

Chapter XII

TEACHING COMPETENCIES OF PRE-SERVICE PRIMARY SCHOOL TEACHERS TO USE AN INTEGRATED APPROACH IN TEACHING SCIENCE, ART, AND MATHEMATICS¹

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Abstract: STEAM (Science, Technology, Engineering, Arts and Mathematics) as a form of integration of different disciplines is recognized as a field that teaches twenty-first century skills since it incorporates many hands-on activities focused on solving problems, development of creativity, innovative and critical thinking, encouragement of social competences through cooperation and sharing results. Teacher education programs predict that preservice primary teachers acquire knowledge of separate scientific disciplines and develop pedagogical skills of subject specific didactics during their studies. On the other hand, integration of different subject contents takes up only a small part, if any, of the curriculum. The purpose of this study is to examine the self-reported teaching competences of final year preservice primary teachers for using an integrated approach in their future work. By using questionnaire technique, qualitative data was collected from 55 pre-service primary teachers. The results showed that although student teachers have a positive attitude towards an integrated approach, they do not possess optimal level of teaching competences to teach it. The results indicate that existing teacher education programs need to be improved and modernized in order to prepare the pre-service primary teachers of the twenty-first century.

Keywords: *STEAM education, integrated approach, pre-service primary teachers, and teaching competencies.*

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Introduction

In recent years, STEAM has become an increasingly present acronym in education, covering five areas: Science, Technology, Engineering, Art, and Mathematics. The starting point of this concept is based on the model of STEM education and it can be said that it represents a more comprehensive answer to the numerous educational challenges and social demands that all participants in the education system meet. The shift from STEM to STEAM education has been prompted by rapid changes in the labour market, primarily in STEM areas. According to the report of the World Economic Forum, by 2022 the global labour market will have undergone a drastic change in the division of labour between people, machines and software, and it will be aimed towards the automation of labour. Some analytic projections forecast that advances in automation will result in the wholesale replacement of the human workforce. One perspective of such development is that work currently performed by humans is being augmented by machine and algorithmic labour. The augmentation strategy takes into account activities that can be accomplished by human workers, often complemented with technology, when they are free of the need to perform routinized, repetitive tasks and therefore are able to use their distinctive human talents. Technological change and progress will make obsolete many of the current job profiles, but will cause the dynamic rise of wholly new ones as well. This in fact means that the children who are now being educated can expect future occupations that are only emerging or do yet not exist. A series of technological and economic trends (ubiquitous high-speed mobile internet, artificial intelligence, widespread adoption of large data analytics and cloud technology) are transforming the sphere of social activities in such a way that new jobs that appear no longer demand expertise and competencies in only one area. It is obvious that many of the new problems we face can be solved successfully if the limitations of narrow specialties are overcome. Along with proficiency in new technologies, skills such as creativity, originality and initiative, critical and analytical thinking, innovation, as well as active learning and learning strategies will have great prominence as twenty-first century skills. The case of a rise in the occurrence of new occupations involving knowledge from STEM and/or other fields is already evident. At the same time, the results of the PISA testing conducted in Serbia in 2012 indicate that the efficiency of the education system is low in the development of competencies that are important for the personal and professional development of the individual, but also for the functionality of society as a community (PISA 2012). Although PISA testing refers to the competencies of students who have support in compulsory curricula and which are content related to the teaching of individual subjects, the literacy that this test assesses is understood as an interdisciplinary and functional category. Literacy refers to knowledge that is considered as educational capital necessary for

continuing education and for successful learning in personal and professional roles, while competence refers to the ability to functionally apply appropriate knowledge. In accordance with the results of PISA testing, regardless of distribution of achievements by level, the general impression is that students do not acquire enough competence from the STEM area to respond to the future needs of society and for full participation in social life flows. Since PISA testing was not repeated in 2015, and judging by the relatively slight improvement in the 2012 levels compared to the 2009 tests, the assumption is that the performance indicators of the education system would not be significantly different.

These analyses and forecasts require urgent changes in education, which (optionally) need to be improved. In response to such challenges, STEAM proposes a dynamic way of functioning and development of education, strengthening of teacher competencies, and creativity as an important component of learning and new pedagogical procedures in practice, about creativity and innovation in the learning process – as well as the identification of concepts, methods and best practices which demonstrate and reflect innovative learning.

The application of the STEAM model as a concrete action for the development of education is in accordance with the vision of the future state of the education system in Serbia. According to the vision of the Education Development Strategy in Serbia until 2020, primary education and upbringing should represent a good and stimulating environment in which students master quality knowledge and skills, basic competencies and basic literacy in all areas studied in elementary school, so that this knowledge can interconnect and be applied in further education and in everyday life (Strategy for Education Development in Serbia 2020). In other words, it seeks to develop the education system “driven to the future”. Considering the fact that the development of schools in the STEM framework in Serbia is in the pilot phase (see http://eu.cpn.rs/active_projects/stem-school-label), the application of innovative ways and methods of teaching certainly represents a good basis for introducing this model, as well as the STEAM model efficiently into the formal frameworks of the education system. Consequently, in the education of teachers as key participants in the education system, special emphasis should be placed on strengthening their K1 competencies for subject teaching and teaching methods, and K2 competencies for teaching and learning.

Theoretical Background

The traditional concept of reproductive teaching, which is still dominant in educational practice, is in its outcomes, and is contrary to the aforementioned social and technological changes. This concept of teaching actually aims to reproduce social values and knowledge that can be defined as stable and

lasting. The static model of traditional reproductive teaching implies passive transmission of information and knowledge from teachers to learners in the final form, and the subjects of such learning are the rules of behaviour and the standards of the school system (Dewey 1966). In such cases, a student does not adopt concepts but words; he uses memory more than his thoughts and is incapable of applying the acquired knowledge with understanding (Vigotski 1977). However, due to the constant multiplication of knowledge, education can no longer be reduced to reproductive learning, i.e. to simple communication of existing knowledge. In a knowledge-based society that is rapidly changing, in which knowledge quickly becomes outdated, in the context of education the path to knowledge has become as important as the acquired knowledge itself.

The quality of the teaching process can also be reflected in the quality of acquired knowledge. "The smaller quantum of knowledge acquired in a more complex and more accurate way, with the participation of more fully thought-out, experiential, creative and seeking activities of pupils, although it took longer to acquire knowledge in a finished form, has a higher value than a larger amount of knowledge acquired by memory in ready form" (Vilotijevic, Vilotijevic 2014: 26). Contemporary teaching approaches based on a constructivist and cooperative model of teaching organization can be described by the metaphor "learning as the construction of knowledge" (Vilotijević, Vilotijević 2014: 23). In particular, educationalists advocate student-oriented education, which sets the student's independent work and his/her optimal thinking activity at the centre of learning activities, which develops motivation for learning, divergent thinking, encouraging the initiative and cooperation of those who are learning and those who teach and thereby contribute to raising the quality of their achievements (Kopas Vukašinović 2014; Mirkov 2013; Šefer 2012). According to the constructivist approach to the learning process "enriched by the socio-cultural theory, it follows that knowledge is active, that it is not a passive copy, an 'impression' of reality, that it is subjective, relative and in development, that it is the process (and not the result) in which social factors have an important formative role" (Pešikan 2010). The role of teachers is to create situations in which pupils actively participate, and act as incentives for their mental activity. In order to achieve the outcome of pupils' education according to the expected development of the twenty-first century skills, it is necessary to apply those teaching methods, models and approaches that go beyond the limitations of teaching based on teaching by lecturing, memorizing and reproduction. It is necessary to connect knowledge of different epistemological nature and to connect academic knowledge with immediate life experiences. Integrated teaching (IT) is certainly such a teaching model that can be applied very effectively in classroom teaching.

Although some pedagogues and educational theorists were advocating forms of curriculum integration in the early XX c. (Vars 1991) it has been

updated more recently. A move towards the integrated curriculum is supported by the premise that predominantly accepted discipline-based education system is not effective as it should be (Loepp 1999). Most of the problems and situations encountered today by students are very complex, they rarely have one exact solution, and require knowledge of multiple disciplines, while the contents that we study through subject-oriented teaching are based on disciplines, and thus the acquired knowledge has poor application in real situations. The very notion of “integration” incorporates the idea of unity between forms of knowledge and the respective disciplines (Pring 1973). The most common are three forms of teaching:

- Full integration – it is accomplished by merging different teaching contents into a single course;
- partial integration – it is achieved by choosing from the teaching material and by jointly processing those related contents;
- block integration – it is accomplished by the construction of freely programmed autonomous blocks (sets) or the separation of parts of a common program that is integrated in the process (Vilotijević, Vilotijević 2016: 262–263).

Integrated teaching relies on the principle of conscious activity and in fact it integrates teaching activity and the learning process. Teaching based on this approach can be very stimulating and an incentive for students. Some studies (Austin, Hirstein, Walen 1997; Kain 1993) have shown that the application of integrated teaching can result in greater intellectual curiosity, increased motivation for education, enhanced problem solving skills, and higher achievement in college, and that the attendance rate of the students is larger when they are engaged in an integrated curriculum (Meier, Dossey 1999).

In practice, the greatest trend of integrative teaching at the level of primary education is noticeable, and this is no surprise. Since the teacher predominantly organizes and performs most of the teaching contents, class teaching in the first cycle of education provides significantly greater opportunities for the realization of integrated classes in relation to subject teaching. The classroom is personally unified and content integration is easier to accomplish. A teacher can freely compile content entities in a way that integration has an interspecific, inter-subject or inter-systemic character. A teacher can easily integrate content within one subject into one problematic whole or combine related elements from several different subjects, or connect the contents of the natural and humanistic areas and thus create a qualitatively new whole by establishing a strong logical whole within.

This is the highest quality level of knowledge, which implies a high degree of development of connections and relationships between knowledge and the ability to apply knowledge in other areas, as well as solving practical problems in everyday life (Antonijević 2006). This is creative knowledge because the

student develops his own knowledge based on acquired knowledge (Potkonjak, Šimleša 1989), that is, he is able to apply knowledge, to transform knowledge and values critically and creatively and to evaluate the results (Blum 1981). In addition to the structure of the knowledge system, the much greater importance of applying an integrated approach in teaching is that, based on the method of acquiring knowledge, the student develops metacognitive knowledge, and reveals and learns the cognitive processes needed to acquire new knowledge. The application of integrated teaching in the educational process, at all levels of education, results in the creation of a rich, incentive situation for learning and the development of students' autonomy. In the context of integrated curricula, opportunities for more effective assessment of the achievements and abilities of students from several subjects are evident (Drake, Reid 2018; Cekić Jovanović, Đorđević, Miletić 2018).

In order to integrate teaching content with the best possible results, the teacher needs to know the curriculum well and to be able to apply different teaching forms, teaching methods and teaching resources. This implies his/her professional competencies, first of all in relation to the teaching field, subject and methodology of teaching, as well as in relation to students' learning and teaching, communication, cooperation and support to their development (*Standards of Professional Competences of Teachers and their Professional Development*, 2011). Great professional, didactic-methodical competence of teachers is required, with detailed knowledge of the materials of all subjects studied within the classroom as well as general culture, and knowledge of a large number of scientific fields (Mihajlović, Golubović Ilić 2018).

Since the faculties for education of teachers have an important and essential role in the development of professional competences of student teachers, we wanted to investigate their attitudes towards the use of an integrated approach as well as their self-reported teaching competencies.

Research methodology

The main aim of the paper was to examine the current state among final year pre-service teachers concerning the use of an integrated approach in teaching. The aim was accomplished through the following *research tasks*:

1. to examine the self-reported teaching competence of pre-service primary teachers for using an integrated approach
2. to investigate the attitudes of pre-service primary teachers towards the use of an integrated approach in teaching.

Instrument

The instrument used was a questionnaire that consisted of two parts. In the first part background information about student teachers was collected (course grades in methodologies of teaching Mathematics, Science, and Art). The second part of the instrument contained a pre-service primary teachers Self-Reported Integrated Approach Teaching Competence Scale (SRIATC) and eight Likert-type items. SRIATC is a five-point Likert-type scale that contained 11 items. It was developed by the authors and it aimed to determine the pre-service primary teachers' self-reported level of teaching competence for using an integrated approach in teaching. The items were constructed in accordance with some previous studies and literature. The Cronbach' alpha reliability coefficient of the SRIATC indicated good reliability ($\alpha=0.800$). The maximum score is 55 and the lowest possible score was 11.

Table 1: SRIATC Items.

Items code	Items
S1	I have gained basic knowledge and skills for applying an integrative approach in my future work with students.
S2	I am able to connect meaningfully (functionally) the contents of different subjects.
S3	I am able to translate real-life situations into the language of science, art, and mathematics and use them in teaching.
S4	The concept of an integrative teaching approach is clear to me.
S5	I am able to design and plan teaching activities that integrate the contents of different subjects.
S6	I am able to carry out teaching activities in which the contents of different subjects are linked.
S7	I am able to design and plan research activities that integrate the contents of different subjects.
S8	I am able to carry out research activities that integrate the contents of different subjects.
S9	I am able to evaluate the work of students during teaching activities that integrate the contents of different subjects.
S10	I am able to motivate students and to get them interested to work during teaching activities that integrate the contents of different subjects.
S11	I'm afraid I will not know how to apply an integrative approach to teaching.

The eight Likert-type items aimed to investigate the participants' attitude towards the certain aspects of using integrated approach in teaching. Participants were requested to rate their level of agreement with certain statements (1 = complete disagreement, 5 = complete agreement). All items are presented in Table 2.

Table 2: Attitudes towards the certain aspects of using integrated approach in teaching.

Items code	Items
A1	I would like to apply integrative approach in my work.
A2	The application of the integrative approach in teaching is interesting to me
A3	I think it is important that the teacher integrates the content of various subjects whenever possible.
A4	I think that the teacher is sufficiently burdened with the teaching of individual subjects and that he should not be burdened with the requirements for integration.
A5	An integrative approach gives the teacher a better insight into the quality of students' knowledge.
A6	It is impossible to assess the knowledge of individual subjects of students during teaching activities that integrate the contents of different subjects.
A7	The application of an integrative approach demands [from] the teacher extra time and effort to prepare the lesson.
A8	Applying an integrative approach requires teachers to continually improve in their profession.

Sample

The research was conducted during the school year 2018/2019 and included a sample of 55 final year pre-service primary teachers. All student teachers were categorized according to their achievement in methodology courses in four groups: low, moderate, high, and a group of students who did not pass the exam. The structure of the sample with regard to the achievement for three courses Methodology of teaching Mathematics (MTM), Methodology of teaching Science (MTS), and Methodology of teaching Arts (MTA) is given in Table 3.

Table 3: Structure of the sample in regard to the MTM, MTS and MTA grades.

		Not passed exam	Low	Moderate	High
MTM	F	20	16	11	8
	%	36.4	29.1	20.0	14.5
MTS	F	8	22	12	13
	%	14.5	40.0	21.8	23.6
MTA	F	2	10	11	32
	%	3.6	18.2	20.0	58.2

Results and Discussion

1. The first task of the research was to examine the self-reported teaching competence of preservice teachers for using an integrated approach in teaching.

Table 4: The level of the self-reported teaching competence for using an integrated approach

Item Codes	N	Mean (M)	Standard Deviation (SD)
S1	55	3.71	0.90
S2	55	3.87	0.75
S3	55	3.78	1.05
S4	55	3.84	0.84
S5	55	3.85	0.87
S6	55	3.93	1.00
S7	55	3.53	0.86
S8	55	3.45	0.96
S9	55	3.54	0.92
S10	55	3.94	0.78
S11*	55	3.25	1.11
SRTC	55	3.70	0.53

* Item S11 was reversed

Individual's score on the SRIATC scale (SRTC) represents the mean-item summated score of the individuals' responses. A mean-item summated score is calculated when an individual's summated score is divided by the number of items constituting the scale which creates a mean-item score for each individual that falls within the range of the values for the response continuum options (Warmbroad 2014).

For Likert average scale [1.00–1.80] indicates very low level of self-reported teaching competence, [1.80–2.60] indicates a low level, [2.60–3.40] indicates a moderate level, [3.40–4.20] indicates a high level, [4.20–5.00] indicates a very high level.

Results show that, in general, the preservice primary teachers self-reported teaching competence for using integrated approach in teaching indicates high level (M = 3.70, SD = 0.53).

As for the individual items, the values of statistical parameters (mean, standard deviation) indicate that pre-service primary teachers reported a high

level of teaching competence for all items except for the item S11 (*I am afraid that I will not be able to use integrated approach in teaching*), where they reported a moderate level (Table 4).

In order to examine if there is statistically significant difference in levels of self-reported teaching competence between different groups with regard to achievement in MTM, MTS and MTA courses, the Kruskal-Wallis test was performed. We determined that there was no statistically significant difference in self-reported teaching competence among different achievement groups of student teachers in any of the courses (MTM: $\chi^2 = 7.480$, $p = 0.058$; MTS: $\chi^2 = 6.268$, $p = 0.099$; MTA: $\chi^2 = 0.949$, $p = 0.914$).

The second research task was to investigate the attitudes of preservice primary teachers towards some aspects of using an integrated approach in teaching.

Table 5: Distribution of preservice primary teachers replies regarding some aspects of using of integrated approach in teaching

Item Codes	N							Mean (M)	Standard Deviation (SD)	Coefficient of Variation (C_v)
		I totally disagree	I partially disagree	I am not certain	I partially agree	I totally agree				
A1	55	f	0	2	8	25	20	4,15	0,80	19,38
		%	0	3.6	14.5	45.5	36.4			
A2	55	f	0	1	11	17	26	4,24	0,84	19,78
		%	0	1.8	20.0	30.9	47.3			
A3	55	f	0	2	4	24	24	4,30	0,77	17,88
		%	0	3.6	7.3	43.6	43.6			
A4	55	f	15	19	6	10	5	2,47	1,32	53,27
		%	27.3	34.5	10.9	18.2	9.1			
A5	55	f	0	3	9	23	20	4,09	0,87	21,18
		%	0	5.5	16.4	41.8	36.4			
A6	55	f	10	19	16	5	5	2,56	1,17	45,52
		%	18.2	34.5	29.1	9.1	9.1			
A7	55	f	1	2	6	29	17	4,07	0,86	21,06
		%	1.8	3.6	10.9	52.7	30.9			
A8	55	f	2	3	6	13	31	4,24	1,09	25,68
		%	3.6	5.5	10.9	23.6	56.4			

Results show that the attitudes of student teachers with regard to the use of an integrated approach in teaching are positive (Table 5). Values of coefficient of variation indicate that student teachers' attitudes concerning items A1, A2, A3, A5, A7 and A8 are relatively the same and homogeneous. The majority of students believed that it is important to integrate contents of different subjects whenever it is possible in teaching (87.2%), and that an integrated approach gives teachers better insight into the quality of pupils' knowledge (78.2%). Also, 81.9% of the students plan to use integrated approach in their future work and 78.2% find an integrated approach interesting. Pre-service teachers are aware that the use of an integrated approach requires teachers to invest additional effort and time in preparing for teaching (83.6%), and that they need to work constantly on their professional development (78%). Still, we cannot neglect those students who were not sure or who disagreed with those statements.

As for the items A4 and A6, the values of coefficient of variation indicate that students' attitudes are heterogeneous. Although the majority of students (61.8%) disagreed with the statement that teachers should not be additionally overloaded with the request to use an integrated approach, there is a significant percentage of those who agreed with this (27.3%) and those who were not sure (10.9%). A little bit more than half of the students (52.7%) disagreed with the statement that it is not possible to evaluate students' knowledge of separate subjects during integrated activities. Almost one third of the students were not sure (29.1%) and 18.2% agreed. All these indicate that special attention should be dedicated to the introduction of an integrated approach in teaching.

We determined that there was no significant difference among different achievement groups in MTS and MTA courses. However, we found that there was significant difference concerning the achievement in the MTM course for Item A2 ($\chi^2 = 14.167$, $p = 0.003$). Students with moderate grades found the use of an integrated approach more interesting than students who still did not pass the exam ($p = 0.003$). This is not surprising if we take into account the fact that students who did not pass the exam in MTM, MTS or MTA courses cannot teach during practice.

Conclusion

Raising the quality of teachers' work is one of the prerequisites for improving the quality of education. Apart from appropriate qualifications, it is necessary to train teachers for the modern concept of teaching. Therefore, the main aim of our research was to examine the current state among final year pre-service teachers concerning the use of an integrated approach in teaching. We investigated attitudes of student teachers towards the use of an integrated

approach as well as their self-reported teaching competencies. The results obtained by this research show that student teachers self-reported teaching competence for using an integrated approach in teaching, in general, indicates a high level. Nevertheless, although these future primary teachers believe that they have the necessary theoretical content and pedagogical knowledge and skills about the integrated approach, they report a moderate level of ability to use the integrated approach in practice. Results show that the attitudes of student teachers with regard to the use of an integrated approach in teaching are positive and relatively the same and homogeneous. However, there is no total agreement among student teachers about the evaluation of pupils' knowledge during integrated activities. Also, student teachers have different attitudes about the statement that teachers should not be additionally overloaded with the request to use the integrated approach. There were no differences among different achievement groups in MTS and MTA courses, but we found a statistically significant difference concerning the achievement in the MTM course for one of the items. Students with moderate grades in MTM course find the use of integrated approach more interesting than students who still did not pass the exam.

In order to make the application of the integrated teaching model in practice efficient, it is necessary to train students, future teachers, in the system of university education for its implementation. There is no current, appropriate course in the curricula of teaching and pedagogical faculties in Serbia that prepares students for the methodical application of the content of several teaching subjects in teaching in an integrated manner, that is, there is no course that approaches teaching as a process. The results of this study indicate the need for adequate training of future teachers in initial education, since the implementation of an integrated approach has become a mandatory part of the curriculum and teaching in primary schools.

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