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Using a Longitudinal Trajectory of Pre-Service Elementary School Teachers' Metacognition as a Quality Indicator of Higher Education

Branka Radulović[1*], *Milanka Džinović*[2], *Gordana Miščević*[2]

[1] University of Novi Sad, Faculty of Sciences, Department of Physics, Novi Sad, e-mail: branka.radulovic@df.uns.ac.rs
[2] University of Belgrade, Faculty of Education, Belgrade, e-mail: milanka.dzinovic@uf.bg.ac.rs; gordana.miscevic@uf.bg.ac.rs

Abstract: Quality of education is comprised in the quality of pre-service teacher education. However, to assess the quality of a teacher training program it is necessary to track some of the non-cognitive parameters. Metacognition is one of these parameters. The present study aimed at the longitudinal trajectory of the development of metacognition in pre-service teachers as an indicator of the quality of the applied teacher training program. The study included 160 pre-service elementary school teachers studying at Teacher Education Faculty at University of Belgrade. The participants' metacognitive development was measured by Metacognitive Awareness Inventory at three points of time (the beginning of studying, the academic year 2021/22 – T1, the end of the first year – T2, and the end of the second year, 2022/23-T3). The elementary school teacher training program is based on a combination of science and pedagogy related courses that together with school teaching practice start from the first semester. The courses based on problem solving and inquiry-based approach encourage students' search for adequate strategies and the assessment of their effectiveness. The findings point to a significant increase in total metacognition score between T1 and T2 and somewhat less intense increase between T2 and T3. The findings also point to a significant increase in all metacognitive subcomponents, with Conditional knowledge and Debugging strategies showing a significant increase only between T2 and T3. Between T1 and T2 the largest differences were detected in Declarative knowledge, Comprehension monitoring, and Planning. The results suggest that the teacher training program is metacognitively stimulating.

Keywords: *metacognition; pre-service elementary school teachers; study program; indicator of quality in higher education*

Introduction

Since the late 1970s when it was introduced, the concept of metacognition has constantly attracted the attention of researchers and educators due to its (in)direct effect on students' performance. According to Kuhn (2000; see Sendurur 2011, p. 102), metacognition is viewed as one of the goals in education or one of the most important aspects of problem solving (Wider and Wider, 2023, p. 359), i.e. factors that affect individuals' problem solving skills (Memnun and Akkaya, 2009, p. 1919). As an awareness of our own cognitive processes, metacognition is considered useful for raising students' awareness and responsibility for their own knowledge and ideas, as well as for applying different learning strategies to better understand the learning material (Anderson and Krathwohl, 2001; see Palennari, 2016). Metacognition has two components (Kankaraš, 2004), one related to knowledge that can be used to control cognitive processes (Palennari, 2016), and one related to the regulation of cognition that can be used to plan, monitor and assess cognitive processes (Feyzioğlu et al, 2018). Both components are further divided into several subcomponents. Thus, metacognitive knowledge consists of three subcomponents: (1) declarative knowledge related to knowledge and sources necessary for solving the task, (2) procedural knowledge related to how to recognize necessary skills and strategies, and (3) conditional knowledge related to knowing how and when to apply specific procedures and strategies. Metacognitive regulation consists of five subcomponents: (1) planning, which is related to setting goals and allocating existing resources, (2) comprehension monitoring, related to monitoring one's own process of learning, (3) information man-

*Corresponding author: branka.radulovic@df.uns.ac.rs

agement strategies, related to using skills and strategies for more efficient information processing, (4) debugging strategies, related to applying strategies for eliminating mistakes in the learning process, and (5) evaluation, related to the final stage, evaluation of strategy effectiveness after learning (Schraw and Moshman, 1995, Tuononen et al., 2023). Through the development of these subcomponents, students are equipped with strategies for solving a specific problem and see the learning benefits of the applied strategies (Vosniadou et al., 2024). However, in order to create a learning environment stimulative for the development of students' metacognition, it is necessary to have teachers who are familiar with the concept of metacognition and how it can be raised (Parlan, 2024). As teacher training is initiated at higher education institutions, the development of metacognition among pre-service teachers may be taken as one of the quality indicators of higher education programs (Stojanović and Gojkov, 2016). It is therefore important to track the metacognitive development of pre-service teachers as it can be a way of assessing the quality of teacher education. With this in mind, the current study is set around the following research tasks:

1. To determine how students' metacognition changes over time.
2. To determine how metacognitive subcomponents change over time.

Materials and Methods

Research Design

The research used a method of systematic non-experimental observation with the assessment scale. Students' achievement was assessed by means of Metacognitive Awareness Inventory developed by Schraw and Dennison (1994) during two consecutive academic years (the beginning of the first year – T1, the end of the first year – T2, and the end of the second year of studying – T3).

In the first semester of undergraduate studies students have a core course entitled Introduction to Science. Within this course, through inquiry-based approach which highlights experiments, students study physical laws related to air and water. At the end of each topic students create their own mental maps as a form of recapitulation of the content. Although quite complex, the course Introduction to Science is taught in the first semester so that though inquiry-based learning and problem solving students develop learning strategies and raise their metacognitive levels. In addition to this course, students attend pedagogy- and psychology-related courses and Educational Technology course in which they also learn through solving problems and evaluating the learning strategies they apply. According to Kramarski and Michalsky (2010; see Feyzioğlu et al. 2018), combination of computer-based learning with metacognitive instruction causes increasing pre-service teachers' ability to reflect on the learning process. This curriculum concept of combining science and pedagogy is also applied in the second year of studying. Thus, within the course Introduction to Social Sciences, inquiry-based learning is applied in the segment related to geography, while the history-related topics imply causal interpretation of the learning content. Students also have some teaching practice hours in the first year of studying and this concept eliminates Thomas' statement that metacognition is not present in "everyday practice of classroom teachers or the mindset and/or curricula of teacher educators and their teacher education programs" (Jahangard et al., 2016, p. 341). This is how "successful learning predominantly based on metacognitive activities performed and monitored during the learning process" is achieved (Feyzioğlu et al. 2018, p. 46).

Sample

The study sample included 160 undergraduates of the Faculty of Education at University of Belgrade. There were three measurements altogether: In October in the academic year 2021/22, i.e. at the beginning of the first year of undergraduate studies (T1), at the end of September in the academic year 2021/22, i.e. at the end of the first year (T2), and at the end of September of the academic year 2022/23, or the end of the second year of undergraduate studies (T3). As the overwhelming majority of students were females, gender differences were excluded from the analysis. The students were informed that the research was anonymous and that their participation was voluntary, as well as that they could withdraw from the research at any time without consequences. No dropouts, however, were recorded. In order to secure

their anonymity, the students created their own codes which they used for signing in the measurements.

Instrument

A Metacognitive Awareness Inventory developed by Schraw and Dennison (1994) was used. The inventory included 52 items. The five-point Likert scale was used for the level of agreeing with the items. The value 1 indicated complete disagreement, while the value 5 indicated complete agreement. Cronbach's Alpha was .847, while Cronbach's Alpha based on Standardized Items was .854. As for the subcomponents, Cronbach's Alpha values were the following: Declarative Knowledge .786; Procedural Knowledge .712; Conditional Knowledge .717; Planning .729; Comprehension Monitoring .771; Information Management Strategies .755; Debugging Strategies .729; Evaluation .708. González Cabañes et al. (2022) reported similar results for Cronbach's Alpha.

Data Analysis

Since the values of skewness and kurtosis were within the range -1 to +1 (Tabachnick and Fidell, 2007), parametric test was used. Descriptive statistics and t-test of paired samples were used to determine differences in metacognition and its subcategories.

All analyses were performed using SPSS 20.0 software.

Results

Figure 1 shows the mean of total sum of students' metacognition over time.

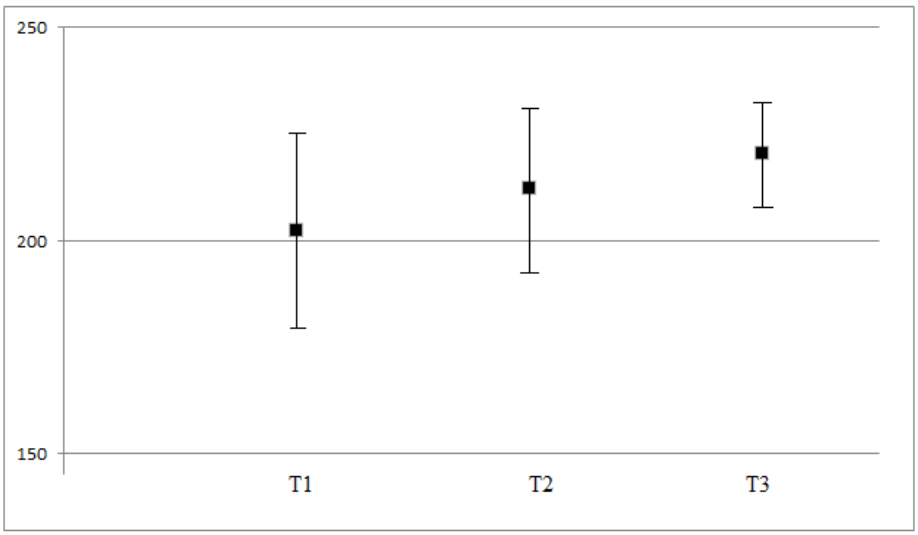

Figure 1. Students' metacognition over time.

Descriptive statistics shows that after the first year of study there is a significant increase in the total score of students' metacognition and that it continues to increase during the second year of study. Spearman's correlation coefficient shows the existence of a correlation between the study year and the total metacognition score (*rho* = 0.359, $p < .001$). Table 1 shows t-test of paired samples.

Table 1. *T-test of paired samples for total metacognition score*

	M	SD	*t*	η^2
T1 - T2	-9.68	29.95	-4.086**	.096
T2 - T3	-8.43	8.53	-12.493**	.497

Note. **p < .01

Since metacognition is a complex construct, in order to better understand the change in metacognition, Figure 2 shows subcomponent changes over time.

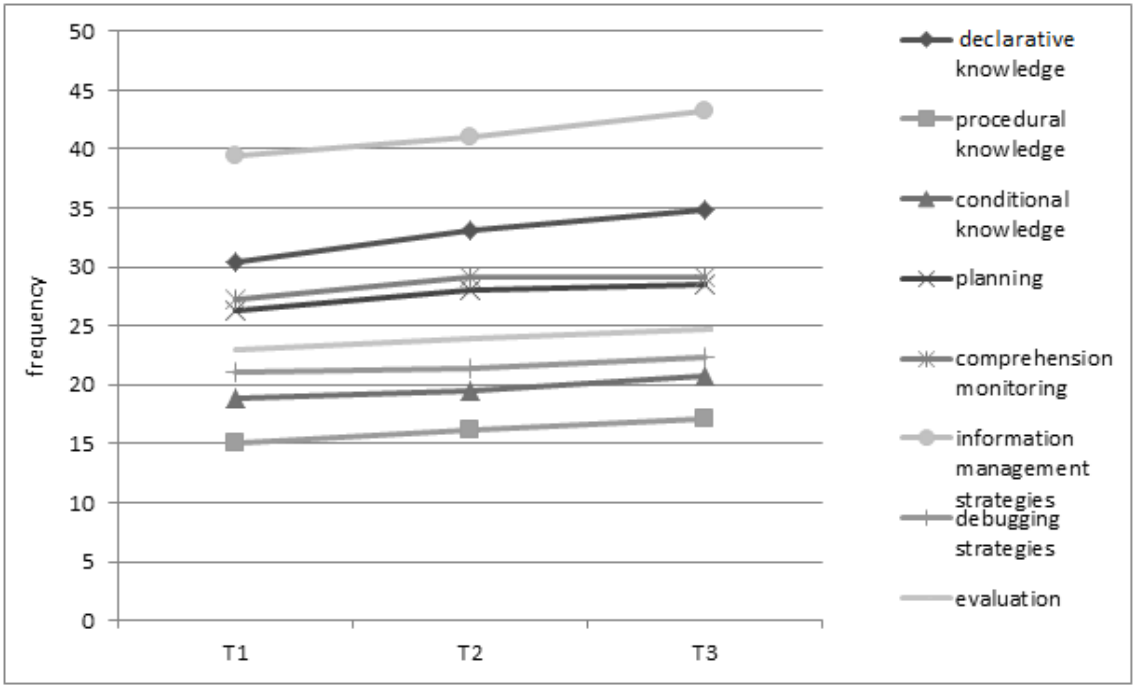

Figure 2. Trajectory of metacognitive subcomponents over time.

As shown in Figure 2, there is an increase in each subcomponent, but the differences in all components are not the same. The largest differences between T1 and T2 are observed in Declarative knowledge, Comprehension monitoring and Planning, while between T2 and T3 the differences are most noticeable in Information management strategies (Table 2). On the other hand, the smallest differences between T1 and T2 are recorded in Conditional knowledge and Debugging strategies, but these competencies increase significantly during the second year of study.

Table 2. *T-test of paired samples for metacognitive subcomponents*

Components	Time	M	SD	*t*	η²
Declarative Knowledge	T1 - T2	-2.65	5.73	-5.853**	.177
	T2 - T3	-1.74	1.81	-12.191**	.483
Procedural Knowledge	T1 - T2	-1.08	3.42	-4.001**	.091
	T2 - T3	-1.04	1.37	-9.590**	.366
Conditional Knowledge	T1 - T2	-0.54	4.05	-1.700	-
	T2 - T3	-1.23	1.94	-8.041**	.289
Planning	T1 - T2	-1.74	5.83	-3.772**	.082
	T2 - T3	-0.56	1.77	-3.970**	.090
Comprehension Monitoring	T1 - T2	-1.91	4.97	-4.869**	.130
	T2 - T3	0.07	2.25	.387	-
Information Management Strategies	T1 - T2	-1.62	7.53	-2.720*	.044
	T2 - T3	-2.16	2.11	-12.983**	.515
Debugging Strategies	T1 - T2	-0.39	4.14	-1.184	-
	T2 - T3	-0.98	1.27	-9.684**	.371
Evaluation	T1 - T2	-1.03	4.47	-2.904*	.050
	T2 - T3	-0.79	1.93	-5.159**	.143

Note. * p < .05; **p < .01

Discussions

The analysis of students' and teachers' metacognitive activities is central for a critical evaluation of study programs and procedures that are in use (Kankaraš, 2004). With this in mind, the current study examined the longitudinal trajectory of pre-teachers' metacognition development in order to assess the quality of their study program. The findings point to a significant increase in the subjects' metacognition from T1 to T2, and to T3.

As for the measured subcomponents, the greatest improvement in the period from the enrolment up to the end of the first year is detected in the components referring to Declarative knowledge, Comprehension monitoring and Planning. When engaged in reflexive activities, such as reflecting on the learning strategies they used, the set goals and the achievements they reached, the students become more aware of their strengths and areas in which they need improvement. It can be assumed that increased metacognition has led to the improvement of comprehension monitoring and planning. This improvement can be reached through practical activities and providing feedback (Rawson and Dunlosky, 2007; see Stanton et al., 2021). More precisely in the case of the current study, inquiry-based learning, which is widely applied at Teacher Education Faculty, puts students in a position to investigate and formulate conclusions based on the results of their experiments and thus multiple feedback is obtained (both from the teacher and by comparing the hypotheses and the experiment results). In this way comprehension monitoring and planning is evaluated as an important predictor of both natural science and language achievement (Hausman et al., 2021, Pesout and Nietfeld, 2021, Stanton et al., 2021).

On the other hand, the subcomponents Conditional knowledge and Debugging strategies showed no significant improvement over the first year. Conditional knowledge and Debugging strategies are metacognitive components that are more complex and require specific guidance and practice in a longer period. Accordingly, the improvement in these segments was observed after the second measurement and the period of one more year. Similar findings are reported in other studies – development of procedural–conditional knowledge mainly occurred during the second year of study" (Schiering et al., 2021, p. 9).

During the period from the first to the second year of studying a significant increase of metacognitive components is detected in all domains except for Comprehension monitoring. A possible explanation may be sought in this preliminary progress detected in the first year of study. Although faced with new challenges and requirements of studying at university, students' further improvement in the use of strategies for monitoring their own learning processes may be less obvious and more demanding for measuring due to the improvement they made.

The study findings comply with recommendations of other researchers that teacher education faculties should invest in the professional development of pre-service teachers, and the curricula should provide added explicit metacognitive scaffolding (Michalsky, 2024). Faculty of Education of the University of Belgrade has recognized the importance of developing metacognition and its components in its students –future teachers. In this way teachers-to-be will become able to support their own students and develop their metacognitive strategies and self-regulated learning once they start their teaching career. Swanson's results (1990; see Wider and Wider, 2023), which indicate that students with a high metacognitive level more effectively solve problems than students with low metacognition, highlight the role of teacher and his/her ability to create a learning environment that stimulates the development of metacognition. The importance of pre-service teacher training in creating metacognitively stimulating learning environment is highlighted by the interaction between metacognition and students' motivation (Palennari, 2016) and better comprehension of science texts, i.e. attractiveness of sciences (Jahangard et al., 2016). Therefore the vision of the Faculty of Education is to create metacognitively stimulating programs that encourage effective learning in all three levels of education and thus contribute to the continuous quality improvement of the study programs.

Conclusions

The aim of the present study is longitudinal trajectory of the development of metacognition in pre-service teachers as an indicator of the quality of higher education. The findings point to a significant increase in the overall metacognition score and in almost all tracked components between the measure-

ments T1 and T2, while the increase is somewhat lower between the measurements T2 and T3. The findings also suggest that all subcomponents of metacognition have substantially increased, with an exception of Conditional knowledge and Debugging strategies which showed a significant incline in T3 measurement. The largest differences between T1 and T2 are detected in Declarative knowledge, Comprehension monitoring, and Planning. The overall results suggest that the first two years of the current teacher education program stimulate metacognitive development.

The main limitation of the study lies in the impossibility of comparing the obtained results with other teacher education faculties since the study programs differ. Also, as almost all students of Faculty of Education of the University of Belgrade participated in this study, there is no possibility of enlarging the research sample. Additional limitation is related to the study length. The participants' metacognitive development was tracked in the first two years of undergraduate studies as these have been reported as the most critical for dropping out (Araque et al., 2009, Bostic 2024, Everaert et al., 2024). Further research, therefore, should encompass a large number of parameters that would serve as additional quality indicators of pre-service teacher education. This would also enable participation of a larger number of teacher education faculties not only in Serbia but in the neighboring countries as well, and these investigations would point to the direction of future educational reforms. Future studies should also focus on reasons for choosing the teaching career and potential changes in these reasons as metacognitive changes occur.

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Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization, B.R. and M.Dž.; methodology, B.R. and M.Dž.; formal analysis, B.R.; writing—original draft preparation, B.R, M.Dž. and G.M. All authors have read and agreed to the published version of the manuscript.

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