UDK 371.3:51(497.11:410.1)

PERCEPTIONS OF MATHEMATICS AND POSITIONING TOWARDS THE DISCIPLINE – PRE-SERVICE PRIMARY TEACHERS' ATTITUDES IN SERBIA

Snežana M. Lawrence*
Middlesex University, London, UK

Aleksandra M. Mihajlović
University of Kragujevac, Faculty of Education in Jagodina, Serbia

Abstract: Teachers' attitudes and beliefs towards mathematics and mathematics teaching might have a significant influence on their instructional practices, the quality of teaching, but also pupils' achievement and attitudes towards the subject. Research indicates that entrants to primary teacher education programmes worldwide often have a negative attitude towards mathematics as a discipline and the teaching of mathematics as their future task. Extant studies point out that poor attitudes towards mathematics were found to be more dominant in pre-service teachers before their teacher training, but improve during the training. This paper aims to examine such attitudes and beliefs towards mathematics of pre-service primary teachers in Serbia, and give some pointers for the improvement based on the work done with Serbian teachers. We then compare our findings with those of the work done over the past decade with teachers in England. In order to investigate the pre-service teachers' attitudes towards mathematics a quantitative research method is applied, using a scale as a measure of attitude. The findings of the study give us a basis for some recommendations for possible further improvements of the teacher training programmes in both countries. Among these, a possibility of an introduction of mathematics appreciation programme in earlier years of education is discussed, having in mind that mathematics teachers have themselves gone through educational experiences during which their attitudes towards mathematics were formed.

Key words: Pre-service primary teachers, attitudes towards mathematics, teacher education programmes.

INTRODUCTION

The first stage in teacher's life course begins before entering teacher education programmes (Ponte & Chapman, 2008). Research suggest that teachers'

*E-mail: snezana@mathsisgoodforyou.com

personal histories, such as those of being a learner of mathematics, shape and become part of their teacher identity (Lutovac & Kaasila. 2014). An important point to remember is that students at early stages of education begin to build their own internal dialogues related to mathematics (Lawrence, 2016a). These are of multiple natures and purposes, e.g. a learner may tell herself:

- that what she is doing is a right or a wrong thing in working on a mathematical problem
- that she likes / does not like what she is doing
- how to proceed
- whether the effort led to success
- whether there is another way of dealing with the problem, etc.

Such dialogues sometimes become entrenched, and with them reactions to various situations learners face, and subsequently beliefs whether the doing of mathematics is an enjoyable or stressful activity, or anything in between. Additionally, the attitudes towards mathematics, and the view of mathematical concepts are also determined by the experience of learning them, which is why it is important for teachers to be able to see mathematical problems and concepts from different angles and in different context, in order that they present them to students in diverse ways (Furinghetti, 2007).

Thus, primary and early year teachers, (i.e. those who did not complete a mathematics or mathematics related degree) begin their initial teacher education programmes with an array of different images of teaching mathematics and themselves as teachers of mathematics (Chong, Low, & Goh, 2011). These initial images are mostly developed during their prior experience as students, and are defined to different degrees, but are all essential in determining their attitudes towards teaching, their understanding of teaching, their professional beliefs and their instructional practices. The impact of these early schooling experiences as well as other factors on teachers' professional identity and teaching practice depends on their view of themselves as teachers before they begin teaching, and whether or not this is challenged by the context of their preparation. Many studies therefore point to the need to pay attention to reflections on teacher identity construction in teacher preparation programmes (Ponte et al. 2002; Goos & Bennison 2008).

Hodgen and Askew (2007) discuss the difficulties mathematics teachers face in their professional development and learning. They indicate that the problem of negative attitudes towards mathematics is especially acute amongst primary teachers. The authors further suggest that these might be explained by the fact that for many primary teachers their relationship with mathematics is full of anxiety and emotions related to negative experience during their earlier educational journeys. On the other hand, we know that a strong disciplinary bond is central to the positive and productive development of the teaching of mathematics practice, and pre-service mathematics teacher identity. To summarise briefly, mathematics teacher identity includes the individual's beliefs and views regarding mathematics as a bond between a teacher and mathematics. Mathematics teacher identity therefore plays a mediating role in teaching and learning practices (Sun, 2017). Teachers' beliefs, views, and experiences with learning mathematics are interrelated and might have impact on their instructional practices (Brown & McNamara, 2011).

How can instruction of teachers during their training influence the teachers so that their beliefs bear most productive influence on their teaching (Lawrence & Ransom, 2011)? It has been argued, as seen above, that there are close relationships among professional identity, classroom practice, teacher knowledge, beliefs and attitudes. While we investigate this further, we should bear in mind that the professional teacher identity should be regarded not as a fixed or unitary but rather as an identity which may take multiple manifestations, is fragmented, and prone to change.

In addition to other important roles teachers' attitudes and beliefs toward mathematics have on learning that we have already discussed above, they might also have impact on attitudes and beliefs of students (Relich, Way & Martin, 1994). In other words, positive attitudes towards mathematics that teachers have contribute to developing the positive attitudes in their students.

Research aim

Our research aims to explore the beliefs, views and attitudes towards mathematics of pre-service primary and kindergarten teachers in Serbia. We recorded these at the beginning and end of training, and sought to find the interventions which may benefit prospective teachers to develop their identity as mathematics teachers before entering schools/kindergartens and helping them to become as effective as possible in the teaching of mathematics.

RESEARCH METHODOLOGY

The study was conducted at the Faculty of Education in Jagodina, University of Kragujevac. Since survey instruments were administered and numerical data collected, a quantitative method was used in analysing the data. Data were collected through questionnaires. The participants were pre-service teachers (PST) enrolled in Preschool and Primary Teachers Education Programmes (Year 1, Year 2 and Year 3). All students are enrolled in Mathematics course at Year 1/Year 2, and in Methodology of Teaching Mathematics course at Year 3 of study.

Sample

The research sample involved 123 teacher students. The study was conducted at the end of the summer semester of academic year 2019/2020. All PST participated in the study on voluntary basis. Initially, the authors intended to survey teacher students both from Serbia and UK, which would allow the authors to make a comparative analysis but due to the COVID 19 situation, it was not possible to conduct a survey in the UK. The sample distribution in regard to the year of study is presented in Table 1.

Table 1. Sample distribution in regard to the year of study as follows.

	Year of the study		
	Year 1	Year 2	Year 3
f	64	31	28
%	52.03	25.20	22.77

Instrument

The used instrument was a questionnaire that had two parts. In the first part, background information about PST was collected (gender and a year of study). The second part of the instrument contained Mathematics Attitudes and Beliefs Scale (MAB) developed by Vlahović – Štetić, Rovan, and Arambašić (2005). The MAB scale consisted of three subscales: Attitudes towards Mathematics - ATM (28 items); Beliefs of Mathematics as Predominantly Male Discipline – BMMD (6 items) and Beliefs that Mathematics Ability is Inborn – BMI (6 items). Each of the items was rated on a Likert scale (1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree). Some items were reverse coded as suggested by authors of the scale (items: 1, 2, 6, 10, 12, 13, 14, 15, 16, 18, 19, 20, 25, 27, 28, 29, 30, 34, 35, 38, 40).

In order to investigate the attitudes and beliefs of PST, we decided to use the MAB scale for the reason that it was developed and used in a country (Croatia) with a historically common educational background as that of Serbia. Therefore, no translation was needed, and we obtained permission to use the scale in our research. The Cronbach's alpha reliability coefficient indicated acceptable reliability (α=0.875). The Cronbach's alpha reliability coefficient for each of the subscales also revealed acceptable reliability: ATM (α=0.945), BMMD (α=0.786), BMI (α=0.848). We present some examples of research items in Table 2.

Table 2. Examples of some items of Mathematics attitudes and beliefs scale (Pavlin-Bernardić, Vlahović-Štetić, & Mišurac Zorica, 2010)

Subscale	Example of items
Attitudes towards Mathematics (ATM)	"Learning Mathematics is boring." "Whatever we do in our lives, we might need mathematics."
Beliefs of Mathematics as Predominantly Male Discipline (BMMD)	"Boys understand mathematical problems better than girls." "Mathematics is a subject more for boys."
Beliefs that Mathematics Ability is Inborn (BMI)	"If you do not posses inborn mathematics ability, you can never learn it well" "Mathematical practice can be improved."

The statistical analyses were conducted using SPSS for Windows, version 19.0. For statistical analysis, p values lower than 0.05 were considered statistically significant. The normality of data was evaluated with the use of the Shapiro-Wilk test of normality. For the quantitative analyses of data methods of descriptive statistics were used (frequency, percentage, mean, standard deviation, mean ranks), Welch ANOVA with Games-Howel post hoc for parametric variables and Kruskal-Wallis H test with Dunn post hoc for non-parametric variables. The effect size was estimated by using Cohen's d. The independent variable in the data analysis was the year of study.

RESULTS AND DISCUSSION

In order to investigate PST attitudes and beliefs, the participants were asked to rate the level of agreement/disagreement with items in three subscales. Table 3 displays the descriptive statistics (Means and Std. deviations) of the questionnaire scales. The mean score is the sum of the subscale scores divided by the total number of the items of the subscale used.

Table 3. Descriptive statistics for each subscale

Subscale		Students N=123
ATM	M	3.15
	SD	0.78
BMMD	M	2.06
	SD	0.72
BMI	M	1.56
	SD	0.74

Narli (2010) indicates that the interval width of five point Likert scale should be computed in order to set up the group boundary value which will help discuss results (Table 4).

Interval Width = (Upper value – Lower value)/n = (5 – 1)/5 = 0.8

Table 4. Group boundary values of five point Likert scale

1.00 – 1.80	1.81 – 2.60	2.61 – 3.40	3.41 – 4.20	4.21 – 5.00
strongly disagree	disagree	undecided	agree	strongly agree

The overall results, presented in Table 3, show that PST, in general, expressed neutral attitudes towards Mathematics. On the other hand, PST demonstrated disagreement with beliefs that Mathematics is predominantly a male discipline and a strong disagreement with beliefs that mathematical abilities are inborn. Arithmetical means and standard deviation for each subscale are presented in the Table 5.

Table 5. Descriptive analysis results for each subscale

					Shapiro-Wilk test	
Scale	Year of study	N	M	SD	W	Sig.
ATM	Year 1	64	2.83	0.77	0.977	0.264
	Year 2	31	3.12	0.55	0.982	0.874
	Year 3	28	3.91	0.44	0.966	0.479
BMMD	Year 1	64	2.27	0.81	0.942	0.005
	Year 2	31	1.85	0.55	0.932	0.051
	Year 3	28	1.79	0.48	0.947	0.165
BMI	Year 1	64	1.75	0.82	0.821	0.000
	Year 2	31	1.49	0.67	0.759	0.000
	Year 3	28	1.22	0.44	0.583	0.000

The data obtained from the scales demonstrate that Year 3 students have more positive attitudes toward Mathematics compared to Year 1 and Year 2 students. Similarly, Year 3 students express stronger disagreement with beliefs that Mathematics is a male discipline and beliefs that mathematical ability is inborn comparing to Year 1 and Year 2 students.

In order to examine possible differences in attitudes and beliefs of PST in terms of the year of study, one-way ANOVA and Kruskal-Wallis test were performed at 0.05 significant level. Before performing one-way ANOVA and Kruskal-Wallis test, the necessary assumptions such as a level of measurement, independence of observations, normality and homogeneity of variance were checked (Pallant, 2007). The first two assumptions were met since the dependent variables (ATM, BMMD and BMI scores) were of a continuous level of measurement and there were no relationships between the observations in each group or between the groups. In order to use ANOVA, the data should be normally distributed and there needs to be homogeneity of variance (which means that the variance among the independent groups should be approximately equal). The Shapiro-Wilk test of normality revealed that the ATM scores were normally distributed in all groups, while BMMD and BMI scores were not normally distributed across the groups. Hence, we used Kruskal – Wallis test to examine the differences between groups of PST in BMMD and BMI scores, and Dunn's multiple comparison test to identify which groups were different. As for the ATM scores, since data failed the homogeneity of variance assumption as obtained by Levene's test of equality of variance, Welch ANOVA (which is not sensitive to unequal variance) was carried out instead of one-way ANOVA. The obtained Welch's adjusted F ratio (reported as Welch's F), which was significant at the 0.05 alpha level indicated that at least two groups differ significantly on their average ATM scores. To identify significant differences between specific groups in ATM scores Game-Howell post hoc was used.

Attitudes towards Mathematics

Levene's test indicated that the assumption of homogeneity of variance was violated, $F(2, 120) = 6.772$, $p=0.002$. Therefore, the Welch F ratio was reported. The results showed significant difference between at least two of the three groups of PST (Welch's $F(2, 70.99)=40.08$, $p<0.05$). A post-hoc analysis was conducted to determine where the differences were within the groups representing different years of study. Games-Howell post hoc analysis revealed a significant difference in ATM scores between Year 1 and Year 3 students, as well as between Year 2 and Year 3 students (Table 6).

An inspection of the mean scores indicated that PST who were at the Year 3 (M=3.91; SD=44) reported more positive attitudes toward Mathematics than PST at Year 1 (M=2.83; SD=0.77) and Year 2 (M=3.12; SD=0.55). In order to calculate the effect size for the comparison between two means, we used Cohen's d. The Cohen's d in the first case was 1.72 and in the second case was 1.59, which suggests large effect size. In other words, these findings suggest that the experience that PST gain through teacher training programmes has significant and positive impact on their attitudes and beliefs. These results were expected, if we take into account that PST do not start their teaching methodology courses in mathematics until Year 3 of their study. Year 2 students have general teaching methodology courses (Didactics), but subject-specific methodology courses represent the main part of Year 3 and Year 4 curricula. Another thing that must not be neglected is the obligatory practice in schools and kindergartens that PST have during the teacher preparation programmes. PST do not have teaching practice until Year 4. Year 1 and Year 2 students spent two and four weeks in primary schools/kindergarten observing lessons. Year 3 spent four weeks in primary school/kindergarten, and although they do not teach yet, they do perform some small teaching tasks and interact more with pupils during the lesson (i.e. teaching a micro teaching unit).

Table 6. The results of Games-Howell Post Hoc test for ATM

Year of Study_1	Year of Study_2	Mean difference	Std. Error	Sig.	95% Confidence Interval	
					Lower	Upper
1	2	-7.99143	3.84262	0.101	-17.1683	1.1855
	3	-30.26563	3.54838	0.000	-38.7329	-21.7984
2	1	7.99143	3.84262	0.101	-1.1855	17.1683
	3	-22.27419	3.59933	0.000	-30.9388	-13.6096
3	1	30.26563	3.54838	0.000	21.7984	38.7329
	2	22.27419	3.59933	0.000	13.6096	30.9388

Usefulness and Enjoyment of Mathematics

For the purpose of analysis we classified ATM items into two categories, the items which measured perceived usefulness and importance of mathematics (items 3, 6, 9, 10, 13, 18, 22, 26, 29, 30, 36, 38, 39 and 40) and liking/ enjoyment of mathematics (items 2, 5, 8, 12, 15, 16, 19, 20, 23, 25, 28, 32, 33, 35). Therefore, we distinguished two dimensions: usefulness of mathematics (UM) and enjoyment of mathematics (EM). For each dimension, the total scores were calculated. The mean score represented the sum of the total scores divided by the total number of the items within each category. Table 7 displays the descriptive statistics (Means and Std. deviations) for these dimensions.

Table 7. Descriptive analysis results for UM and EM

					Shapiro-Wilk test	
	Year of study	N	M	SD	W	Sig.
UM	Year 1	64	3.01	0.69	0.961	0.042
	Year 2	31	3.42	0.52	0.973	0.614
	Year 3	28	4.05	0.42	0.953	0.241
EM	Year 1	64	2.65	0.95	0.967	0.085
	Year 2	31	2.81	0.75	0.950	0.160
	Year 3	28	3.77	0.55	0.973	0.672

Year 3 teacher students expressed more positive attitudes regarding both usefulness and enjoyment of mathematics in comparison to Year 1 and Year 2.

Since the homogeneity of variance was violated both for UM ($F(2, 120)=4.799$, $p=0.010$) and for EM ($F(2, 120) =6.345$, $p=0.002$), the Welch F ratio was reported. The findings indicated a significant difference between three groups of PST in UM scores (Welch's $F(2, 69.91)=40.27$, $p<0.05$) and in EM scores (Welch's $F(2, 69.83)=29.82$, $p<0.05$). A Games-Howell post hoc analysis was performed to determine which groups significantly differed in scores. It showed that there were significant difference in UM and EM scores between Year 1 and Year 3 students, as well as between Year 2 and Year 3 students (Table 8). Year 3 students perceive mathematics as more useful in everyday life and reported higher level of enjoyment in doing mathematics in comparison to Year 1 and Year 3 students.

Table 8. The results of Games-Howell Post Hoc test for UM and EM

	Year of Study_1	Year of Study_2	Mean difference	Std. Error	Sig.	95% Confidence Interval	
						Lower	Upper
UM	1	2	-5.74798	1.78698	0.005	-10.0195	-1.4765
		3	-14.56250	1.63571	0.000	-18.4679	-10.6571
	2	1	5.74798	1.78698	0.005	1.4765	10.0195
		3	-8.81452	1.71591	0.000	-12.9454	-4.6837
	3	1	14.56250	1.63571	0.000	10,.6571	18.4679
		2	8.81452	1.71591	0.000	4.6837	12.9454
EM	1	2	-2.24345	2.51696	0.647	-8.2644	3.7775
		3	-15.70313	2.20323	0.000	-20.9608	-10.4454
	2	1	2.24345	2.51696	0.647	-3.7775	8.2644
		3	-13.45968	2.37993	0.000	-19.1935	-7.7259
	3	1	15.70313	2.20323	0.000	10.4454	20.9608
		2	13.45968	2.37993	0.000	7.7259	19.1935

Beliefs of Mathematics as Predominantly Male Discipline

The Kruskal-Wallis test was used to test the significance of the difference observed between the BMMD scores of the PST attending different years of study. The results point out that the BMMD scores were significantly different in regard to the groups representing different years of study, $\chi^2(2)=11.468$; $p=0.003$ (Table 9). In other words, these results point out that there are statistically significant differences in beliefs that mathematics is a predominantly male discipline between different groups of the PST.

Table 9. Comparison of the BMMD beliefs in terms of the year of study

Year of study	N	Mean Rank	χ^2	p	Significant
Year 1	64	72.32	11.468	0.003	1 – 3 1 – 2
Year 2	31	52.81			
Year 3	28	48.59			

To identify the difference among the groups the Dunn test was performed to reveal in which groups a significant difference in the BMMD scores occurred.

A significant difference was noticed between the students of Year 1 and Year 3 (p=0.010) and between the students of Year 1 and Year 2 (p=0.036). The results suggest that teacher education programmes might affect the beliefs of PST that Mathematics is a predominantly male discipline. Year 3 and Year 2 students express stronger disagreement with this belief, comparing to Year 1 students.

Beliefs that Mathematical Ability is Inborn

The Kruskal-Wallis test was conducted to determine if BMI scores were different for three groups in regard of the year of study. Findings showed that there was a statistically significant difference in BMI scores between different groups of PST, $\chi^2(2)=12.087$; $p=0.002$ (Table 10).

Table 10. Comparison of the BMI beliefs in terms of the year of study

Year of study	N	Mean Rank	χ^2	p	Significant
Year 1	64	70.74			
Year 2	31	60.03	12.087	0.002	1 – 3
Year 3	28	44.20			

We performed the Dunn's post hoc test for pairwise differences. A significant difference was noticed between the students of Year 1 and Year 3 (p=0.002). Year 3 students expressed stronger disagreement with beliefs that mathematical abilities are inborn than Year 1 students.

CONCLUSION

Pre-service primary and kindergarten teachers represent the first 'face' of mathematics young children see. This indicates that it is of extreme importance to educate future generations of teachers to be as effective as possible in teaching mathematics. The fact that Year 1 and Year 2 students have mostly neutral attitudes toward Mathematics suggests that more attention should be given to promoting positive views among this population. In general, a significant number of prospective primary and kindergarten teachers who study at the teacher education faculties in Serbia did not have enough mathematics classes throughout high school. Some authors point out that in order for a prospective teacher to be able to achieve positive learning experiences in Mathematics, they need to have studied it at a higher level (Hill &

Bilgin, 2018). This implies that teacher education faculties should consider increasing a number of classes in general Mathematics courses. Since there are some limitations due to the official accreditation standards, introduction of some elective mathematics appreciation courses might be considered.

The major issues we investigated here concern the perception of usefulness and enjoyment of mathematics, and we believe that introducing more topics such as episodes from the history of mathematics and STEM contents might be beneficial for developing more positive views of mathematics in pre-service teachers. As Dejić and Mihajlović (2014) indicate, a history of mathematics helps students "understand that mathematics from its foundation up to now has played one of the most significant roles in all areas of human life" (p.17). On the other hand, an emerging need for STEM careers requires primary teachers who will prepare their pupils and support them with relevant STEM opportunities of which mathematics represents an integral part.

The study findings cannot be generalized considering that it was conducted at only one university. Nevertheless, the value of this study can be recognized in the fact that there was no previous research about the beliefs and attitudes towards mathematics of future primary and kindergarten teachers in Serbia.

Similar studies from England (Lawrence, 2016a & 2016b; Lawrence, 2019; Lawrence & Ransom, 2011; Grattan-Guiness, 2004) suggest that the history of mathematics can bring lasting improvements to the teaching of mathematics in a school classroom. They show that the disengagement of teachers from the actual mathematical content is the most important reason for the disengagement of students. The reasons for this are given in the fact that teachers who are not specialist mathematics teachers (i.e. they do not have a first or higher degree in mathematics) are not introduced to mathematical culture which they are supposed to transfer and transform through their own practice, either by 'doing maths' in a research environment, or by the appreciation of the different ways of such 'doing' that manifest through different geographical and historical mathematical cultures. Subsequently, student teachers cannot induct their own students into such practices (Lawrence & Ransom, 2011). In fact, this happens whatever curriculum one follows – whether the one that is in place in Serbia, Croatia, or England. In other words, the studies show that whatever curriculum is in place, the teachers who are not specialist mathematics teachers at the start of their training follow the 'heritage' path – i.e. they teach and transfer their knowledge of mathematics in the same way or mimick the ways they learnt mathematics themselves when they were of the same age as their students (Grattan-Guiness, 2004). This means that:

a) they are rarely aware of the origin of concepts or their meaning and connections with other concepts in mathematics, and
b) they transfer the attitudes that they have formed in relation to that particular concept when they learnt it themselves as young children.

In order to overcome such unproductive teaching practices, the history of mathematics embedded in the practice of teacher instruction can offer teachers different techniques and methods that help their own development of a mathematics teacher identity. This is done as the teacher students become aware of their own mathematical cultural heritage, and acquire a set of skills in identifying such heritage, and at the same time the research skills that allow them to see mathematical concepts in different cultures and historical eras. Such practice of developing their own understanding of mathematics will give them opportunities to re-position themselves in relation to the topics they teach.

REFERENCES

Arambašić, L., Vlahović-Štetić, V. & Severinac, A. (2005). Je li matematika bauk? Stavovi, uvjerenja i strah od matematike kod gimnazijalaca. *Društvena istraživanja*, 14(6), 1081–1102.

Brown, T., & McNamara, O. (2011). *Becoming a mathematics teacher: Identity and identifications.* New York: Springer.

Chong, S., Low, E. L., & Goh, K. C. (2011). Emerging professional teacher identity of pre-service teachers. *Australian Journal of Teacher Education*, 36(8), 50–64.

Dejić, M. & Mihajlović, A. (2014). History of mathematics and teaching mathematics. *Teaching Innovations*, 27 (3), 15–30.

Furinghetti, F. (2007). Teacher education through the history of mathematics. *Educational Studies in Mathematics*, 66, 131–143.

Hill, D. & Bilgin, A. A. (2018). Pre-service primary teachers' attitudes towards mathematics in an Australian university. *Creative Education*, 9, 597–614.

Hodgen, J., & Askew, M. (2007). Emotion, identity and teacher learning: Becoming a primary mathematics teacher. *Oxford Review of Education*, 33(4), 469–487.

Goos, M. E. & Bennison, A. (2008). Developing a communal identity as beginning teachers of mathematics: Emergence of an online community of practice. *Journal of Mathematics Teacher Education*, 11(1), 41–60.

Grattan-Guinness, I. (2004). The mathematics of the past: distinguishing its history from our heritage. *Historia Mathematica*, 31 (2), 163–185.

Lawrence, S. (2016a). The Old Teacher Euclid: and his science in the art of finding one's mathematical voice. *Menon: Journal of Educational Research*, 2, 146–158.

Lawrence, S. (2016b). What are we like… In: Larvor, B. (Ed.), *Mathematical cultures: the London meetings 2012-2014. Trends in the history of science* (pp. 111–126). Birkhauser/Springer.

Lawrence, S. (2019). The art and architecture of mathematics education: A study in metaphors. In: Barbin, É., Jankvist, U. T., Kjeldsen, T. H., Smestad, B. & Tzanakis, C. (Eds.), *Proceedings of the Eighth European Summer University on History and Epistemology in mathematics Education (ESU-8)*, Skriftserie 2019. Oslo: Oslo Metropolitan University, 515–530.

Lawrence, S. & Ransom, P. (2011). *How much meaning can we construct around geometric constructions?* In: Pytlak, M, Rowland, T. & Swoboda, E. (Eds.), *Proceedings of the seventh congress of the European Society for Research in Mathematics Education – Cerme 7,* Rzeszow, Poland, 9-13 February 2011. University of Rzeszow, Rzeszow, 1730–1739.

Lutovac, S., & Kaasila, R. (2014). Pre-service teachers' future-oriented mathematical identity work. *Educational Studies in Mathematics*, *85*, 129–142.

Narli, S. (2010). *An alternative evaluation* method for Likert type attitude scales: rough set data analysis. *Scientific Research Essays*, 5(6), 519–528.

Pallant, J. (2007). *SPSS survival manual - A step by step guide to data analysis using SPSS for windows (3rd ed.).* Maidenhead: Open University Press.

Pavlin-Bernardić, N., Vlahović-Štetić, V. & Mišurac Zorica, I. (2010). Studentski i učiteljski stavovi i uvjerenja o matematici. *Odgojne znanosti,* 12(2), 385–397.

Ponte, J. P. D., Oliveira, H., & Varandas, J. M. (2002). Development of pre-service mathematics teachers'professional knowledge and identity in working with information and communication technology. *Journal of Mathematics Teacher Education*, 5, 93–115.

Ponte, J. P. D., & Chapman, O. (2008). *Preservice mathematics teachers' knowledge and development.* In L. D. English (Ed.), Handbook of International Research in Mathematics Education, 2nd edition, New York: Routledge.

Relich, J., Way, J., & Martin, A. (1994). Attitudes to teaching mathematics: Further development of a measurement instrument. *Mathematics Education Research Journal, 6*, 56-69.

Sun, J. (2017). *Mathematics teacher identity in the context of mathematics reform: Elementary teacher experiences* (Doctoral Dissertation). University of California, Irvine. Retrieved from https://escholarship.org/uc/item/3m35k889