COMPARING THE STRUCTURES OF 3RD GRADERS' MATHEMATICS-RELATED AFFECT IN CHILE AND FINLAND

Laura Tuohilampi[1], Markku S. Hannula[1], Valentina Giaconi[2], Anu Laine, and Liisa Näveri

[1]University of Helsinki, [2]University of Chile

Affective factors are a significant indicator of the quality of learning. However, cultural differences in affective factors have not been studied comprehensively. In this report we will present Chilean and Finnish 3rd graders' affective structures regarding mathematics. We identified both similarities and differences between the structures in these two countries. The study contributes to our knowledge of cultural comparison in affect research by extending the comparisons to the Western-Latin axis.

INTRODUCTION

In affect-related research it is widely claimed that affective factors regarding mathematics play a significant role when learning mathematics (for reviews, see Op't Eynde, De Corte, & Verschaffel, 2002; Leder, 2006; Hannula, 2011). However, international comparative studies have shown that students from different countries have different affective relations with mathematics from those elsewhere (Lee, 2009; Pehkonen, 1995). More importantly, the relations between affective variables and achievement also seem to have culturally specific characteristics (Lee, 2009). To date, some cultural features in affective structures have been acknowledged. However, the focus has mostly been on examining the distinction between Western and Eastern cultures, and not Western and Latin cultures.

In this article we study the affective structures of students in Finland and Chile in order to identify both similarities and differences. In so doing, the study contributes to research in comparative education by examining countries representative of both Latin (Chile) and Western (Finland) cultures. In addition to the cultures being different, the countries also differ in how their students have been performed in international assessments of mathematics, such as in PISA and TIMSS tests (OECD, 2010; Mullis et al., 2000). Our focus is on young pupils (9-year old), so we will also learn about the possibilities of measuring affective aspects by a questionnaire with respect to pupils as young as that. By doing the study, we aim to go deeper into understanding the cultural features that influence the affective side of learning.

THEORETICAL BACKGROUND

Mathematics related affect has been conceptualized in a variety of ways, for example as attitudes, beliefs, emotions, motivation, values and identity. Important dimensions of different theoretical approaches are 1) the distinction between state- and trait-type constructs, 2) distinction of social (group level), psychological (individual level) or physiological (biological level) theories of affect, and 3) distinctions between cognitive, emotional and motivational aspects of affect (Hannula, 2011, 2012).

In this article, we look at the relatively stable affective traits of individuals. We are interested in the influence of social factors in the formation of affective traits, but we do not theorize affect as a social construct. More specifically, we are interested in the structure that the cognitive, motivational and emotional traits are forming.

The cognitive dimension - beliefs

In this article, we define the cognitive dimension of affective traits as "mental representations to which it makes sense to attribute a truth value" (Hannula, 2011, p. 43). This is very similar to Goldin's (2002) and Op 't Eynde and others' (2002) definition of beliefs. Argued by Op 't Eynde and others (2002), beliefs become from what is "first told". This means that if they perceive no contradiction with given information, whether true or false), students tend to accept it as true. Only when contradictions appear do students have reason to evaluate their former beliefs, as well as given information in the light of former beliefs.

Students' mathematics-related beliefs can be structured into beliefs about mathematics as a subject, beliefs about mathematics teaching and learning, beliefs about the self, and beliefs about the social context (e.g., Pehkonen, 1995, Op 't Eynde & al, 2002). Regarding beliefs, we will in this study concentrate on the first and the third aspect, beliefs about mathematics as a subject (difficulty of mathematics) and beliefs about the self (self-efficacy). Both aspects, i.e. self-efficacy beliefs and beliefs about the difficulty of mathematics can be construed as mental representations that an individual can cognitively evaluate: a truth value or a justification can be attributed at least by the person him/herself.

Emotional dimension – liking

Here, we define the emotional dimension of mathematics-related affective traits, as "typical emotional reactions to typical situations in the mathematics classroom" (Hannula, 2011, p. 45). To be more exact, the definition refers to how the stable emotive trait is revealed during the lessons: the students have their own typical ways of reacting to the situations that emerge based on their long-term emotional traits. Hence, we are not discussing here the fleeting emotional states that occur, for example, during problem solving.

In mathematics education research, mathematics anxiety is a special case of an emotional trait that has been studied extensively (for a meta-analysis, see Hembree, 1990). Another emotional trait that has been studied comprehensively is liking of mathematics (for a meta-analysis, see Ma & Kishor, 1997). In this study, we are interested in the latter, i.e. the enjoyment aspect regarding mathematics. Many studies show that teenagers tend to not find pleasure in doing mathematics (McLeod, 1992; Metsämuuronen, 2010), whereas primary students have more positive emotions (Tuohilampi, Hannula & Varas, accepted).

Motivational dimension

Motivation research has several theoretical approaches and use of terminology is sometimes confusing (Murphy & Alexander, 2000). Motivation reflects personal preferences and explains choices and, unlike for cognitive dimension, it is not possible to attribute truth to motives, because they are volitional in nature (e.g. Op ’t Eynde et al., 2002). The trait aspect of motivation is related to the overall values the person attributes to mathematics and to the general motivational orientations for learning. In this study, we are interested in students’ mastery goal orientation, which is one dimension of their achievement goal orientation (Pintrich & Schunk, 2002).

The structure of affect in Chile and Finland

Although it is generally assumed that there is a relationship between mathematics-related motivation, beliefs, and emotions, the theories of their relationships are fairly recent (Op ’t Eynde, De Corte, & Verschaffel, 2006). In this study, we consider the affective structure to include a cognitive dimension, an emotional dimension, and a motivational dimension, each influencing the affective structure as a whole. In addition, we are interested in students’ effort in mathematics. These dimensions are of interest, because we think that self-efficacy beliefs (cognitive dimension) influence how students attempt to work with mathematics; goal orientations (motivational dimension) imply students’ initiative in mathematics; emotions frame how students experience working with mathematics; and effort shows their resilience in working with mathematics.

Affective structures are noticed to be culturally dependent (e.g. Lee, 2009). In Finland, the structures have been noticed to constitute of separable dimensions within older (15-year) students (Lee, 2009). Despite top performance in PISA, Finnish students were also characterised by less favourable results on the affective measures. Finnish students lack interest and enjoyment in mathematics, they have below average self-efficacy, and low level of control strategies. As a more positive result, levels of anxiety were also low. The study also revealed that gender differences favouring males in affect were larger in Finland than in OECD on average. (OECD, 2004)

With respect to the affect towards mathematics in Chile, positive affective dimensions are connected to good achievement. Also, in study that used TIMSS data and a survey about students’ affect showed that the following dimensions exist among Chilean 8th graders: *liking mathematics*, *importance of mathematics*, *difficulty of doing mathematics* and *importance of luck and talent in doing mathematics*. Also there were found that Chilean students have an inflated self-perception of their mathematical competence and that students who perceived that mathematics is difficult have lower scores in TIMSS. (Ramírez 2005)

METHOD

Affective traits are typically measured by questionnaires. This is an economic, fairly simple method that is familiar to many students, and is particularly appropriate for measuring established, fairly resilient aspects of examinees' views (trait aspect) (Leder, 2006). With respect to affective structures, questionnaires, wherein students report their views in relation to different items, enable the collection of data appropriate for statistical analysis in general and correlations in particular.

The data used in this study were gathered within an on-going research study aiming to develop mathematics learning in Chile and Finland. In Chile, the number of participants was 459, and in Finland 466, giving a total of 925 participants. Data were collected during the academic year 2010-2011: September-October 2010 in Finland and February-March 2011 in Chile. The Chilean school year begins half a year later than it does in Finland, so the research phase, despite such apparent differences in date, was undertaken at the same time in the respective school years.

By means of a survey, 3rd grade students were asked their views on effort, competence, enjoyment, difficulty, confidence and mastery goal orientations regarding mathematics. The instrument has a long history of gradual development. It is a shortened and simplified version of the instrument used in Hannula and Laakso (2011), which was based on a number of earlier instruments: The Patterns of Adaptive Learning Study (PALS) (Midgley, Maehr, Hruda, et al., 2000); The view of mathematics indicator (Rösken, Hannula & Pehkonen, 2011); The Fennema-Sherman mathematics attitude scales (Fennema & Sherman, 1976).

The results in Hannula & Laakso (2011) suggested that the reliability of the instrument might have been compromised in their younger population of 10 year olds because of the relatively demanding language of the questionnaire items. Therefore, we carefully modified the language to make items easier to comprehend. Moreover, we reduced the number of response options from the original 5 to 3. Some of the items were presented as a direct claim (e.g. “I have done well in mathematics”), while some consisted of an indirect claim (e.g.” I am not very good in mathematics”). The items that had an inverse content were recoded to share the same direction with directly stated items.

Analysis

To find out the structure of students' mathematics-related affect, we did both exploratory and theory-driven factor analyses. The structure, as well as the similarities and differences between the structures in the two countries were inferred by comparing different types of factor solutions.

The initial factor analyses were undertaken separately with both data sets (Finnish / Chilean data) using criteria of all the eigenvalues being greater than 1. This is an exploratory approach to factor analyses, as the number of the factors is not predetermined. After that, we forced the number of factors according to the theory underlying instrument construction (Hannula & Laakso, 2011).

Statistical criteria were used to support decisions concerning the number of factors, as well as to justify that the explored solutions were appropriate. We tested the following assumptions (see e.g. Leech, Barret & Morgan 2008): The determinant of the correlation matrix should be more than 0,0001: if this value is close to zero, there are considerable amount of collinearity; if zero, the solution is impossible. The Kaiser-Meyer-Olkin (KMO) measure should be greater than 0.70, and it is inadequate if less than 0.50. The Bartlett test should be significant ($p. < 0.05$). The analysis itself was made using principal component analysis with Varimax (orthogonal) rotation.

RESULTS

The structure in Chile

Regarding Chilean students, the non-predetermined solution comprised seven dimensions. The dimensions were *negative self-beliefs in mathematics* (inverse items from competence), *easiness and fun* (1 item from competence, 1 item from EoM), *determination* (MGO + confidence), *effort*, *displeasure* (inverse items from EoM + inverse items from DoM), *confidence,* and *enjoying calculations (*1 item from EoM). Within this solution, the statistical criteria were satisfied: det= 0,005> 0,0001; KMO= 0,801>0,70; p= 0.00< 0,05. These five factors accounted for 54% of the variance.

The scree plot suggested a 5-factor solution which produced dimensions that could be easily interpreted. These were *determination* (MGO + confidence), *willingness* (effort + 1 item from competence + direct items from EoM + direct item from DoM), *displeasure* (inverse items from EoM + inverse items from DoM), *competence* (inverse items from competence + inverse item from effort), and *confidence*. This structure is presented below (Table 1), so that it can be compared both with the theory-driven solution and with the 3-dimensional solution from Finnish students. In Chile, there are also dimensions concerning negative perspectives related to mathematics. Further, the structure seems to be more unclear within Chilean students, which was also seen in the reliabilities that were lower regarding Chilean data (see Tuohilampi & al, accepted).

Within this predetermined solution, the statistical criteria were satisfied, and the values were equivalent with the non-predetermined Chilean solution. The five factors explained 46% of the variance.

The structure in Finland

When the number of factors was not predetermined, the solution for Finnish 3rd grade students consisted of five dimensions that complied with instrument construction. The dimensions were *competence*, *enjoyment of mathematics* (EoM), *mastery goal orientations* (MGO), *effort*, and *confidence*. However, the theory-based dimension *difficulty of mathematics* (DoM) was lost: all the items of that scale loaded on the same dimension as the items of competence. Within this solution, the statistical criteria were satisfied, though not thoroughly: det= 0,00005< 0,0001 (still, det≠0, see method part for interpretation); KMO= 0,895>0,70; p= 0.00< 0,05. These five factors accounted for 56% of the variance.

After initial solution, we forced the solution to be three dimensional as suggested by the scree plot. Again, all the dimensions were easily labelled. The dimensions were *capability* (competence + DoM + confidence), *enjoyment of mathematics* (EoM + MGO), and *investment* (MGO + effort + confidence). As this solution did not follow the original theorization, it is reported below (Table 1). In this solution, the motivational dimensions effort and MGO (investment) were united. However, all the items of MGO had correlations also to EoM. Confidence did not build up an own dimension. Its items had correlations with competence and with investment. The relation between confidence and competence could be expected as many of these items originate from the same scale (Fennema & Sherman, 1976).

Within this predetermined solution, the statistical criteria were satisfied, the values were equivalent with the ones in previous solution presented above. The three factors accounted for 47% of the variance.

Comparison

Among Finnish students, enjoyment was connected to mastery goal orientations. Chilean students' emotions were divided: different types of emotions built up separate dimensions. In both countries, mastery goal orientations were connected to confidence. In the Finnish population effort was connected to confidence and mastery goal orientation. In Chile, effort was connected to emotions and easiness. This suggests that in Finland students' effort for learning mathematics is more independent of their feelings than in Chile. Yet, this may not be a positive thing: if Finnish students go on trying and making an effort in spite of feeling no enjoyment, the two belief clusters (emotions and behavior) might become thoroughly distinct. This may in the future turn up to be a barrier for a change, as the change in beliefs needs an open and irritating conflict (Chapman, 2002). The conflict is not likely, if the clusters are too distinct or if the student has constructed explanations for the conflict (e.g. emotions are not important, enjoyment does not belong to school context, making effort does not give satisfaction).

Within Finnish students, the emotions, confidence, and mastery goal orientations are in interaction. Further, in Finnish students' structure, confidence is connected to competence. Poor achievement (low feeling of competence) is likely to decrease confidence and vice versa: low confidence is likely to decrease effort, resilience and thus achievement. Whatever the causation, it is possible that once confidence decreases, emotions become more negative, and this influences mastery goal orientations, effort, and eventually achievement. In Chile, effort connects to enjoyment. What is more, there is a negative dimension of beliefs connected to emotions and perceived difficulty of mathematics. The Chilean students' connection between effort and enjoyment may be protective with respect to that pattern: effort is an attribute to behavior, so if the Chilean students avoid making much effort when not feeling pleasure, they might avoid facing frustration caused by forced attempts with disappointing consequences.

	Finnish students' structure			Chilean students' structure				
Items	Capability	Enjoyment	Investment	Determination	Willingness	Displeasure	Competence	Confidence
Effort: hard working			,454		,604			
Effort: preparing carefully for exams			,591		,693			
Effort: much working			,579		,630			
Effort: working too little (recoded)			,430		,323		,487	
Competence: not that good (recoded)	,738						,743	
Competence: have made it well	,677				,461			
Competence: not the type who can (recoded)	,718						,615	
Competence: weakest subject (recoded)	,601						,657	
Enjoyment of Mathematics (EoM): enjoy pondering		,669			,414			
EoM: pleasant to calculate		,756			,263			
EoM: has been something of a core (recoded)		,542				,628		
EoM: boring to study (recoded)		,762				,543		
EoM: mechanical and boring subject (recoded)		,677				,677		
Difficulty of Mathematics (DoM): easy	,729				,425			,537
DoM: laborious (recoded)	,538					,627		
DoM: difficult (recoded)	,704					,531		

Confidence: can get good grade	,634							,597
Confidence: can succeed	,353		,497					,531
Confidence: would handle more difficult	,533		,324	,536				,407
Confidence: confident that can learn	,365		,498	,409				,479
Mastery Goal Orientation (MGO) item 2		,468	,482	,501				
MGO item 7		,387	,500	,685				
MGO item 10		,471	,571	,493				
MGO item 12		,382	,472	,680				
MGO item 25		,421	,614	,606				

Table 1. Factors in Finland and Chile in the solution suggested by the scree test.

DISCUSSION

This study suggests that 9-year old students' affective structures might consist of different types of connections in the two countries. Further examinations need to be done with respect to verifying the structures, as well as to further elaborate the interaction and hierarchy within the belief structures. More specifically, we noticed that in the Chilean, but not in the Finnish, population the inversely and directly formulated items tended to load on different factors. This suggests that questionnaires may be sensitive to the linguistic context. In our future analyses we intend to explore this phenomenon further.

Chilean pupils had lower reliabilities and are noticed to be lower in their reading skills (OECD, 2010). Thus the quantitative results may be less well justified regarding Chilean students than Finnish. All in all, this study suggests that 9-year old students' belief structures might consist of different types of dimensions and connections in the two countries, and in Latin culture, the view of affect might be more complex than what has been measured in most studies (see e.g. Chamberlin, 2010).

In an earlier study, Pehkonen (1995) noticed that the cultural differences between the countries in mathematics related beliefs can be larger than the variation within the countries. In our study we observed variation in the structure of affect which, in our opinion, is much more fundamental difference between countries. However, to know about the differences is not enough; we also have to understand the meaning of the beliefs in different countries and cultures.

NOTES

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