FINNISH PRE-SERVICE TEACHERS' BASIC MATHEMATICAL SKILLS — A COMPARISON BETWEEN 2008 AND 2020

Aida Ohtonen, Elin Mårtensson, Ann-Sofi Röj-Lindberg & Mats Braskén

Åbo Akademi University, Finland

ABSTRACT

This study examined how first-year primary school teacher students at Åbo Akademi University in Vaasa, Finland, performed in a basic mathematics test, through a comparison between the years 2008 and 2020. By comparing the results of the mathematics tests from the two time points, it was possible to identify significant differences in basic mathematical skills demonstrated by the prospective teachers. The results were tested for significance, which showed that the grand total means of the mathematics test, and the task-specific means, had all declined. Furthermore, the test score distributions were compared. The results showed that the portion of students with high scores had decreased, and the portion with low scores had increased, a change that agrees with previous reports on the development of Finnish students' mathematical skills.

INTRODUCTION

It is imperative that teachers at all educational levels possess mathematical knowledge in order to teach efficiently. Studies emphasising the correlation between mathematical knowledge and efficient teaching are, for example, Ball et al. (2001), Ball et al. (2005), Ball et al. (2008), Hill et al. (2005) and Stacey (2008). However, Pehkonen (2011) indicates that Finnish primary school teacher students do not always possess the mathematical skills needed to efficiently teach mathematics in the lower grades of basic education. Furthermore, Tossavainen and Leppäaho (2018) note that their previous research (see Häkkinen et al., 2011; Hihnala & Leppäaho, 2011) seem to suggest that the only branch of mathematics which the majority of Finnish primary school teacher students master, is addition and subtraction of integers. Due to the varying and partially weak mathematical skills that Finnish primary school teacher students possess, both discussion and concern have emerged in Finland (Häkkinen et al., 2011; Merenluoto & Pehkonen, 2001; Tossavainen & Leppäaho, 2018). Concern regarding weak mathematical skills has also been expressed outside of the teacher education, for instance among Finnish universities of applied sciences in the 1990's (Pehkonen, 2011). These concerns are additionally supported by previous research regarding mathematical skills, including international PISA examinations and national learning outcome evaluations pinpointing past, and current, levels of mathematical skills among Finnish 9th grade students.

Finnish primary school teacher students' mathematical skills have not been subject to research during the past decade. However, it should be in the interest of both Finnish teacher education as well as the Finnish society to identify possible deficiencies in primary school teacher students' basic mathematical knowledge, since primary school teachers' mathematical knowledge is known to affect student learning outcomes (e.g., Ball et al., 2005; Hill et al., 2005). Since previous research indicate a negative development in Finnish 9th grade student's mathematical skills (e.g., Julin & Rautopuro, 2016; Leino et al., 2019), this study was conducted with an aim to identify possible changes in mathematical skills among prospective teacher students attending the primary school teacher education at Åbo Akademi University. The research question became the following: how do first-year primary school teacher students at Åbo Akademi University perform in a basic mathematics test, do the achieved test scores differ between the years 2008 and 2020, and do these possible differences reflect the general decline in mathematical proficiency among Finnish students? By comparing the results of the mathematics tests from the years 2008 and 2020, it was possible to identify differences in basic mathematical skills demonstrated by the prospective teachers. This paper will describe the character of these differences. However, analysing the possible underlying factors causing changes in mathematic proficiency among Finnish students, and the affect these factors may have had on the population in this study, is not within the framework of this paper.

FINNISH STUDENTS' MATHEMATICAL SKILLS

The first PISA study that focused on 15-year-old students' mathematical skills was conducted in 2003. Finnish students performed well and were ranked in first place among the OECD countries, and in second place among all the participating countries and regions (Kupari et al., 2004). Among the countries that achieved the best results in 2003, Finland's score had declined the most in 2012 (see Kupari et al., 2004; Kupari et al., 2013). According to the Ministry of Education and Culture (Finnish Government, 2013), this 25-point decline was equivalent to roughly half a year of schoolwork and indicated a negative development in Finland regarding students' mathematical skills. In the PISA studies, mathematics results were categorised into seven proficiency levels, with level 6 being the highest, and below level 1 being the lowest. The portion of Finnish students who performed within the two lowest levels increased with six percentage points, from 6 % in 2003, to 12 % in 2012, and the portion of students who performed within the two highest levels decreased with nine percentage points, from 24 % to 15 % (Kupari et al., 2004; Kupari et al., 2013).

Results from PISA studies which did not mainly focus on mathematical skills, suggest a similar negative development. In 2006, Finland attained its highest PISA score (Hautamäki et al., 2008). However, the most recent available PISA study, conducted in 2018, showed that Finland attained its lowest score since PISA was introduced, and Finland was ranked in tenth place among the OECD countries, and in sixteenth place among all the participating countries and regions (Leino et al., 2019). An analysis of these PISA results shows an evident negative trend, as Finnish students' mathematical skills have considerably declined since PISA was introduced in the year 2000. See Table 1 for an overview of the Finnish PISA results in mathematics.

Table 1. Finland's PISA results in mathematics.

Year and source	Score	Rank OECD	Rank All
2000 (Välijärvi & Linnakylä, 2002)	536	4	4
2003[a] (Kupari et al., 2004)	544	1	2
2006 (Hautamäki et al., 2008)	548	1	2
2009 (Sulkunen et al., 2010)	541	2	6
2012[a] (Kupari et al., 2013)	519	6	12
2015 (Vettenranta et al., 2016)	511	7	13
2018 (Leino et al., 2019)	507	10	16

Note: [a] marks that the PISA study focused on mathematics.

On a national level, the Finnish National Agency for Education (EDUFI) and the Finnish Education Evaluation Centre (FINEEC) have evaluated mathematical learning outcomes of 9th grade students in multiple areas of mathematics. An assessment scale, containing the grades 5–10, was used for the evaluations. Table 2 shows the portions of the samples that achieved the grades *excellent* (*10*), *very good* (*9*), and at least *good* (*8*), as well as the portions that failed to achieve an approved level of skills (<*5*), in the years 2004, 2011 and 2012.

When the results from 2011 were compared to previous evaluations conducted between 1998 and 2004, the average success rate appeared to have decreased in all task categories, and in all areas of mathematics (Hirvonen, 2012). When EDUFI (Rautopuro, 2013) evaluated the results from 2012, a noticeable decrease in the level of mathematical knowledge could be observed in all areas of mathematics, and the previous suspicions of a decline in mathematical knowledge were confirmed. For instance, the results showed that the lowest performing students' mental arithmetic skills and percentage calculation skills might not be enough for managing everyday mathematics, nor for succeeding in upper secondary education. Another finding was a bimodal distribution of the students' results — a worrisome finding indicating a polarisation of mathematical knowledge. Finally, the results from 2015 showed an average success rate of 43 %, and comparisons to the results from 2011 and 2012 showed next to no new changes (Julin & Rautopuro, 2016).

Table 2. Results from national reports of mathematical learning outcomes.

Year and source	Average success rate	10	9	≥ 8	< 5
2004 (Mattila, 2005)	56 %	23 %		47%	2 %
2011 (Hirvonen, 2012)	54 %	6 %	16 %	42 %	5 %
2012 (Rautopuro, 2013)	52 %	2 %	13 %	38 %	2 %

FINNISH PRE-SERVICE TEACHERS' MATHEMATICAL KNOWLEDGE

In 1979, a multiple-choice test was introduced at the primary school teacher education programme at the University of Helsinki, to identify students in need of support in mathematics. Students were expected to correctly solve 80 % of the tasks. The tasks were solely based on the level of mathematical content in basic education. The results showed that the average percentage of correctly solved tasks was 71 %. In the years 1979–1983, the portion of students who did not reach an approved score varied between 19 % and 34 %. (Pehkonen, 2011.)

In 2000, a test was introduced at the primary school teacher education programme at the University of Turku. The aim of the test was to examine applicants' mathematical and scientific thinking. It was found that the prospective students displayed difficulties with reading comprehension in basic tasks. A test was also introduced in the basic course in mathematics didactics, to examine students' basic arithmetic skills and problem-solving skills. The students had to successfully solve nine out of ten simple arithmetic tasks. However, the students were not failed based on their performances in the problem-solving tasks. In the year 2000, the students mastered 78 % of the arithmetic tasks, yet only 45 % of the problem-solving tasks. In the years 2000–2003, the portion of failed students varied between 21 % and 49 %. (Merenluoto & Pehkonen, 2001; Pehkonen, 2011.)

In 2009, Häkkinen et al. (2011) conducted a study at the primary school teacher education in the city of Savonlinna. The applicants' mathematical skills were tested in connection to an aptitude test in the admission process. The test included mathematical content from grades 1–7. The same test was also performed by eight graders. The results showed that the mathematical knowledge among the prospective teacher students was weak. When the eight graders' results were compared to the prospective teacher students' results, no considerable differences in basic mathematical skills were identified. Häkkinen et al. (2011, p. 60) expressed it as "suorastaan noloa" [downright embarrassing] for prospective teachers to not possess greater skills than eight graders. Further, 9 % of the prospective teachers performed perfectly in the aptitude test, yet a third of the high-achieving students failed to correctly calculate a simple addition of two fractions (Häkkinen et al., 2011; Tossavainen & Leppäaho, 2018). Moreover, 60 % of the whole sample had difficulties with simple divisions of fractions (Häkkinen et al., 2011; Tossavainen & Leppäaho, 2018).

METHODOLOGY

The empirical material used in this study, was gathered within the long-term project *Teacher Students' Mathematical Knowledge*, at the Swedish-speaking teacher education at Åbo Akademi University in Vaasa, Finland. The material consisted of a mathematics test, constructed at the educational unit, which aimed to test the basic mathematical knowledge among prospective primary school teachers for the grades 1–6 (ages 6–13). For this paper, the students' basic mathematical skills, i.e., the students' applied mathematical knowledge, were examined through the results from the mathematics test. The skills required for an adequate test result were primarily basic arithmetic skills needed to solve simple and basic mathematical tasks in different mathematical areas, concerning, for example, unit conversions, simple plane geometry, and operations with percentages and fractions.

All prospective primary school teachers completed the test before, but in connection to, the initial mathematics course, during the first year of their education. For this study, the completed tests from 2008 (N = 98) and 2020 (N = 81), were analysed. All respondents gave their consent for the material to be used for research purposes. The test consisted of 15 tasks that were solely based on the level of mathematical content in the Finnish basic education. Internal consistency, measured with Cronbach's Alpha, showed a level of 0.8. The tasks were graded with whole numbers varying between 0 and 4 points. Most tasks were worth 2 points. The maximum score for the whole test was 30 points, and an arbitrary limit for a passed test was set at 20 points. A passed test was required to continue the course in 2008, a requirement not applied in 2020. The 2020 tasks were equivalent to the 2008 tasks, with only minor changes. These were, for example, minor clarifications in task wording, and minor differences in the basic arithmetic operations. The symbol used for division had also been changed. The whole test from 2020, and examples of differences, are presented in the appendix. Moreover, no aids, such as calculators, were allowed. The test had a time limit of 90 minutes.

Data from the years 2008 and 2020, were selected for this study based on their proximity, in terms of time, to previous studies and evaluations. The youngest primary school teacher students who participated in the mathematics test in the autumn of 2008 (PSTS08), were at the end of their basic education in the spring of 2005. Therefore, the participants in the PISA studies conducted in 2003 and 2006, and in the evaluation by EDUFI conducted in 2004, could be seen as representative for the generation of primary school teacher students participating in the mathematics test in 2008. Furthermore, the youngest primary school teacher students who participated in the mathematics test in the spring of 2020 (PSTS20), were at the end of their basic education in the spring of 2016. Therefore, the participants in the PISA studies conducted in 2015 and 2018, and in the evaluation by FINEEC conducted in 2015, could be seen as representative for the generation of primary school teacher students participating in the mathematics test in 2020.

Data were divided into continuous quantitative variables and grouped by year in categorical variables. Descriptive statistics and measures of dispersion were analysed for both years. The test results were further categorised into six different performance levels, using arbitrary intervals, with the aim to examine how the respondents' performances were distributed. The performance levels became the following: 0–4 points, 5–9 points, 10–14 points, 15–19 points, 20–24 points, and 25–30 points.

With an aim to present accurate and representative results, data from 2008 and 2020 were compared to equivalent data from 2007 and 2018, respectively. The two control data years, 2007 and 2018, were selected based on their proximal time frame to the main data. The task-specific means were compared to the control data, from which the tasks that were not sufficiently consistent between the proximal years, were eliminated from further statistical comparisons of task-specific means. For a task to be included, the following criterion had to be met: the mean difference in equivalent tasks, between the main year and the control year, could not exceed 0.20. In addition, no significant differences were allowed between the equivalent tasks. After performing the comparison, the cleaned data, compatible with the criteria, consisted of 10 tasks.

Furthermore, to identify significant differences, two types of statistical tests were used. The differences within the 15-task set, and the 10-task set, were tested using Student's T-test, since data were normally distributed and with equal variances. The task-specific means were nonnormally distributed, and therefore Mann-Whitney U-test was used. The effect size measures Cohen's d (d), and Rank Biserial Correlation (r), were used in cases of normally distributed data, and nonnormally distributed data, respectively.

RESULTS

Descriptive statistics

An overview of the descriptive statistics is found in Table 3.

Table 3. The descriptive statistics in 2008 and 2020. Maximum score: 30 points.

Measure	2008	2020
Sample size	98	81
Missing	0	0
Mean	18.5	15.3
Median	19.0	16.0
Mode	14.0	11.0, 17.0
Standard deviation	5.28	6.10
Variance	27.8	37.3
Lowest grand total	5	3
Highest grand total	30	28

The grand total in 2008 was normally distributed with a skewness of –0.224 and a kurtosis of –0.341. The grand total in 2020 was normally distributed with a skewness of 0.172 and a kurtosis of –0.602. For the distribution curves, see Figure 1.

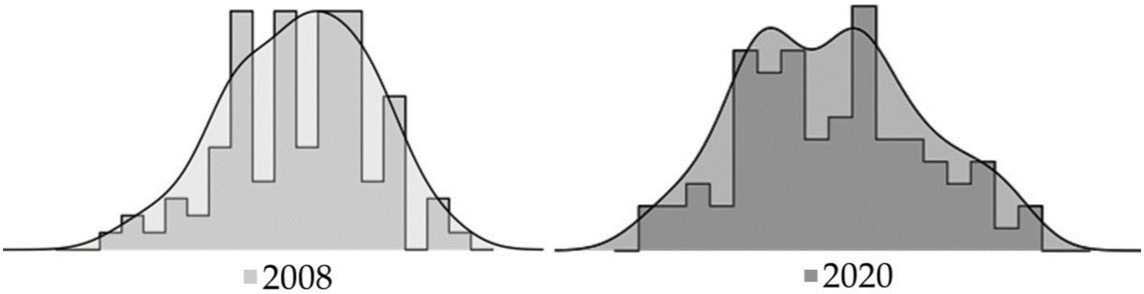


Figure 1. The histograms and density distributions of the grand totals.

The portion of performances within each of the four lowest performance levels had increased. Simultaneously, the portions of performances decreased from 33 % to 15 % within the second highest level, and from 13 % to 9 % within the highest level. Thus, the portion of performances within the limit for a passed test decreased from 46 % in 2008, to 24 % in 2020. See Figure 2 for an overview of the performance levels.

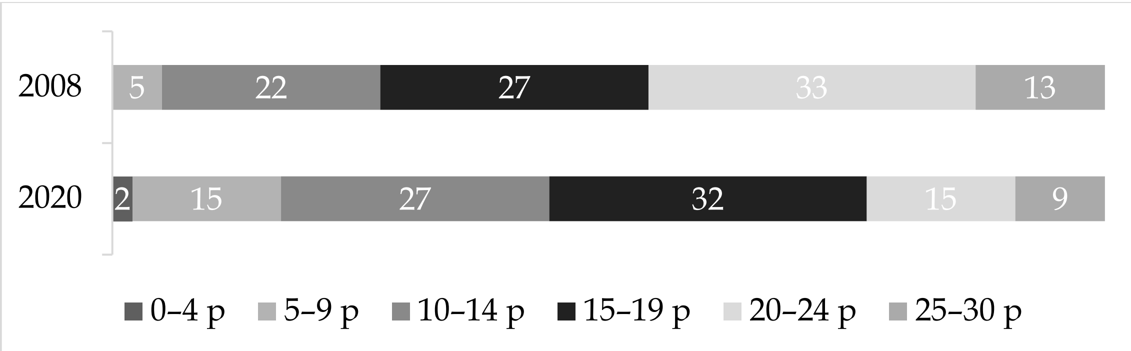


Figure 2. The distribution of the grand totals, divided into performance levels.

Elimination of tasks through a comparison to control data

When the task-specific means from 2007 and 2008 were compared, deviations where differences exceeded the set limit of 0.20 points occurred in the following tasks: task 5, 10 and 15. Furthermore, when the task-specific means for 2018 and 2020 were compared, deviations occurred in the following tasks: task 4, 6, 10 and 15. Since these tasks did not meet the criteria for continued inclusion in statistical testing of task means, they were eliminated. The remaining tasks did not exceed the set limit of 0.20 points, nor did significant differences occur. Thus, no further eliminations were made. See Table 4 for an overview of the task-specific means.

Table 4. The task-specific means from 2007, 2008, 2018, and 2020.

Task	Mean 2007	Mean 2008	Mean 2018	Mean 2020	Maximum score
1	1.33	1.31	1.01	1.00	2
2	0.986	0.918	0.814	0.778	1
3	0.833	0.786	0.743	0.741	1
4[b]	0.597	0.571	0.186	0.395	1
5[a]	3.49	2.82	2.91	2.81	4
6[b]	1.53	1.50	1.26	1.63	2
7	1.74	1.72	1.53	1.60	2
8	1.10	1.17	0.786	0.827	2
9	1.04	1.05	0.70	0.704	2
10[a, b]	2.03	1.58	1.60	1.40	3
11	0.764	0.724	0.514	0.494	2
12	1.00	0.867	0.371	0.420	2
13	1.03	1.13	0.471	0.531	2
14	1.75	1.70	1.66	1.59	2
15[a, b]	0.278	0.663	0.614	0.383	2

Note: [a] marks that the difference in task-specific means between 2007 and 2008 exceeds the set limit of 0.20. [b] marks that the difference in task-specific means between 2018 and 2020 exceeds the set limit of 0.20.

Significant differences in grand totals and in specific tasks

In both the 15-task set and the 10-task set, the differences between 2008 and 2020, were significant and of medium effect. In the 10-task set, the grand total mean had decreased from 11.4 to 8.69, the median had decreased from 11.0 to 8.0, and the standard deviation had increased from 3.77 to 4.30. The differences are presented in Table 5, and the descriptive details for the 15-task set are presented in Table 3.

Table 5. Differences in the grand totals between 2008 and 2020.

Task set	Significance (p)	Effect (d)	Mean difference	Maximum score
15-task set	<.001***	.567	–3.2	30
10-task set	<.001***	.671	–2.71	18

Note: Data were normally distributed with equal variance (Student's T-test). * p <.05. ** p <.01. *** p <.001.

All significant differences in task-specific means in the 10-task set were of small effect (r = <.3), except for task 13, which was of medium effect (r = .362). These results show that the means had decreased in all the specific tasks, including the tasks where the differences were not significant. See Table 6 for an overview.

Table 6. Differences in specific tasks between 2008 and 2020.

Task	Significance (*p*)	Effect (*r*)	Mean difference
1	.023*	.185	–0.31
2	.008**	.141	–0.14
3	.482	.045	–0.045
7	.266	.0755	–0.12
8	.004**	.235	–0.343
9	.006**	.223	–0.346
11	.041*	.151	–0.23
12	<.001***	.256	–0.447
13	<.001***	.362	–0.599
14	.384	.0510	–0.11

Note: Data were nonnormally distributed (Mann-Whitney U-test).
* p <.05. ** p <.01. *** p <.001.

DISCUSSION AND CONCLUSIONS

The most essential findings of the analyses are the declined results in the mathematics tests. The mean had declined significantly in both the 15-task set and in the 10-task set. The task-specific means had declined in all the ten analysed tasks, of which seven of the declines were significant. The most severe declines in task-specific means were decreases of roughly half a point. Additionally, the achieved highest and lowest grand totals had decreased with two points each, the standard deviation had increased, and a visual change in the distribution curve (see Figure 1) was evident. A dynamic examination of the measures of dispersion, in relation to the worsened measures of averages, suggests that an increased number of primary school teacher students performed poorly in 2020, compared to 2008. Moreover, the portion of primary school teacher students who reached the limit for a passed test was barely 24 % in 2020, in contrast to 46 % in 2008. According to the set conditions for normal distribution, the grand totals of both 2008 and 2020 were normally distributed. However, two modes were identified in 2020. The distribution curve therefore exists of two peaks, which suggests a bimodal distribution — a concerning development. Based on the distribution, it can be presumed that the 81 participants in 2020 were divided into two populations, one much more low-performing than the other.

The distributions within the six different performance levels (see Figure 2) offer a wide range of results. In 2008, a total of 46 % of the respondents performed within the two highest levels, and a total of 5 % performed within the two lowest levels. However, in 2020, a total of only 24 % of the respondents performed within the two highest levels, and a total of 17 % within the two lowest levels. Thus, the portion of performances within the two highest levels had decreased by half, and the portion of performances within the two lowest levels had more than tripled. Within the highest and the lowest levels, as well as within the level of 15–19 points, the portions had not changed remarkably. However, an examination of the distribution in the other performance levels showed an evident difference in performance. The portion of respondents that achieved 20–24 points, had decreased with 18 percentage points between 2008 and 2020. Additionally, the portion of respondents that had achieved only 5–14 points, had increased with 15 percentage points. Thus, the portion of primary school teacher students with high scores has decreased, and the portion of primary school teacher students with low scores has undoubtedly increased.

Similar results can be observed, for example, in the PISA studies with a proximal time frame to these data. In 2018, only 11 % of the students performed within the two highest proficiency levels (Leino et al., 2019), compared to 24 % in 2003 (Kupari et al., 2004). In 2018, 15 % of the students did not reach level 2 (Leino et al., 2019), a level considered the threshold for possessing the skills needed in today's information society, compared to only 6 % in 2003 (Kupari et al., 2004). Thus, the changes seen in the PISA studies are certainly similar to the changes seen in this study, considering the portion of high performing students in the PISA studies had decreased by over half, and the portion of low performing students had more than doubled. Similarly, national reports of mathematical learning outcomes show recurrent declines, and a transition of a portion high-performers, to low-performers. The average success rate has also decreased over time, from students in average mastering 56 % of the test in 2004 (see Mattila, 2005), to not even mastering half of the test (43 %) in 2015 (see Julin & Rautopuro, 2016).

Regarding the differences in specific tasks, three specific task means (tasks 3, 7 and 14) did not flag for significance. When grouping the test tasks into the sub-area categories *fractions and rational numbers* (tasks 1, 2, 3 and 4), *unit conversions* (tasks 7, 8 and 9), and *textual tasks* (tasks 11, 12, 13 and 14), each of these three non-significant tasks origin from one category each. These three tasks appear to be on the simpler side, with the calculations containing addition of common fractions as well as conversion of the common units centimetre and kilometre, and with the textual task to be more of a riddle and less arithmetically demanding than the other textual tasks.

Firstly, the performances in all these arbitrary sub-areas had declined. Proportionally, the results in the textual tasks differed the most. Similarly, Merenluoto and Pehkonen (2001) found reading comprehension to be a challenging part of interpreting the tasks at hand. Secondly, the differences in the specific task means showed to be rather modest in the fractions sub-area. However, the results still suggest primary school teacher students may have difficulties in skills regarding fractions, and more specifically, comparisons of fractions. In 2020, 40 % (n = 32) of students failed to receive a single point in task 1 (rearranging fractions and decimal numbers in ascending order; see Appendix 1), an increase of 23 percentage points from 2008 (17 %, n = 17). Merenluoto and Pehkonen (2001) and Häkkinen et al. (2011) also found the sub-area of fractions challenging for students. In a similar task, comparing two fractions and choosing the bigger one, a third of the students chose the wrong answer (Merenluoto & Pehkonen, 2001). Likewise, calculation with fractions showed to be difficult for many prospective teachers (Häkkinen et al., 2011; Tossavainen & Leppäaho, 2018).

As previously mentioned, concerns have been expressed, regarding if the mathematical knowledge among students admitted to the primary school teacher education programme is sufficient for teaching mathematics, and whether the poor mathematical knowledge possessed by primary school teacher students could affect their future teaching negatively (see Häkkinen et al., 2001; Merenluoto & Pehkonen, 2001; Pehkonen, 2011). The correlation between teacher knowledge and student achievement is affected by the teacher's complete set of mathematical knowledge, as presented by Ball et al. (2005) and Ball et al. (2001). However, Ball et al. (2005) also identified a correlation between teachers' common and specialised content knowledge in mathematics, and student achievement. Additionally, they stated that teachers should possess skills in analysing and evaluating students' work and implementing curriculum efficiently. Teachers should further be able to explain and examine students' work, use representations, make connections between mathematical concepts, and have fluency with mathematical language — skills that require mathematical insight and understanding. Lastly, Ball et al. (2005) indicated that all these common skills involve mathematical reasoning as much as they do pedagogical skills. Further, Kaasila (2000) found that primary school teacher students who had a great level of mathematical knowledge did possess the skills mentioned above, but also that mathematical content knowledge on its own is not sufficient for teaching, especially when teaching low performing students. Kaasila (2000) also found that weak mathematical knowledge might contribute to teachers avoiding certain mathematical content. Therefore, it is not enough for teachers to only possess the pedagogical aspects of mathematical knowledge, nor is it enough for teachers to only possess specialised content knowledge.

Previous research display no explicit consensus regarding the extent of mathematical knowledge needed for efficient teaching, nor to what extent specific mathematical content should be included in teacher education (e.g., Ball et al., 2005; Stacey, 2008). However, multiple studies have shown that it is possible for prospective teachers, who have poor mathematical knowledge, to positively develop their conceptions of mathematical content, and their view of themselves as mathematics teachers, within the teacher education (Kaasila, 2000; Kaasila & Laine, 2018; Pietilä, 2002). Since the teachers' experiences and conceptions of mathematics greatly affect their teaching, a didactical approach at universities is supported. Nonetheless, many Finnish researchers are of the opinion that the observed mathematical knowledge among primary school teacher students simply is not sufficient (e.g., Pehkonen, 2011).

The results in this study correspond with research that recurringly has shown insufficient mathematical skills among primary school teacher students (e.g., Häkkinen et al., 2011; Merenluoto & Pehkonen, 2001), and with the general decline in mathematical proficiency that has been discussed for many years, also including research concerning the generations of PSTS08 and PSTS20 (e.g., Julin & Rautopuro, 2016; Kupari et al., 2004; Leino et al., 2019; Mattila, 2005). In conclusion, the results from this study show serious differences, which indicate that primary school teacher students' basic mathematical skills are weaker than before. The skills, knowledge and abilities that are valued and of importance change over time, and the test in this study has included the mathematical content which teachers in the basic education are, and have been, expected to master. Thus, the identified differences in demonstrated mathematical skills, between these two time points, are concerning. The differences might indicate that a change has occurred, but future research would need to study the phenomenon with more time points.

Limitations

There is no gathered data regarding motivational factors, or other possible independent variables, affecting the respondents' performances. However, there are some considerable factors that cannot be disregarded when interpreting the results. For instance, in 2008, Åbo Akademi University was the only Swedish-speaking university in Finland with a primary school teacher education programme, and therefore the sample from 2008 consists of all Swedish-speaking primary school teacher students in Finland. In 2016, the University of Helsinki began educating primary school teacher students in Swedish. Thus, the sample of 2020 does not contain all Swedish-speaking students.

Furthermore, the mathematical content in upper secondary education varies a lot between general upper secondary education, and vocational education and training. The vocational education and training does not include a compulsory mathematic syllabus as expansive as the advanced or the basic mathematic syllabi in general upper secondary education. In this study, the respondents' educational backgrounds were not known.

Finally, on the one hand, a passed test was required to continue the course in 2008, a requirement not applied in 2020. On the other hand, the participants in 2020 were allowed to create and bring a cheat sheet to the test, which was not allowed in 2008. Studies have shown that even small changes in assignments might contribute to notable declines in solving rates (e.g., Tossavainen et al., 2015). However, the variations in the mathematics test analysed in this study were mostly clarifications in task wording. The changes can therefore be interpreted as in favour of the participants in 2020.

REFERENCES

Ball, D. L., Hill, H. C., & Bass, H. (2005). Knowing Mathematics for Teaching: Who Knows Mathematics Well Enough to Teach Third Grade, and How Can We Decide? *American Educator*, *29*(1), 14–46. http://hdl.handle.net/2027.42/65072

Ball, D. L., Lubienski, S. T., & Mewborn, D. S. (2001). Research on Teaching Mathematics: The Unsolved Problem of Teachers' Mathematical Knowledge. In V. Richardson (Ed.), *Handbook of Research on Teaching* (pp. 433–456). American Educational Research Association. https://www.academia.edu/2548010/Research_on_teaching_mathematics_The_unsolved_problem_of_teachers_mathematical_knowledge

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content Knowledge for Teaching: What Makes it Special? *Journal of Teacher Education*, *59*(5), 389–407. https://doi.org/10.1177/0022487108324554

Finnish Government. (2013, december 2). *PISA 2012: Finländska ungas kunskapsnivå har sjunkit*. https://valtioneuvosto.fi/-/1410845/pisa-2012-finlandska-ungas-kunskapsniva-har-sjunkit?languageId=sv_SE

Hautamäki, J., Harjunen, E., Hautamäki, A., Karjalainen, T., Kupiainen, S., Laaksonen, S., Lavonen, J., Pehkonen, E., Rantanen, P., & Scheinin, P. (2008). *PISA06: Analyses, Reflections, Explanations*. Ministry of Education and Culture. http://urn.fi/URN:ISBN:978-952-485-609-6

Hihnala, K., & Leppäaho, H. (2011). Aloittavien luokanopettaja- ja erityisopettajaopiskelijoiden perusmatematiikan taidot. In L. Tainio & A. Kallioniemi (Eds.), *Ainedidaktiikan symposium 2010* (pp. 70–82). University of Helsinki.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of Teachers' Mathematical Knowledge for Teaching on Student Achievement. *American Educational Research Journal*, *42*(2), 371–406. https://doi.org/10.3102/00028312042002371

Hirvonen, K. (2012). *Onko laskutaito laskussa? Matematiikan oppimistulokset peruskoulun päättövaiheessa 2011*. Finnish National Agency for Education. https://www.oph.fi/sites/default/files/documents/140234_onko_laskutaito_laskussa1.pdf

Häkkinen, K., Tossavainen, T., & Tossavainen, A. (2011). Kokemuksia luokanopettajaksi pyrkivien matematiikan soveltuvuustestistä Savonlinnan opettajankoulutuslaitoksessa. In E. Pehkonen (Ed.), *Luokanopettajaopiskelijoiden matematiikkataidoista* (pp. 47–64). University of Helsinki. http://hdl.handle.net/10138/28075

Julin, S., & Rautopuro, J. (2016). *Läksyt tekijäänsä neuvovat: Perusopetuksen matematiikan oppimistulosten arviointi 9. vuosiluokalla 2015*. Finnish Education Evaluation Centre. https://karvi.fi/publication/laksyt-tekijaansa-neuvovat/

Kaasila, R. (2000). *"Eläydyin oppilaiden asemaan": Luokanopettajaksi opiskelevien kouluaikaisten muistikuvien merkitys matematiikkaa koskevien käsityksien ja opetuskäytäntöjen muotoutumisessa*. [Doctoral dissertation, University of Lapland]. https://urn.fi/URN:NBN:fi:ula-20111131022

Kaasila, R., & Laine, A. (2018). Miten tulevien luokanopettajien matematiikkakuvaan voidaan vaikuttaa? In J. Joutsenlahti, H. Silfverberg & P. Päsänen (Eds.), *Matematiikan opetus ja oppiminen* (pp. 306–318). Niilo Mäki Institute. http://hdl.handle.net/10138/294753

Kupari, P., Välijärvi, J., Linnakylä, P., Reinikainen, P., Brunell, V., Leino, K., Sulkunen, S., Törnroos, J., Malin, A., & Puhakka, E. (2004). *Nuoret osaajat: PISA 2003–tutkimuksen ensituloksia*. University of Jyväskylä. http://urn.fi/URN:ISBN:951-39-2011-9

Kupari, P., Välijärvi, J., Andersson, L., Arffman, I., Nissinen, K., Puhakka, E., & Vettenranta, J. (2013). *PISA12 ensituloksia*. Ministry of Education and Culture. http://urn.fi/URN:ISBN:978-952-263-241-8

Leino, K., Ahonen, A., Hienonen, N., Hiltunen, J., Lintuvuori, M., Lähteinen, S., Lämsä, J., Nissinen, K., Nissinen, V., Puhakka, E., Pulkkinen, J., Rautopuro, J., Sirén, M., Vainikainen, M-P., & Vettenranta, J. (2019). *PISA 18 ensituloksia*. Ministry of Education and Culture. http://urn.fi/URN:ISBN:978-952-263-678-2

Mattila, L. (2005). *Perusopetuksen matematiikan kansalliset oppimistulokset 9. vuosiluokalla 2004*. Finnish National Agency for Education.

Merenluoto, K., & Pehkonen. E. (2001). Tulevat luokanopettajat: Matematiikan perustaidot hukassa? *Dimensio*, *65*(6), 46–49.

Pehkonen, E. (2011). Luokanopettajaopiskelijoiden matemaattisen lähtötason testauksesta 30 vuoden ajalta. In E. Pehkonen (Ed.), *Luokanopettajaopiskelijoiden matematiikkataidoista* (pp. 65–77). University of Helsinki. http://hdl.handle.net/10138/28075

Pietilä, A. (2002). *Luokanopettajaopiskelijoiden matematiikkakuva: Matematiikkakokemukset matematiikkakuvan mudostajina*. [Doctoral dissertation, University of Helsinki]. http://urn.fi/URN:ISBN:952-10-0454-1

Rautopuro, J. (2013). *Hyödyllinen pakkolasku: Matematiikan oppimistulokset peruskoulun päättövaiheessa 2012*. Finnish National Agency for Education. https://www.oph.fi/sites/default/files/documents/148019_matikkaa_13_netti1.pdf

Stacey, K. (2008). Mathematics for Secondary Teaching: Four Components of Discipline Knowledge for a Changing Workforce. In P. Sullivan & T. Wood (Eds.), *Knowledge and Beliefs in Mathematics Teaching and Teaching Development* (pp. 87–113). Sense Publishers.

Sulkunen, S., Välijärvi, J., Arffman, I., Harju-Luukkainen, H., Kupari, P., Nissinen, K., Puhakka, E., & Reinikainen, P. (2010). *PISA 2009 Ensituloksia*. Ministry of Education and Culture. http://urn.fi/URN:ISBN:978-952-485-960-8

Tossavainen, T., & Leppäaho, H. (2018). Matematiikan opettajien ja opettajaksi opiskelevien matemaattisesta osaamisesta. In J. Joutsenlahti, H. Silfverberg & P. Päsänen (Eds.), *Matematiikan opetus ja oppiminen* (pp. 294–305). Niilo Mäki Institute.

Tossavainen, T., Väisänen, P., Merikoski, J. K., Lukin, T., & Suomalainen, H. (2015). A Survey on the Permanence of Finnish Students' Arithmetical Skills and the Role of Motivation. *Education Research International*, *2015*, 1–8. https://doi.org/10.1155/2015/213429

Vettenranta, J., Välijärvi, J., Ahonen, A., Hautamäki, J., Hiltunen, J., Leino, K., Lähteinen, S., Nissinen, K., Nissinen, V., Puhakka, E., Rautopuro, J., & Vainikainen M-P. (2016). *PISA 15 ensituloksia*. Ministry of Education and Culture. http://urn.fi/URN:ISBN:978-952-263-436-8

Välijärvi, J., & Linnakylä, P. (2002). *Tulevaisuuden osaajat: PISA 2000 Suomessa*. University of Jyväskylä, Finnish Institute for Educational Research; Finnish National Agency for Education. http://urn.fi/URN:ISBN:951-39-1183-7

APPENDIX 1: The mathematics test from 2020, in Swedish, with examples of changes in tasks.

1. Ordna talen i storleksordning. Börja med det minsta talet.

$\frac{1}{5}$ 0,6 0,25 $\frac{1}{7}$ $\frac{2}{3}$ $\frac{2}{9}$

____ ____ ____ ____ ____ ____

2. Hur mycket är $\frac{2}{3}$ av 75 m? ________

Example of changes: task 3 in 2008.
$\frac{3}{4} + \frac{1}{3} - \frac{1}{2}$

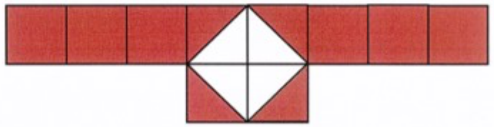
3. Beräkna $\frac{3}{4}+\frac{1}{3}+\frac{1}{2}$ ________

Example of changes: task 4 in 2008.
$1\frac{1}{4} : 1\frac{1}{2} - \frac{2}{3} : \frac{4}{5}$

4. Beräkna $1\frac{1}{4}/1\frac{1}{2}-\frac{2}{3}/\frac{4}{3}$ ________

5. a) Beräkna summan av talen 4 och 1,2. ________
   b) Beräkna produkten av talen 4 och 1,2. ________
   c) Beräkna differensen av talen 4 och 1,2. ________
   d) Beräkna kvoten av talen 4 och 1,2. ________

6. Hur många procent av figuren är färgad/svärtad?



7. Skriv som meter.
   a) 3215 cm = ________ b) 0,08 km = ________

8. Skriv som m^2
   a) 2,5 ha = ________ b) 250 dm^2 = ________

9. Skriv som m^3
   a) 105 dm^3 = ________ b) 12 dl = ________

Example of changes: task 9.
2008: Write in dm^3. a) 1,05 m^3
2020: Write in m^3. a) 105 dm^3

10. Beräkna
    a) $1{,}3m - \frac{2}{5}m =$ ________
    b) $\frac{3}{4}l / \frac{1}{2}l =$ ________
    c) $\frac{16\ m}{0{,}4\ m} =$ ________

Example of changes: task 11.

11. Lottas bil förbrukar 50 liter bensin på 750 km. Hur många liter bensin förbrukar bilen per kilometer?

2008: Lotta's car consumes 50 litres of petrol in 750 km. How much does the car consume per kilometre?
2020: Lotta's car consumes 50 litres of petrol in 750 km. How many litres of petrol does the car consume per kilometre?

12. Patrik sätter ihop en cykel, vars framdäck har omkretsen 2 m 20 cm och bakdäck omkretsen 1 m 25 cm. Hur många varv rullar det större hjulet på en sträcka där det mindre hjulet rullar 176 varv?

13. Av en viss choklad kostar 750 gram 6 euro. Hur mycket kostar 120 gram av samma chokladsort?

14. Tomas är nu 11 år. "Om två år är jag tre år äldre än du Tomas är idag" sade Anders. Hur gammal är Anders nu?

15. Olsons har tagit ett lån på 20 000 euro. Hur mycket betalar de i ränta under tre månader då räntesatsen är 12 %?