Prospective class teachers' attitude profiles towards learning and teaching mathematics

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In our study, we measured prospective class teachers' (n = 175) attitudes, on one hand, towards learning mathematics and, on the other hand, towards teaching mathematics. We used a previously validated questionnaire called ALM (Attitudes toward Learning Mathematics), and we constructed another questionnaire called ATM (Attitudes toward Teaching Mathematics) by modifying the items of ALM to focus on teaching instead of learning. Prospective teachers' attitude profiles towards learning and teaching mathematics were compared with each other. In general, the observed attitudes were quite positive and the attitudes towards teaching were more positive than towards learning. Component-wise differences between ALM and ATM were found. We also compared attitude profiles between two class teacher programs. Prospective teachers' attitudes were more positive in the more mathematically focused program, which had a test of mathematics skills in the entrance examination.

Keywords: Attitudes, mathematics, learning, teaching.

Introduction

In Finland, prospective class teachers (PCTs) are educated in master's degree programs in eight universities, all of which have their own teacher education strategies and curricula that makes the best use of the local university's resources. These teacher education programs must contain 60 European Credit Transfer and Accumulation System (ECTS) credits of minor studies in subject didactics with a focus on the teaching and learning of subjects and themes in basic education (Sahlberg, 2010). The degree qualifies class teachers to teach all school subjects in the Finnish primary schools (grades 1–6). Since mathematics in primary schools is usually taught by a class teacher who does not have a major or minor in mathematics, we find it relevant to explore PCT's attitudes towards learning and teaching mathematics (see also, e.g., Boyer & Mailloux, 2015; Hourigan, Leavy, & Carroll, 2016).

At the University of Turku, the Department of Teacher Education operates in two units in two cities, Turku and Rauma. Both units have their own class teacher programs with different curricula and different entrance examinations reflecting the profiles of the units. In Turku, the emphasis is on mathematics and natural sciences, and the students have to pass an entrance examination containing a test of mathematics and natural sciences skills. In the Rauma unit, the student admission does not take mathematical skills into consideration, and the unit specializes in arts, crafts, and physical education. Hence, we are interested in studying whether there are differences in PCTs' attitudes concerning mathematics between the two degree programs. The selection process for class teacher education is under constant review in Finland, and therefore scientific information concerning the effects of the entrance examination and different degree profiles is valuable as a basis for discussion.

There is no overall agreement concerning the definitions of the concepts like attitudes, believes and conceptions in the domain of mathematics-related affects (e.g. Goldin et al, 2016; Hannula, 2012). In this paper, attitudes are "manners of acting, feeling, or thinking that show one's disposition or opinion" (Philipp, 2007, p. 259). We interpret that this definition covers the components of Wong and Chen's (2012) attitude scale, which will be used in the empirical part of this study. The *Checking solutions* component is related to the looking back feature of Polya's problem solving framework. The *Confidence* scale measures respondents' self-conception about their ability to learn mathematics. *Enjoyment* deals with the degree to which students enjoy mathematics, and the *Use of IT* component enquires how much respondents believe that information technology supports their learning of mathematics. The *Multiple solutions* component measures students' tendency to look for multiple solutions for mathematical problems. *Usefulness* of mathematics is related to respondents' beliefs about the usefulness and relevance of mathematics to their daily life.

The affective domain plays an essential role both in teaching and learning mathematics. The research suggests a reciprocal causality between the learners' achievement and affect (Hannula, 2012). Hence, promoting the students' positive attitudes should be reflected in their improved mathematical performance (Ignacio, Nieto, & Barona, 2006). According to Atnafu (2014), students' academic achievements in mathematics are associated with their teachers' attitude to teaching mathematics. Namely, teachers' pedagogical practices are aligned with their attitudes regarding mathematics, teaching, and learning (Boyer & Mailloux, 2015; Hourigan et al., 2016). Self-confident teachers who see mathematics interesting, pleasant and useful are likely to improve students' positive attitudes towards mathematics (Boyer & Mailloux, 2015). Prospective teachers' attitudes towards mathematics may originate from their early schooling years, and these attitudes, together with prospective teachers' conceptions about teaching mathematics, seem particularly difficult to change (Boyer & Mailloux, 2015; Philipp, 2007). Unfortunately, PCTs have been reported as having rather negative mathematics-related attitudes, but current research also indicates some positive indications. PCTs are found to hold positive beliefs about mathematics, find it interesting and enjoyable and value its role in the sciences and in the society (Hourigan et al., 2016).

Many aspects of the affective dimension have been examined also in the Finnish mathematics education context (see, e.g., Hannula, Bofah, Tuohilampi, & Metsämuuronen, 2014; Holm, Hannula & Björn, 2017; Kaasila, Hannula, Laine, & Pehkonen, 2008; Sorvo et al., 2017). The studies are mostly focused on the affective factors of the students. More research on teachers' attitudes, especially prospective primary teachers' attitudes, are required (Philipp, 2007; Hourigan et al., 2016).

Research questions and methodology

We formulated the following research questions for this study: 1) What kind of attitudes do the prospective class teachers have towards learning mathematics and towards teaching mathematics? 2) How do the prospective class teachers' attitudes towards learning of mathematics relate to their attitudes towards teaching of mathematics? 3) Are there differences in the prospective class teachers' attitude profiles between the two class teacher programs with different emphasis on mathematics?

In this study, we measured PCTs' attitudes towards learning mathematics using the *Attitudes toward Learning Mathematics* (ALM) scale developed and validated by Wong and Chen (2012). The scale was originally designed in the Singapore Mathematics Assessment and Pedagogy Project to be used with lower secondary school students. We chose to use this scale for several reasons. First, the test has a very concise form, and therefore it is plausible that the respondents will consider and answer the items carefully. Second, the components seem to have a practical orientation relevant to the

Finnish context. Third, the test has been carefully validated by its developers, and we did not find any cultural features which would prevent us from using it. In our questionnaire, the variables were measured on a 5-point Likert scale ranging from strongly disagree = 1 to strongly agree = 5.

According to Wong and Chen (2012), the psychometric properties of attitude scales towards learning may be culture dependent. Therefore, the translated scale ALM from English into Finnish was validated by confirmatory factor analysis ($\chi^2(194) = 446.36$, $p < .001$, CFI = 0.92, TLI = 0.91, RMSEA = 0.054, SRMR = 0.067). In order to examine the interconnections between PCTs' attitudes towards teaching and learning mathematics, we constructed a new questionnaire, the *Attitudes toward Teaching Mathematics* (ATM) scale, with the aim of measuring the same attitude components as in ALM. For this purpose, we rephrased the items of ALM to focus on teaching instead of learning. Examples of the rephrased items are exhibited in Table 1.

Component	Example item of ALM	Example item of ATM
Checking solutions	When I know I have made a mistake in solving a problem, I will try to find out why.	I encourage my pupils to find mistakes from their incorrect solutions by themselves.
Usefulness	I think mathematics is useful in solving real world problems.	In my teaching, I regularly emphasize the usefulness of mathematics for solving real world problems.
Enjoyment	Solving mathematics problems is fun to me.	Most of my (future) students think that solving mathematics problems is fun.
Use of IT	IT has been helpful to my mathematics learning.	IT is helpful to my (future) students' mathematics learning.
Multiple solutions	I often figure out different ways to solve mathematics problems.	During my lessons, I often emphasize that there may be several ways to solve a mathematics problem.
Confidence	I am confident in solving mathematics problems.	I am confident in teaching mathematics well.

Table 1: Example items for the components of the questionnaires ALM and ATM

Based on exploratory factor analysis, the new ATM scale was divided into six components. The rephrased items did not entirely fit into the components for which they were originally designed. Some of the rephrased items were omitted, and some were regrouped with other components. However, the components could still be interpreted to measure similar aspects as the components of ALM. The components *Checking solutions* and *Multiple solutions* measure teachers' attitudes towards guiding their pupils to check the correctness of their solutions and to figure out alternative solutions, respectively. *Usefulness* is related to teachers' attitudes towards highlighting the relevance of mathematics for solving practical problems in their teaching. *Enjoyment* measures teachers' impressions of whether or not his or her pupils enjoy learning mathematics. *Use of IT* is related to respondents' believes that information technology can be used to help pupils to learn mathematics. *Confidence* deals with teachers' self-reliance on teaching mathematics. Furthermore, The ATM scale was validated by confirmatory factor analysis ($\chi^2(120) = 162.40$, $p = .006$, CFI = 0.94, TLI = 0.92, RMSEA = 0.045, SRMR = 0.060). The Cronbach's alpha values for the six components of both questionnaires and the number of items related to each component are given in Table 2. Some of the alpha values are rather low indicating weak internal consistency of the corresponding component. In particular, in order to increase the internal consistency of the *Usefulness* component, we abandoned one item of the original ALM scale leaving only two items remaining for that component.

Components of the questionnaires	ALM		ATM	
	No. of items	Cronbach's α	No. of items	Cronbach's α
Checking solutions	4	0.616	5	0.663
Usefulness	2	0.651	2	0.522
Enjoyment	4	0.889	4	0.735
Use of IT	4	0.670	3	0.731
Multiple solutions	4	0.740	2	0.752
Confidence	4	0.830	2	0.759
Whole test	22	0.863	18	0.785

Table 2: Internal consistency of the items for the components of ALM and ATM

The data was collected using Webropol-questionnaires from the two units of the Department of Teacher Education at the University of Turku during the years 2015 and 2016. In both units, all PCTs take 6 ECTS credits compulsory mathematics education courses during their first and second year of studies. In the more mathematically focused program in Turku, the response rate was around 63% (n = 70) and in the less mathematically focused program in Rauma around 61% (n = 105).

The data was analysed using IBM SPSS Statistics 22 software. The negatively worded items were reverse-coded, and the composite variables *Checking solutions*, *Usefulness*, *Enjoyment*, *Use of IT*, *Multiple solutions* and *Confidence* were formed by calculating the mean values of the items of the corresponding components for both questionnaires separately. Moreover, the composite variables *ALM* and *ATM* were formed by calculating the mean value of all items of the corresponding questionnaire. These variables were used to describe the students' overall attitudes towards learning and teaching mathematics. Each variable was measured on a 5-point Likert scale where 1 corresponds to strongly negative attitude and 5 corresponds to strongly positive attitude.

Results

Considering our first research question, we observed that prospective class teachers' attitudes towards learning (*ALM:* M = 3.47, SD = 0.546) and teaching (*ATM:* M = 3.77, SD = 0.411) of mathematics were, in general, positive. The values of *ALM* ranged from 2.18 to 4.86 and the values of *ATM* from 2.39 to 4.89. Based on Shapiro-Wilk normality test, both variables *ALM* and *ATM* were normally distributed. By one-sample t-test, the mean values of *ALM* ($t(174) = 11.394$, $p < .001$) and *ATM* ($t(174) = 24.832$, $p < .001$) were statistically significantly greater than the neutral value 3. Furthermore, the mean values of the six components of both questionnaires differed statistically significantly from the neutral value 3, except for the ALM components *Confidence* and *Multiple solutions*. The mean values of the components are depicted in Figure 1.

The composite variables of the ALM and ATM components *Checking solutions, Usefulness, Enjoyment, Use of IT, Multiple solutions,* and *Confidence* were not normally distributed. Friedman test revealed statistically significant differences among the components of ALM ($\chi^2(5) = 411.87$, $p < .001$) and ATM ($\chi^2(5) = 250.92$, $p < .001$). Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied, resulting in a significance level set at $p < 0.0033$. Statistically significant differences were found between all the components of ALM except for the pairs *Confidence–IT* and *Confidence–Multiple solutions*. Similarly, almost all components of ATM differed statistically significantly from each other. Only between the components *Confidence*, *Use of IT* and *Multiple solutions* were no statistically significant differences found. Hence, PCTs responded differently towards the different components of the scales. The highest mean values were obtained by the components *Usefulness* and *Checking solutions* in both questionnaires. The only component with the mean value below the neutral value was the ALM component *Multiple solutions*.

In order to examine our second research question, we compared the data from the two questionnaires. First of all, the attitudes of the respondents towards teaching (*ATM*) were more positive than towards learning mathematics (*ALM*), $t(174) = 8.646$, $p < .001$. The Spearman's rank-order correlation was used to examine the relationship between the components of learning and teaching. In the component-wise comparison, the r_s-values ranged from 0.321 to 0.631 at significance level $p < .001$. A strong positive correlation was found between the *Use of IT* components of ALM and ATM ($r_s(173) = .631$, $p < .001$), as well as between the *Confidence* components of the two questionnaires ($r_s(173) = .619$, $p < .001$). There was also a strong, positive correlation between the ALM components *Confidence* and *Enjoyment* ($r_s(173) = .694$, $p < .001$). Moreover, the scatterplot of the variable *Confidence* of ALM and ATM revealed that a PCT who is not confident in learning mathematics may nevertheless be confident in teaching it. However, confidence in learning mathematics seemed to imply confidence in teaching mathematics. Even though there were correlations between the attitude components of teaching and learning, statistically significant differences between the distributions of each of the components of ALM and the corresponding components of ATM were found by Wilcoxon signed ranks test. The components *Checking solutions*, *Confidence, Multiple solutions* and *Use of IT* obtained higher mean values in teaching than in learning, whereas the attitudes towards *Usefulness* and *Enjoyment* were more positive in ALM than in ATM (see Figure 1).

When comparing the prospective class teachers' overall attitudes towards learning mathematics between the two class teacher programs, we noticed that the students in the more mathematically focused program had higher scores of *ALM* than the students in the less mathematically focused program, $t(173) = 4.626$, $p < .001$. However, no statistically significant differences were found between these programs when considering attitudes towards teaching mathematics (*ATM*). Descriptive statistics of the components of both questionnaires for the class teacher programs are given in Table 3. We noticed that the distributions of the components *Enjoyment* (ALM: $U = 2030.5$, $p < .001$, $r = .38$; ATM: $U = 2946.0$, $p = .025$, $r = .19$) and *Confidence* (ALM: $U = 1960.5$, $p < .001$, $r = .40$; ATM: $U = 2571.5$, $p = .001$, $r = .26$) differed in both scales between the two programs, the attitudes in the more mathematically focused program being more positive than in the less mathematically focused program. There was also a statistically significant difference in the attitudes of using IT in mathematics teaching ($U = 2798.5$, $p = .007$, $r = .20$), this time in the favor of the less mathematically focused program. Moreover, the differences in the distributions of *Checking solutions* ($U = 2982.5$, $p = .033$, $r = .16$) and *Multiple solutions* ($U = 2761.0$, $p = .005$, $r = .21$) in ALM were statistically significant between the programs.

Program		*ALM*	*ATM*

		Useful	*Check*	*Enjoy*	*IT*	*Conf.*	*Multi*	*Useful*	*Check*	*Enjoy*	*IT*	*Conf.*	*Multi*
Turku	M	4.54	4.16	4.05	3.18	3.52	3.11	4.10	4.32	3.30	3.46	4.04	3.61
	SD	0.423	0.686	0.815	0.872	0.890	0.877	0.611	0.447	0.627	0.734	0.788	0.826
Rauma	M	4.41	3.97	3.34	3.25	2.75	2.75	4.11	4.26	3.09	3.76	3.55	3.56
	SD	0.661	0.695	0.953	0.741	0.897	0.741	0.676	0.584	0.685	0.723	0.970	0.833

Table 3: Descriptive statistic of the components of ALM and ATM for the mathematically-focused program (Turku) and the non-mathematically-focused program (Rauma)

We used K-means cluster analysis to group the students into classes with different attitude profiles. The clustering was based on the twelve composite variables of ALM and ATM. After exploratory analysis, the number of clusters was fixed on three. According to the attitude profiles of the clusters depicted in Figure 1, Cluster 1 contains the students with the most positive attitudes. The prospective class teachers in Cluster 2 have the lowest confidence both in learning and in teaching mathematics. Interestingly, the use of IT for teaching and for learning mathematics was higher in this group than in the other clusters. Cluster 3 contains the students with the lowest mean values of the components, except for the ALM components *Confidence* and *Enjoyment* and the ATM component *Confidence*. Cross tabulation of the clusters revealed that the class teacher programs differed from each other ($\chi^2(2) = 19.43$, $p < .001$). For the more mathematically focused program, 71% of the PCTs belonged to Cluster 1, 10% belonged to Cluster 2 and 19% to Cluster 3. For the less mathematically focused program, 39% belonged to Cluster 1, 33% to Cluster 2 and 28% to Cluster 3.

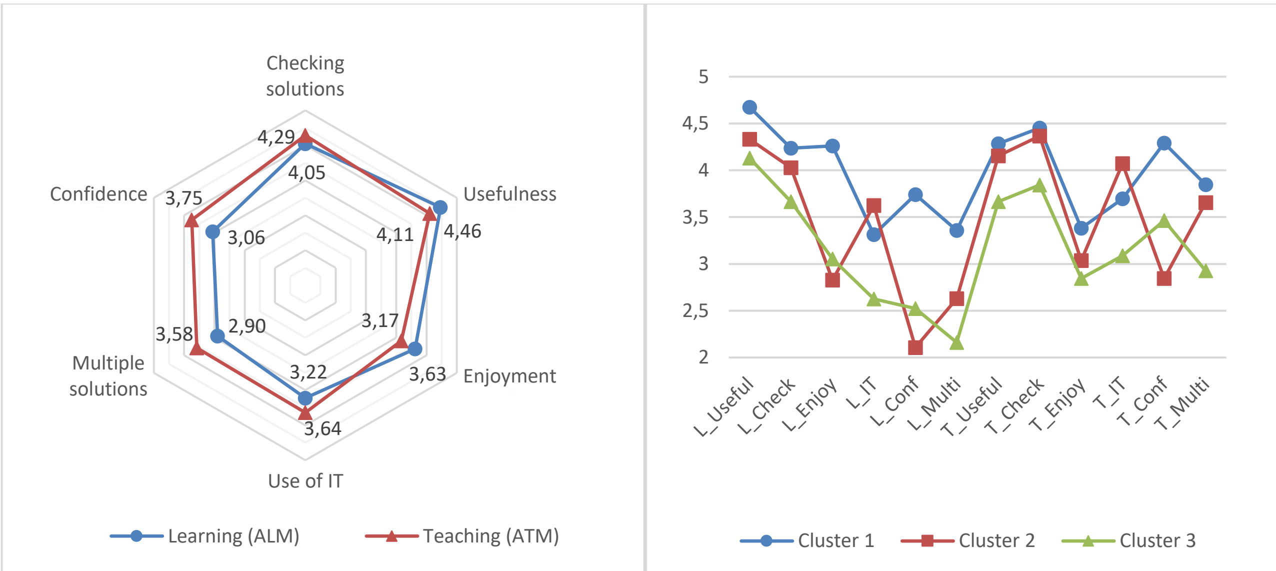

Figure 1: Mean values of the components of ALM and ATM in the whole sample and in the clusters

Discussion and conclusions

Based on our analysis, the PCTs seemed to have quite positive attitudes towards teaching and learning mathematics. We interpret that PCTs consider mathematics useful and emphasize its usefulness in their teaching. When learning mathematics they want to check the correctness of their solutions and also guide their pupils to do so. They enjoy learning mathematics, and they believe that their pupils enjoy learning mathematics as well. To some extent, they have a positive attitude towards using IT for learning mathematics. In particular, they see the potential of using IT in order to foster their mathematics teaching and their pupils' learning. They also emphasize the importance of finding out multiple solutions when they are teaching, but do not so much report doing so when learning mathematics themselves. Although PCTs have formerly been reported as having negative mathematics-related attitudes (Philippou & Christou, 1998), our findings are in line with recent positive indications (Hourigan et al., 2016).

There are recent results showing that mathematics education programs may have positive effects on PCT's attitudes (Hourigan et al., 2016). Based on this study, we cannot draw any conclusions whether the PCTs' attitudes have changed during our programs. However, we noticed that PCTs' attitudes were more positive in the program which has a mathematics and natural sciences test as a part of the entrance examination. It seems reasonable to think that by selecting students with good skills in mathematics and natural sciences, we also select students with positive attitudes towards learning and teaching mathematics. Indeed, studies suggest a reciprocal causality between achievement and affect (Hannula 2012). Moreover, students with less skills and less positive attitudes towards mathematics will probably apply to teacher education programs which have no entrance test in mathematics. Hence, as a contribution to the reforms of the student selection processes of the Finnish class teacher education, we may say that from the perspective of PCTs' attitudes towards mathematics our findings support using a mathematics and natural sciences test in the entrance examination for the mathematically focused programs.

Furthermore, we found out that attitudes towards teaching mathematics were more positive than towards learning mathematics. It seems that the PCTs are more willing to emphasize the use of information technology, checking the correctness of solutions and finding multiple solutions in teacher's work than in solving mathematical problems personally. The PCTs had also higher confidence in teaching than in learning mathematics. In addition to earlier studies (see, e.g., Ünlü & Ertekin 2013) showing a positive correlation between mathematics teaching self-efficacy and mathematics self-efficacy, the similarity between the structures of the instruments ALM and ATM has enabled us here to compare the different components of the learning and teaching scales. We consider this comparison the most important theoretical aspect of our study.

We acknowledge the limitations of the new ATM scale, which should be further developed to better correspond to the components of ALM. Although the scales were validated by confirmatory factor analysis, some original items had to be omitted from the composite variables and the Cronbach's alpha values were still quite low. In addition, the low response rate may compromise the external validity of our results. Finally, we note that in the cluster with low mean values of confidence and enjoyment, the PCTs' attitudes towards the use of IT for both learning and teaching mathematics were higher than in the other clusters. More investigations about teacher's attitudes towards the integration of IT and mathematics teaching are needed (Goldin et al., 2016) and this interesting finding should be further examined.

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