different time phases, and by investigating gender differences by t-tests.

Finnish children start going to school normally around the age of 7. Before that most children have a year of pre-schooling. Almost all schools are public and free of charge. The number of school hours per week in Finland is one of the lowest compared to other countries (23 hours per week is the minimum at 3rd grade), and there are about 3 mathematics lessons a week in the 3rd grade. All teachers in Finland need to have a master's degree in education. On primary level, each teacher teaches all or nearly all subjects, and pupils study all subjects in one group, whereas in lower secondary level the teachers are subject teachers, and though the group typically still stays the same all the time, the students move from one class to another depending on the subject. The profession of a teacher is fairly valued in Finland, and the salaries are slightly above the country's medium (OECD 2012). In general, having a childhood without much competition is valued in Finland, but one the other hand the children are given lots of independence: even first graders may walk or cycle to school without an accompanying adult.

RESULTS

In the first measurement the pupils' mathematics-related affect appeared high. The mean for overall affect score was 71%, enjoyment being slightly higher than self-efficacy (mean for enjoyment 72%; mean for self-efficacy 68%). On following years the development turned negative. The overall affect score decreased from 71% to 60% by the second measurement, and to 52% by the last measurement.

The decrease did not happen in similar vein regarding both of the affective dimensions. When examining the dimensions separately, it was found out that the decrease began stronger with respect to enjoyment. In first measurement, this dimension was at a high level (72%), but by the second measurement it had decreased to 54%. The decrease continued after that, but less dramatically: at the last measurement the dimension was at 47%. Regarding self-efficacy, the decrease was very reasonable between the first and the second measurement (from 68% to 66%) despite the decrease of the enjoyment. Instead, by the last measurement the self-efficacy decreased very clearly, becoming 57% of the maximum score (see Figure 1).

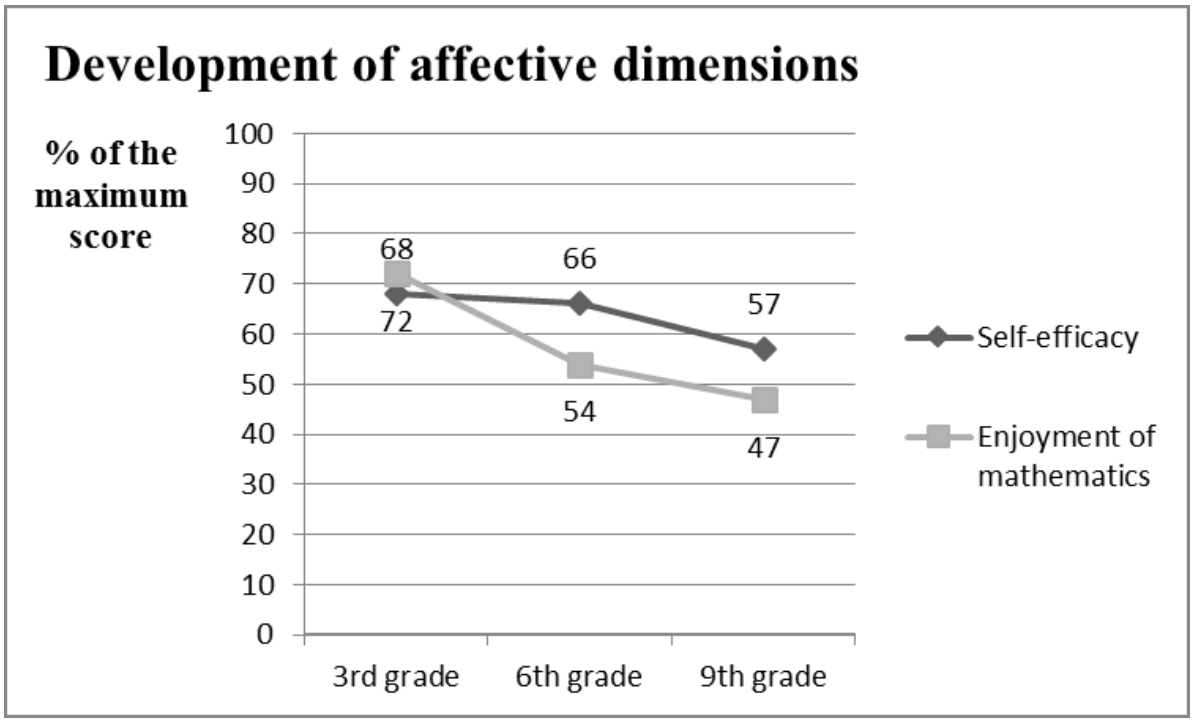

Figure 1: Development of affective dimensions from 3rd to 9th grade

With respect to different genders, the development of affect was similar, but the decrease was more dramatic regarding girls. The degree of overall attitude was statistically significantly different in all the three measurements to the detriment of the girls. At the first measurement, the mean for girls was 68%, whereas the mean for boys was 72%. At the second measurement, the mean for girls was 57%, while for boys it was 64%, and at the third measurement the mean for girls was 50%, whereas the mean for boys was 54%. In all three measurements the difference between genders was statistically significant according to t-tests (the test values were $t = 4.63$, $p < 0.001$; $t = 10.29$, $p < 0.001$; $t = 5.02$, $p < 0.001$ regarding the three measurements respectively).

Examining the gender difference further according to the affective dimensions, it was seen that the difference was greater concerning the cognitive dimension of affect, and it was at its highest at the second measurement. The situation seemed less dramatic regarding the emotional dimension of affect. According to t-tests, the difference was statistically significant in all the three measurement regarding self-efficacy (the test values were $t = 6.4$, $p < 0.001$; $t = 14.1$, $p < 0.001$; $t = 9.5$, $p < 0.001$; covering the three measurements respectively); whereas the difference regarding enjoyment was largest at the second measurement, and disappeared by the last measurement (the test values were $t = 2.3$, $p < 0.05$; $t = 5.2$, $p < 0.001$; $t = 0.2$, $p > 0.05$ covering the three measurements respectively).

DISCUSSION

This study gives confirmation to the previous result that, as is the case internationally, Finnish students' affect decreases rather dramatically during comprehensive school years. Further, perhaps the most important result of this study is that enjoyment of

mathematics is most likely to decrease during primary school years, whereas self-efficacy is most likely to decrease during lower secondary school years among Finnish students. There are also clear gender differences: the decrease is more dramatic among girls than it is among boys. As all this happens at the time when students construct their identity according to responses from significant others, it is likely that students in Finland are not getting the right kind of feedback regarding that construction.

The decrease of enjoyment of mathematics during primary school years happens independent of pupils' self-efficacy feelings: boys maintain their self-efficacy during primary school years, girls do not, yet both genders' enjoyment decreases. As earlier studies indicate that student anxiety in Finland is low, it is not likely that enjoyment would be declining due to mathematics being too difficult. On the contrary, we suggest that the declining enjoyment is due to boredom, and this feeling may become socially shared. If looking from the perspective of social responses, it looks like either pupils get negative responses regarding how enjoyable mathematics is, or they do not get enough positive responses of the enjoyability of mathematics independent of their ability to do mathematics. What is the mechanism in Finnish schools that makes this happen? One plausible reason is that no matter the good performance level, teaching seems rather traditional in Finland. According to Joutsenlahti and Vainionpää (2010), teaching practices are largely determined by the textbooks, and the content of the teaching is fairly mechanic. This might lead into needless emphasis on routine tasks, which might further narrow creativity and ability to see mathematics as something interesting. Showing mathematics as a largely mechanical subject, consisting of routines determined by textbooks, may also increase the feeling that one has to have specific univocal skills to be able to work with it.

The decrease of self-efficacy might be connected to the move from primary school to lower secondary school. The teaching is from there on given by subject teachers, and the change might be too challenging for many students. The content of mathematics becomes more abstract, and the students start to notice that some classmates are able to reach the level of abstract thinking easily. Looking from the perspective of social responses, it is possible that because of subject teachers and the most capable students an average student starts to see mathematics unnecessarily challenging. If the students are used to mechanical, routine tasks wherein only one solution is possible, they might value too much finding a solution immediately. In that case it would be important for teachers to start emphasising the value of making progress with the tasks, so that also those students that cannot exceed to the solution easily can have experiences of success because of being able to proceed.

In Finland it has been found that what is most valued by teachers, concerning their teaching, is students' positive affect towards mathematics (Niemi, 2010). Yet, teachers feel they have challenges with class management and they wish to have smaller groups than they do, although the class sizes are fairly small in Finland (the average is 19 at the primary level; OECD, 2012). According to the results of this study, pupils have a

positive affect at the beginning of school, and the decrease comes concurrently with the school years. If there is a need for strong class management in Finland despite the fairly small groups and good performance level, we see this as a sign of social responses concerning mathematics learning being poor, affecting to pupils' affect negatively. Thus there is a need for knowing what kind of working methods will help students to construct their affect based on more positive social responses by their significant others.

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