

*Barbara Barańska, Małgorzata Zambrowska*

## **Postgraduate studies qualifying for teaching mathematics as another subject\***

### **General description of the project**

The idea for the project was inspired by experiences and observations related to postgraduate studies qualifying for teaching mathematics as a second subject (PSQTM). One important goal of the project was a comprehensive analysis of the issues related to postgraduate mathematics teacher education. In the project we wanted to diagnose substantive and didactic competences of teachers taking postgraduate studies qualifying for teaching mathematics as another subject in primary and secondary school.

The project was carried out from 2019 to 2023. During the course of the project, the following tasks were completed:

- two rounds of comparative analyses of plans and programs of PSQTM run by various universities in Poland,
- a survey among academics who teach courses at PSQTM, addressing selected aspects of their students' competences,
- three surveys among mathematics teachers who have obtained qualifications for teaching this subject at PSQTM, regarding selected aspects of their substantive and didactic preparation for teaching mathematics,
- a survey among mathematics teachers who have gained mathematics teaching credentials in full-time studies on their evaluation of postgraduate studies as a means of obtaining qualifications for teaching a second subject,
- a survey among teachers who, while teaching mathematics after full-time studies, have undertaken postgraduate studies qualifying them to teach a second subject (other than mathematics)
- two rounds of research on mathematical competences of PSQTM students.

It is important to note, however, that the duration of the project unhappily coincided with the pandemic period. At the stage of planning the project, it was assumed that the tests diagnosing substantive and didactic competencies would be conducted among postgraduate students stationary. As postgraduate studies began to be conducted remotely or their implementation was suspended (e.g., at the Jagiellonian University), a decision was made first to extend the duration of the project, and then to slightly modify the original design of the planned research. The progress of the project was monitored on an ongoing basis. Having discussed the emerging issues, the project team concluded that the tests prepared for stationary use, would not give reliable results if implemented without changes in their on-line version. For the reasons outlined above, in addition to analysing the documents regulating teacher education, and analysing the plans, programs and admission policies applicable to PSQTM, all surveys and tests conducted in the project, were completed remotely.

We will briefly summarize selected key findings from our research and offer some recommendations based on what we have learned during the project.

## **Enrolment principles and general conditions for the organization of post-graduate studies**

The Act on Higher Education and Science specifies that:

Postgraduate studies or other forms of training may be conducted by a university, a research institute and an institute of the Polish Academy of Sciences (...). (Journal of Laws 2018, Item 1668)

The same law indicates the provision of postgraduate education as one of the basic tasks of universities. According to Article 160 of this Act:

- 1) Postgraduate studies shall last no less than 2 semesters and shall enable the acquisition of partial qualifications at either PRK level 6, 7 or 8.
- 2) The program of postgraduate studies shall specify the learning outcomes for partial qualifications taking into account the characteristics of the second level of the PRK at level 6, 7 or 8 of the PRK specified in the regulations issued pursuant to Article 7, paragraphs 3 and 4 of the Act of December 22, 2015 on the Integrated Qualification System and shall enable the acquisition of at least 30 ECTS points.

According to the official website<sup>1</sup> of the Ministry of Education and Science:

The conduct of postgraduate studies by universities does not require applying for a permission from the minister, nor does it require their notification or registration (...). The Ministry does not keep a register of postgraduate studies, information on this form of education should be sought directly from universities.

---

<sup>1</sup><https://www.gov.pl/web/edukacja-i-nauka/ksztalcenie#podyplomowe>

Postgraduate studies are also not subject to direct control by the Polish Accreditation Commission (PKA). This commission, when conducting periodic evaluations of the quality of education in specific fields of study conducted by universities in Poland, takes into account the following criteria in its assessments<sup>2</sup>: construction of the program of studies; program implementation; enrolment, verification of students' achievement in learning, completion of semesters and years, and graduation; the competencies, experience, qualifications and number of teaching staff, as well as the development and improvement of staff; infrastructure and educational resources used in the implementation of the program and their improvement; cooperation with the socio-economic environment in the construction, implementation and improvement of the program and its impact on the development of the faculty; conditions and ways of increasing the internationalization of the educational process in the field of study; support for students in learning, social, scientific or professional development and entry into the labour market, as well as the development and improvement of forms of support; public access to information about the program of the studies, the conditions for its implementation and the results achieved; quality policy, design, approval, monitoring, review and improvement of the study program.

Studies qualifying for teaching mathematics as a second subject must meet the requirements of the Decree of the Minister of Science and Higher Education of July 25, 2019 on the standard of education preparing for the teaching profession (Journal of Laws 2019, item 1450) and the requirements of the Decree of the Minister of National Education of August 1, 2017 (with subsequent amendments) on detailed qualifications required of teachers (Journal of Laws 2017, item 1575). According to the contents of the first of these documents:

The program of postgraduate studies that includes training preparing for the teaching profession (...) shall ensure the achievement of the same learning outcomes as the program of studies. (Journal of Laws 2019, Item.1450)

Education at postgraduate studies preparing for the teaching profession may be conducted in the field of:

(...) substantive and didactic preparation for teaching another subject  
(...) for graduates of first-cycle studies and second-cycle studies or unified master's studies in faculties, the study programs of which specified learning outcomes including knowledge and skills corresponding to the general requirements (...) of the core curriculum of the subject of teaching (...), having substantive, psychological and pedagogical preparation in the basics of didactics and voice emission and didactic preparation for teaching the subject (...) (Journal of Laws 2019, item 1450).

Universities that conduct qualifying postgraduate programs must resolve whether a teacher applying for admission to them has previously completed a course of

---

<sup>2</sup>Appendix No. 2 to the Statute of the Polish Accreditation Commission: Detailed criteria for program evaluation: <https://www.pka.edu.pl/ocena/kryteria-oceny-programowej/>

study whose learning outcomes include knowledge and skills corresponding to the general requirements of the mathematics core curriculum. Some universities provide general information on their websites regarding the rules of admission, indicating only a university degree as required. Other universities quote requirements from the Ministry of Science and Higher Education Regulation on their recruitment websites. In order for teachers to be clear about whether they meet the requirements for postgraduate studies, some universities are very precise in formulating their admission criteria for candidates, requiring them to have a degree in science or technology and to have pedagogical training. There are universities that require confirmation that a person who intends to enter PSQTM has taken, for example: not less than 60 hours of mathematics courses in their previous studies, or: a minimum of 90 hours of mathematics teaching courses, or: at least 100 hours total in mathematics, physics or computer science.

The analysis of the plans, programs and recruitment policies for postgraduate courses qualifying for teaching mathematics as a second subject allows us to make some observations. We would like to recommend drawing attention to some of the problems that have been noticed during the project.

**Recommendation 1:** First of all, it is necessary to unify the interpretation of the provisions contained in the Decree of the Minister of Science and Higher Education of July 25, 2019 on the standard of training preparing for the teaching profession (Journal of Laws 2019, item 1450). For how should one understand and interpret the clause stating that candidates for postgraduate studies are to be graduates of studies "whose programs specified learning outcomes that include knowledge and skills corresponding to the general requirements (...) of the core curriculum of the teaching subject"? The fact that some universities require candidates to document that they have taken a certain number of hours of mathematics courses shows that this issue needs to be clarified. This raises the question of why are such requirements not made by other universities? The question should be asked whether we actually know who can apply for postgraduate studies qualifying for teaching mathematics as a second subject - except of what is obvious, that it must be a person who already can teach some subject. In light of the current regulations, are physical education teachers or catechists still admitted to such studies? Maybe it is sufficient for candidates if they prove that as part of their former studies they have taken a course providing competencies that are close to the general requirements of the mathematics core curriculum. These general requirements, however, are quite universal as they include: computational proficiency, using and creating information, using and interpreting representations, and reasoning and argumentation. Could such skills can be declared as acquired in courses that had little to no connection with mathematics? We do not know for sure.

**Recommendation 2:** There should be clearly defined criteria regulating the organization of postgraduate studies qualifying for teaching a second subject. What we need a reflection and deeper awareness of the responsibility inherent in educating not only the teachers in postgraduate studies, but also in

educating the students with whom the graduates of these studies will work. We need to take more efforts to ensure the quality of the education and comparable standards of what is offered to the teachers.

**Recommendation 3:** In our opinion, it is necessary **to verify the proper implementation of postgraduate studies**. In fact, many such studies are conducted by educational centres that collaborate with universities. It is the universities that issue the graduation diploma, but what is their role in the organization of studies? Who has actual supervision over the substantive quality and the actual delivery of the training? What are the qualifications and competencies of the staff teaching students at postgraduate programs?

## Postgraduate studies plans and programs

Programs and plans of PSQTM are not always available to the candidate on the website of the university or a recruiting centre. Among those that are available, one can find a considerable variety of courses offered to teachers. For example, one of the programs offered to prospective teachers of mathematics provides the following courses:

- Real numbers set, Linear function, Quadratic function, Algebraic expressions and inverse proportionality, Polynomials. Rational functions, Exponential function and logarithms, Number sequences, Trigonometry, Planimetry, Analytical geometry, Stereometry, Elements of statistics. Probability and combinatorics, Derivatives of functions.

The names of the courses correspond to the topics that high school students learn. Other postgraduate studies, which give the same qualifications for teaching mathematics at school, cover courses such as:

- Set theory and mathematical logic; Foundations of mathematics; Mathematical analysis I; Differential equations; Mathematical analysis II; Elements of probability and measure theory; Elements of budgetary, financial and insurance mathematics.

It is important to note, however, that completion of PSQTM allows one to be authorized to teach the subject in both primary and secondary schools, regardless of what topics were covered during the studies.

In one of the studies conducted during the project, we asked a group of teachers who obtained qualifications to teach mathematics as a second subject, about the knowledge and skills that they did or did not acquire in their postgraduate studies. The surveyed teachers most often indicated as *useful and acquired at university* knowledge and skills related to mathematical topics and didactical issues. Among the examples of what they did not acquire at university, teachers first indicated didactical issues and issues related to psychology, pedagogy or education, rather than those strictly related to mathematics. Our particular attention was drawn to the significant number of statements indicating that it is a major problem for teachers to work in a classroom, where students have diverse and specific

educational needs. It does not seem possible to prepare teachers in just three semesters at the same time to work with students having a variety of dysfunctions, requiring appropriate individualized adjustments, students with major learning difficulties in mathematics, gifted students, as well as students with behavioural problems. And since the need for training in such areas was reported by those already teaching at the school, it means that the problem is serious. Added to this are the specific skills of working in the area of a particular subject with children suffering from disorders and dysfunctions. This voice of teachers seems particularly relevant in the context of recent debates on inclusive education.

The responses of the teachers surveyed clearly indicate that there is considerable variation in the courses offered at postgraduate programs. Some of the examples of knowledge and skills gained in postgraduate studies that were provided by the respondents, were exactly the same indications that other respondents gave when pointing out to what was lacking in the studies they completed. The curricula offered by different universities for postgraduate courses preparing to teach mathematics seem to differ substantially. There are those whose content is devoted largely to selected topics of higher mathematics, and there are those that are limited almost exclusively to the scope of school mathematics. At the same time, it is clear that, in general, the courses offered at postgraduate programs related to issues of psychology, pedagogy and upbringing do not meet the needs of teachers.

Our recommendations regarding the plans and programs of postgraduate studies qualifying to teach mathematics as a second subject are as follows:

**Recommendation 4: The scope of material covered in such postgraduate studies should be standardized** - since PSQTM give equal qualifications, they should be similar in the program they follow.

**Recommendation 5:** Teachers entering postgraduate studies usually know whether they are going to teach mathematics in primary or secondary school. Due to the fact that some programs inadequately address the actual needs of teachers and also for the sake of the quality and efficiency of postgraduate education, we advocate that **studies qualifying for teaching mathematics in primary school be conducted separately from analogous studies qualifying for teaching in secondary school.**

**Recommendation 6:** Polish universities employ many mathematicians who introduce students to higher mathematics. They also employ many experienced pedagogues and psychologists who help students acquire the knowledge and skills necessary to build relationships with students and respond to the needs of the individual while coordinating the work of the entire class team. However, the lack of a sufficient number of experts in the field of the didactics of mathematics is worrisome. Their knowledge and experience in the theory and practice of teaching mathematics at different educational stages cannot be replaced by an increased number of hours of training in mathematics or psychological-pedagogical subjects. There is a great need for specialists in the field of didactics of mathematics, also in the context of training mathematics teachers in extremely short postgraduate programs. **There is an urgent need to give Polish researchers the possibility of obtaining habilitations on the basis of research conducted in the di-**

**didactics of mathematics.** Such habilitations should be granted in the discipline of mathematics, with an indication of the specialty “didactics of mathematics”.

### **Motivation of teachers to pursue postgraduate studies in general and in mathematics in particular<sup>3</sup>**

In the studies conducted during the project we wanted to (among others) identify and analyse motivational factors that lead Polish teachers of various school subjects to enrol in postgraduate studies that provide qualifications for teaching mathematics as a second subject. Our two motivation-related questions were: Why do the Polish teachers decide to take part in non-degree postgraduate qualifying studies? and What motivates the choice of mathematics as the second subject they would like to teach?

Whereas studies on pre-service teachers’ motivation for becoming a teacher have typically revealed the intrinsic nature of their motivation (e.g., Watt, Richardson, 2008; König, Rothland 2012; Glutsch, König, 2019), many of the reasons given by the respondents in our study had external origins. They were closely related to:

- (a) the desire to retain or gain employment,
- (b) the desire to fill in the missing hours in order to keep a full-time position,
- (c) reforms (which reduced the number of teaching hours for some subjects and put teachers at risk of losing their full-time positions or changed the qualifications required from teachers),
- (d) the problem of staff shortages at school, and e. the expectation or recommendation of the principal.

Many of the responses gave the impression that, even if teachers’ life situation forced them to obtain new qualifications, they tended to at least partially assimilate these new external goals. Our study did not address this issue, but the analysis of the respondents’ answers leads us to the conclusion that in further research it would be worthwhile to ask teachers whether, if not for external circumstances, they would decide to undertake postgraduate studies all by themselves.

Regarding the question related to the choice of mathematics as a field of study, the group of responses pointing to teachers’ own interests related to mathematics was the most numerous. It would seem that the desire to teach mathematics should be one of the main and obvious reasons for choosing it as a field of study. However, such indications constituted only about 11% of the total. The categories of maintaining or gaining possibility of employment and obtaining formal qualifications came next, with a similar number of indications. Nearly half of the indications were related to factors such as personal interests, preferences or sense of competence.

---

<sup>3</sup>For more details see: Barańska, Zambrowska, 2022.

## **Positive and negative aspects of postgraduate studies according to graduates' opinions<sup>4</sup>**

The results obtained during the project provide some insight into how the teachers themselves perceive postgraduate education. In a surveyed group of teachers who have completed PSQTM, more teachers were able to give positive sides of the completed studies than negative ones: 150 respondents indicated positive sides and only 66 people reported some negatives. There were 2.5 times more indications of positives than indications of negative sides. Regarding the positive sides of the completed studies in the surveyed group about 80% of the teachers referred to the impact the studies have had on their lives and only 1 out of 5 respondents referred to the features of the studies. Less than half, about 40%, of the respondents pointed to the negative sides of the postgraduate studies they completed. Within this group only 10% of teachers referred to the impact the studies have had on their lives and 90% referred to the features of the studies. Among the responses concerning the impact of the studies on different aspects of teachers' lives, there were about 32 times more indications of positive features. On the other hand, among the responses concerning the characteristics of the studies, there were almost 2 times more indications of negative features. According to the respondents complaining about the educational offer of the studies, the following kind of classes or topics were indicated as missing or tackled during insufficient number of hours:

- too few hours of didactics of mathematics: teaching methods, examples of interesting activities, ability to solve tasks, little use of modern technologies,
- too little or no preparation to work in a primary school,
- too little or no preparation to work with gifted students or students with difficulties,
- lack of analysis of the core curriculum,
- lack of psychological preparation for: working with difficult youth, talking to parents.

## **Substantive competences of the participants of postgraduate studies qualifying for teaching mathematics as a second subject**

As part of the project, we conducted a study where we used a specially constructed on-line test. The "Check Yourself!" test was developed as a tool for diagnosing the substantive competencies of the participants attending PSQTM in the area of issues covered by the core curriculum in mathematics implemented in secondary school at the basic level. The test consisted of 30 tasks taken directly from books preparing for the high school final exam in mathematics at the basic level. When creating the test, we selected the tasks so that they referred to issues

---

<sup>4</sup>For more details see: Barańska, Zambrowska, 2021.



from various areas of secondary school mathematics. Each task allowed to get 1 point. We wanted the tasks not to be difficult so that they could be solved by memory or with the help of a short write-up that did not require complicated calculations. The test included 28 closed tasks in which, in addition to the answers provided by the authors of the tasks, we added the answer "I don't know" as one that could also be marked. In two tasks where the answer had to be written by a person filling the form, the answer "I don't know" was also possible.

The test pursued two main objectives. First, it provided an opportunity for postgraduate students to test their knowledge and skills in high school graduation-type tasks at the basic level. The second purpose of the test was to obtain information on whether – and if so, which of the – given tasks are difficult to the pre-service mathematics teachers, and what issues are therefore worth paying attention to during PSQTM. In two rounds of this study, a total of 54 teachers attending PSQTM participated.

The test consisted of 30 tasks, each of which could earn 1 point, so each participant could earn a total of 30 points. The arithmetic mean of the point scores obtained by the test participants was 16.87. The median value was 15.5. The most common score – 14 points – was obtained by five people. In the study group, the lowest score – 3 points – was obtained by one person. Also, one person scored the maximum number of points.

In the test completed by the teachers, there was not a single task in which the correct answer was given by all respondents. Three tasks of the test turned out to be significantly easier for the respondents than the others. They were related to a linear inequality with absolute value, a linear function and a triangle, the type of which had to be determined on the basis of information about the lengths of its sides. On the other hand, in the case of 9 tasks, the level of completion of each of them was below 50%. This group included tasks related to trigonometry, probability and spatial geometry. It is surprising that many of the respondents failed on a task involving square roots and a task addressing the quadratic function. In the tasks that proved most difficult for teachers, an average of 1 in 3 respondents was able to give the correct answer. Among the participants, there were people with various levels of knowledge and skills. It may be that those who scored low on the test consisting of high-school final exam tasks plan to teach mathematics only in primary school. And yet, by completing postgraduate studies, they will become qualified to teach mathematics in secondary school, even in classes where the core curriculum is implemented on an extended level.

Analysing the responses given by the teachers in each task brought our attention to the "I don't know" response category. In total, "I don't know" answers were given 166 times, and this is a significant number, which can be worrying. It informs us of gaps in specific areas of mathematical knowledge of the participants. A more serious problem in our opinion, however, is the numerous category of wrong answers. Filling the test was carried out under "safe" conditions for the student (anonymously and on-line), and each participant was encouraged that if they did not know how to solve a given task, they should give the "I don't know" answer, which also gave us valuable feedback. Meanwhile, many of the answers given by the respondents were incorrect. This is alarming because the solvers were con-

vinced that they knew how to solve the given task, while in reality they unaware that they did not actually know. This leads us to the following recommendations.

**Recommendation 7:** It is necessary to increase efforts taken towards the **improvement of substantive preparation of mathematics teacher candidates** studying at PSQTM.

**Recommendation 8:** Mathematics teachers should know well the mathematics they are going to teach. It is necessary to revise PSQTM plans and programs in order to equip teachers with the knowledge and skills necessary for the stage of education at which they intend to teach mathematics. It is not possible to deeply analyse and rework primary and secondary school material in three semesters. What is needed here is **reasonable differentiation and adaptation of teacher training to meet teachers' actual needs**.

## Summary

The availability of postgraduate studies in Poland seems to solve the problem of the shortage of teachers, unfortunately, perhaps only at the formal level. We must not forget that whether teachers are *qualified* is a matter of meeting certain (constantly changing) formal requirements, rather than having actual competence. The undeniable advantage of postgraduate studies is that teachers who have an aptitude for teaching mathematics, who like and know the subject well and want to teach it, can easily and quickly become qualified. But postgraduate studies are undertaken by people with different motivations, which also prompts greater attention to the quality of education and concern for the competence growth of all those willing to work as mathematics teachers. A teacher who is motivated and interested in the subject may already have more solid knowledge and more skills at the start than a teacher who begins studies for fear of losing his job or because of the school principal's expectations. One and the other, however, will gain the same qualifications, although the difference in their substantive and didactic competence can be huge.

To the best of our knowledge, our project was the first attempt to address the broadly understood problem of mathematics teacher education on postgraduate studies in Poland. We hope that research in this area will be continued. We have formulated some observations and recommendations. We hope that the new Ministry of Education and Science will bend to the unregulated status and functioning of postgraduate studies being an essential part of the teacher education system which significantly affects the quality of children and youth education in our country.

## Acknowledgements

This work is supported by the National Science Centre, Poland [grant number: 2018/31/N/HS6/03976].

## References

- Barańska, B. , Zambrowska, M.: 2021, Teachers' perspective on the advantages and disadvantages of postgraduate studies allowing to teach mathematics as a second subject. In S. Walczak (Ed.), *Proceedings of the Contemporary Mathematics in Kielce 2020* (21–36). Sciendo. De Gruyter Poland. <https://doi.org/10.2478/9788366675360-003>.
- Barańska, B. , Zambrowska, M.: 2022, Neither fully “in”, nor completely “out” of the field: The case of teaching mathematics as a second subject in Poland. In L. Hobbs, R. Porsch (Eds.), *Out-of-field teaching across teaching disciplines and contexts* (s. 285-307). Springer. [https://doi.org/10.1007/978-981-16-9328-1\\_14](https://doi.org/10.1007/978-981-16-9328-1_14).
- Glutsch, N., König, J.: 2019, Pre-service teachers' motivations for choosing teaching as a career: Does subject interest matter? *Journal of Education for Teaching*, 45(5), 494–510.
- König, J., Rothland, M.: 2012, Motivations for choosing teaching as a career: Effects on general pedagogical knowledge during initial teacher education. *Asia-Pacific Journal of Teacher Education*, 40(3), 289–315.
- Watt, H.M., Richardson, P.W.: 2008, Motivations, perceptions, and aspirations concerning teaching as a career for different types of beginning teachers. *Learning and Instruction*, 18(5),408–428.

*Barbara Barańska*  
*University of the National Education*  
*Commission in Krakow, Poland*  
*e-mail: barbara.baranska@up.krakow.pl*

*Małgorzata Zambrowska*  
*The Maria Grzegorzewska University*  
*in Warsaw, Poland*  
*e-mail: mzambrowska@aps.edu.pl*