DOI: 10.46793/STREAM25.181B
UDC: 316.644:[371.213:811.111
37.091.3::811.111

STEM APPROACH FOR 21st CENTURY SKILLS AND INTERDISCIPLINARY DEVELOPMENT – EFL TEACHERS' ATTITUDES

Tamara Bradonjić*
Faculty of Education, University of Kragujevac, Jagodina, Serbia
PhD Student

Abstract: STEM education is an approach that has affected all countries of the world in recent years. The study aims to explore English as a foreign language (EFL) teachers' beliefs about the potential of the STEM approach to contribute to interdisciplinary and 21st-century skills development in teaching EFL in primary and secondary school education. It deals with EFL teachers' attitudes towards the relevance of the STEM approach for moving from de-contextualized use of technology in learning towards a learning flow that fosters engagement with digital experiences in a way that can develop students' cooperation, critical thinking, autonomous learning, and their mindset growth. The participants of the study were 45 EFL teachers working both in primary and secondary schools situated in various regions in Serbia. This paper describes their attitudes towards the relevance of the STEM approach in primary and secondary education on the basis of quantitative and qualitative data obtained through teachers' questionnaires. The results show how positive attitudes of EFL teachers toward the STEM approach can effectively support students' development of interdisciplinary connections and 21st-century skills. Findings are discussed with regard to teachers' level of education, place of work, and years of experience intending to reveal their awareness and knowledge of professional skills required for possible application of this approach and to indicate relevance for using the STEM approach in primary and secondary school education. This study concludes by listing the benefits of the STEM approach summarized by primary and secondary EFL teachers in Serbia on the basis of their experience in implementing the STEM approach in the primary and secondary school curriculum.

Keywords: STEM approach, interdisciplinary connections, 21st-century skills, primary and secondary school education

INTRODUCTION

Contemporary knowledge-driven society prospers on scientific and technological revolutions in new technologies, entailing people to constantly engage

* rockygirl81@gmail.com

in its flow (National Academies of Science, 2007). Intending to make it available to everybody and provide them with the required skills for thriving in this new information-oriented and digital society, education in the fields of science, technology, engineering, and mathematics (STEM) is becoming progressively more significant (National Society of Professional Engineers (NSPE), 2013). Mathematics is a part of the cultural inheritance that computes mathematical ideas, demanding work competencies to keep pace with time development (Hedlin& Gunnarsson, 2014). Additionally, people cannot be able to differentiate between mathematical and other knowledge when solving ordinary problems, thus problems cannot be solved without a set of knowledge. It involves a combination of different aspects of knowledge highlighting the need for STEM education.

In the digital area of the 21st century, the STEM concept has gradually taken its place in the educational system encouraging teachers to implement it in their teaching practice. The concept of STEM involves the integration of the four disciplines, i.e. science, technology, engineering, and mathematics into one component (Abdullah et.al., 2017). Moreover, the STEM concept is supported by the integration of 21st-century skills, focusing on a student-centered teaching approach where students work on solving problems through various projects and analytical assignments that require the involvement of critical thinking, collaboration, and cooperation (Breiner et.al., 2012). Practical application in daily life activities is the crucial outcome of the STEM concept in education. Similarly, the learning process involves the activation of social elements and cultural factors just like the physical interaction of students in creating skillful and competitive students ready to become a part of the global world. Gradually, the STEM concept has overtaken educational systems worldwide due to its relevance and dynamics of development raising the awareness of the need for integrating it in teaching practice. Nevertheless, it is mainly in the developed countries that students feel reluctant to take part in STEM activities (Schreiner & Sjøberg, 2007). For that reason, a teacher's role is predominantly relevant in changing students' attitudes towards STEM concepts in education. Moreover, teachers are expected to motivate their students by facilitating the very process of learning with STEM activities and engaging students in STEM. Subsequently, teachers need to be well educated and prepared on how to use the STEM concept in their teaching.

The purpose of this research is to study the teachers' attitudes towards STEM aiming to contribute to the current research by employing a comprehensive method to observe teachers' attitudes towards STEM. Therefore, a questionnaire was used that specifically emphasizes defining features (or key principles) of STEM to measure the attitudes.

The defining features were obtained by systematically reviewing present literature focusing on teachers' attitudes to (1) STEM impact on teachers' role in 21st century skills development, (2) pedagogical aspects in STEM teaching, (3) integrated contextual learning impact on interdisciplinary development, and (4) STEM impact on students' learning. Examining teachers' attitudes about each of these features separately may help focuse exclusively on the factors related to teachers' attitudes toward teaching with STEM. Previous studies were focused on examining aspects linked to teachers' attitudes toward introducing STEM in their teaching practice, emphasizing the connections between the attitudes and professional development (e.g. Han et al., 2015; Nadelson et al., 2013). Nevertheless, there might be other factors like those of individual and contextual nature, affecting the teachers' attitudes toward STEM concepts (Clark et al., 2014). This study aims to discover how teachers of English perceive the role of the STEM approach in contributing to interdisciplinary connections and 21st-century skills development in teaching EFL. Furthermore, it seeks to explore whether there are differences in EFL teachers' attitudes regarding the relevance of the STEM approach for developing cross-curricular connections and 21st-century skills, based on teachers' experience, level and type of education, and type of school they work at.

THE THEORETICAL FRAMEWORK OF THE STEM APPROACH

The necessity for STEM implementation in primary education is now a common acknowledgement of the majority of teachers, even of those who express their concerns, due to a deficiency of acceptable relevant trainings or due to a lack of experience. As stated by Wagner (2008), 21st-century students need the ability to generate new knowledge and apply this knowledge to new situations and problems rather than memorizing existing knowledge. Moreover, based on interviewed business leaders, Wagner identified seven central skills in which students need to develop proficiency: 1. Critical thinking and problem-solving; 2. Collaboration across networks and leading by influence; 3. Agility and adaptability; 4. Initiativeand entrepreneurialism; 5. Effective oral and written communication; 6. Accessing and analyzing information; and 7. Curiosity and imagination (Wagner, 2008). These skills, called "21st-century skills," are a blend of knowledge, skills, literacy, and expertise that students require to achieve success at work and in life (P21, 2015). Considering the popularization of the STEM concept in the 2000s, several STEM educators have performed researchassociated to integrated STEM education (Cervetti et al., 2012; Guzey et al., 2016; Harwell et al., 2015; Lam et al., 2013; Lederman & Lederman, 2013; Roehrig, Moore, Wang & Park, 2012). In spite of many benefits of STEM

integration that have been supported, teachers struggle to indulge in the idea of teaching through an integrated technique.

Studies focused on learning outcomes, sustain that learning science in an integrated way develops students' problem-solving skills, their critical thinking skills, collaboration skills and results in better theoretical understanding. Nevertheless, there are no studies proving that these reported benefits are significantly different from learning science through a single-subject approach or not, so additional empirical support is needed. Furthermore, even when teachers are persuaded of the value of integration, they have restricted knowledge of learning through STEM integration or lack academic knowledge to teach through integration (Ring et al., 2017). The crucial challenges linked with teaching through an integrated manner include: a) teachers' unwillingness to teach through an integrated method (attitudinal) because of absence or limited experiences (Frykholm & Glasson, 2005; Gresnigt, Taconis, van Keulen, Gravemeijer & Baartman, 2014), b) teachers' beliefs that teaching through integrated method demands students' theoretical understanding of central subject content (Estapa &Tan, 2017), c) absence of resources to teach through an integrated method, d) teachers' absence of knowledge and experiences in engineering and technology, and e) lack of time for shared planning (Lederman & Lederman, 2013; Yeung & Lam, 2007). Nevertheless, the mutual suggestion of all these studies leads to the lack of teachers' perceptions of STEM integration supported by inadequate theoretical knowledge and skills for STEM integration. Consequently, EFL teachers feel reluctant to implement STEM in their teaching practice.

On the other hand, Moore (2008) assumes that STEM integration fosters students' motivation, engagement, and interest in STEM careers. Supporters of STEM integration argue that these outcomes are achievable due to the fact STEM integration focuses on students' engagement with real-world problems, enabling students to acquire content knowledge and practices from various disciplines (Moore, 2008). Subsequently, teachers are supposed to develop responsibility towards promoting theoretical knowledge of STEM and to allow their students opportunities for meeting STEM conceptions. To accomplish this, Moore (2008) advocates measuring pre-service teachers' conceptions of STEM together with theoretical knowledge of STEM. Furthermore, such an approach will withstand recognizing possible challenges of pre-service teachers' conceptions of STEM and support their theoretical knowledge related to STEM integration.

PURPOSE AND RESEARCH QUESTION

The present study draws upon prior research on teachers' readiness toward STEM-based contextual learning. The results of the previous research indicate that in some teaching contexts, 97% of elementary school teachers have readiness to implement STEM-based contextual learning and that 97% of them have implemented it in their teaching context (Shidiq & Nasrudin, 2021). The participants involved in the described study were 32 elementary school teachers in Bandung, West Java, Indonesia, coming from 23 different elementary schools. Contextual learning has a focus on the delivery of knowledge relevant to the concept and the student life. STEM-based contextual learning contributes to learning making it more meaningful. STEM learning has been applied at various levels of school, but there are still not many who conducted it in elementary schools (Akaygun & Aslan-Tutak, 2016; Fassa, Tytler, Freeman, & Roberts, 2013; Jho,2016; Madden et al., 2013).

Subsequently, the present study focuses on providing insight into EFL teachers' readiness toward STEM implementation, with a particular emphasis on teachers' beliefs. The total of 45 participants was a mixture of both primary and secondary school teachers coming from various regions in Serbia. In addition, the study examines the relationship between background characteristics, school context, and teachers' attitudes separately for each of the defining features of STEM: a) STEM approach contribution to teacher's role in developing 21st-century skills, b) STEM techniques (project/problem-based learning, inquiry-based learning, collaborative learning, personalized learning, integrated learning, peer teaching, flipped classroom, differentiated instruction, and formative assessment), c) integrated contextual learning impact on interdisciplinary development and d) STEM teaching impact on the students. By examining teachers' attitudes toward each of these characteristics separately, a more detailed analysis of teachers' beliefs toward teaching STEM can be obtained. The specific research question of this study is: How do teachers of English see the role of the STEM approach to contribute to interdisciplinary connections and 21st-century skills development in teaching EFL in primary school education?

RESEARCH METHOD

Sample and Procedure

The aim of this study was to highlight EFL teachers' beliefs about the potential of the STEM approach to contribute to interdisciplinary and 21st-century skills development in the educational school system. The data were collected

by means of a questionnaire and presented in the form of descriptive statistics. An online questionnaire was administered to 45 EFL teachers working both in primary and secondary schools situated in various regions in Serbia between January and March 2024. All the teachers participating in the research formed an accidental convenience sample being members of the online group of EFL teachers – *Reaching English*. Having expressed their willingness to participate in the study, the respondents received the questionnaire by email. The participants were predominantly female teachers (95.6 %) with a mean age between 40 and 50 (66.7%) and an average MA level of education (60.0 %). The largest is the percentage of teachers whose work experience was between 10 and 20 years as EFL teachers (48.9%). With regards to STEM pre-knowledge, 51.1% of participants declared to be acquainted with STEM. On the other hand, in terms of the STEM vision of their colleagues at school, 75.6% of the participants stated they did not know whether they had positive attitudes. The descriptive variables of the participants are shown in *Table 1*.

Table 1: Descriptive statistics of the sample of participants

Variable	Description	Percent
Female	Gender	95.6
Between 40 and 50	Age	66.7
10-20	Years of experience as EFL teacher	48.9
MA	Level of education	60.0
I'm acquainted with STEM	STEM pre-knowledge	51.1
I don't know	STEM vision	75.6
Elementary school	Place of work	82.2

RESULTS AND DISCUSSION

Measures of Attitudes towards the Relevance of STEM

To determine EFL teachers' attitudes toward the relevance of STEM, a questionnaire in alignment with the theoretical framework was developed.[1] Items were created for each of the four distinguished STEM principles: a) STEM approach contribution to the teacher's role in developing 21st-century skills, b) STEM techniques (project/problem-based learning, inquiry-based learning, collaborative learning, personalized learning, integrated learning, peer

[1] The questionnaire for the purpose of this research paper was adapted from: https://www.surveymonkey.com/r/TI-STEM-EN.

teaching, flipped classroom, differentiated instruction, formative assessment), c) integrated contextual learning impact on interdisciplinary development and d) STEM teaching impact on the students. In line with the theoretical framework for teachers' attitudes of STEM, respondents were asked to indicate their level of agreement with these items on a five-point Likert scale (1 = strongly disagree, 2 disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

All items about STEM relevance were formulated as "In your opinion, how could the STEM approach contribute to teacher's role in developing 21st-century skills?", and the items about STEM techniques as "In your opinion, could the following pedagogical approaches be part of STEM teaching?", the items about integrated contextual learning "In your opinion, how could integrated contextual learning have impact on developing interdisciplinary connections?", and the items about STEM impact on students "In your opinion, how does innovative STEM teaching have a positive impact on the following?" The sample items for all STEM principles are shown in the questionnaire.[2] In favor of confirming the validity of the questionnaire, a factor analysis (FA) was performed. All the items for all four scales had values above 0.4 and no items were excluded after the Confirmatory Factor Analysis (CFA). Each of four scales saved the same items which were grouped into new named factors. Moreover, mean values and standard deviations for the four scales had high values (21st Century-Teacher, STEM-Techniques, Learning-Development and Students'-Benefits).

According to the suggested value of Pearson correlation coefficient, scales covary linearly in the following way: the highest linear correlations are between the scales Learning Development and 21 Teachers (r=0.805) and scales Students Benefits and STEM Techniques (r=0.801). The variance of the named scales changes in a linear manner as the variance of the others change. Subsequently, the values of Pearson coefficients are nearest to the suggested value 1, which signifies the positive correlation (*Table 2*).

Table 2: Bivariate correlation with Pearson correlation coefficient

Scales	21 Teacher	STEM Techniques	Learning Development	Students Benefits
21 Teacher	1	0.730	0.731	0.648
STEM Techniques	0.730	1	0.735	0.005
Learning Development	0.805	0.755	1	0.628
Students Benefits	0.648	0.801	0.628	1

[2] The questionnaire: https://docs.google.com/forms/d/1E1aY_-TGj8SJt5Msp2Ve91jIktBDQykkxQNSYMDDfcY/edit

In addition to Levene's T-test of equality and indicator of significance, a few items in each of all four scales reached statistical significance according to the gender variable. In the scale 21 Teacher, two items out of nine had F values less than 0.05 and the marked values from the original table are extracted and shown in the *Table 3*. Alternatively, the scale STEM Techniques had three items statistically different. Levene's T-test was proceeded according to gender variable *(Table 3)*.

Table 3: Levene's T-Test with equality of means (F-test statistics, t- and p-Significance)

Scales with items	F	t	p
Scale 21Teacher			
A teacher can provide constructive feedback to students and uses assessment data to adjust teaching strategies as needed	1.147	0.966	0.494
A teacher can establish and maintain a positive and inclusive classroom environment conducive to learning	1.117	0.792	0.562

Table 4 shows the standardized regression weights, p values and explained variances of the five different regression analyses. Data Analysis SPSS software (version 17.0) defined the predictor variables most suited to explain the variance in teachers' attitudes via regression analysis for all four STEM principles. Standardized regression proves the results based on the model with 71% of the variance explained according to the adjusted r^2(r^2=71). Furthermore, predictive variables *21 Teacher, place of work, gender, STEM vision, age, level of education, knowledge about STEM, Students Benefits, years of experience as EFL teacher, Learning Development* can predict EFL teachers' answers for the dependant variable *STEM Techniques*. The relationship between teachers' contextual characteristics and their beliefs differs depending on the STEM scale. While teachers' beliefs in *Learning development* reached statistical significance (p = 0.019, standardized coefficients beta= 0.34 and standardized error= 0.226) just like in *Students Beliefs* (p=0.000, standardized coefficients beta=0.504 and standardized error=0.104)other background characteristics had values far above the desired value toward the dependant variable STEM Techniques. In addition, three background characteristics had negative standardized beta coefficients: age, level of education and knowledge about STEM. However, these variables had positive values in terms of standard error (*Table 4)*.

Table 4: Standardized regression weights, p values, and explained variances of the five different regression analyses

Model	Unstandardized Coefficients B	Stand. Error	Standardized Coefficients Beta	t	Sig
Background characteristics Constant	4.006	6.508		.616	.542
TS_Learning_Development	.557	.226	.340	2.463	.019
TS_Students_Benefits	.463	.104	.504	4.448	.000
STEM vision	.908	1.166	.073	.779	.442
Gender	.531	2.328	.019	.228	.821
Age	-.904	1.175	-.092	-.769	.447
Years of experience as EFL teacher	.031	1.087	.003	.028	.978
Level of education	-.397	.721	-.053	-.550	.725
Place of work	.250	.706	.036	.354	.730
Knowledge about STEM	-.261	.751	-.034	-.348	.214
TS_21_Teacher	.180	.142	.175	1.265	.586

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1113.023	10	111.302	11.828	.000[a]
Residual	319.955	34	9.410		
Total	1432.978	44			
Dependent variable: Stem_Techiques					

MAIN FINDINGS

The emphasis of this study was on exploring EFL teachers' attitudes on the role of the STEM approach in contributing to interdisciplinary and 21st-century skills development in primary school education. Prior research was focused on STEM-based contextual learning questioning teachers' readiness to implement STEM-based contextual learning, resulting in 97% of participants in other studies who have implemented it in their teaching context (Shidiq & Nasrudin, 2021). Therefore, this study specifically examined the relationship between the participants' background characteristics, level of education, place of work, and years of experience, and their attitudes toward teaching STEM.

Namely, the participants of the study were mainly female teachers. This does not diminish the relevance of the results. The EFL teachers working both in primary and secondary schools are predominantly females in the Serbian educational system. Speaking of experience, the participants working between 10–20 years prevail just like those holding MA degrees. The data is relevant for evaluating other results and discussing the participants' attitudes towards STEM relevance. Participants who are primary EFL teachers are predominant in this study and their attitudes towards STEM prove their awareness and knowledge of professional skills required for the possible application of this approach and to indicate relevance for using STEM approach in primary school education. One participant states:

> *I put a lot of work into the realization of my ideas that are student, reality, and time-driven, I do not put much effort into the writing procedures of plans or objectives, that can stand in the way of my creativity in the classroom. Programs can provide boundaries that keep teachers stuck and in stagnation. Education is progress, which depends on students' needs, interests, and goals. A teacher's inner desire to help the student maximize his/her potential is the most important effort to put in the process of teaching.*

The results of FA demonstrate that the participants consider all the items relevant for all four scales due to the values (all the items remained high values after CFA). Another participant clarified:

> *I put a lot of effort and my students enjoy innovations in the classroom. It takes a lot of planning and materials and it's time-consuming, but it's worth it because the effects of the STEM approach are far more practical and lasting than teaching with traditional methods."*

This statement correlates with the item *A teacher can establish and maintain a positive and inclusive classroom environment conducive to learning* which reached statistical significance (*Table 4*). The results of Pearson correlation coefficients prove the significance of teacher role (21 Teacher scale) on students' progress (Learning Development scale) as well as the dependence of the two (*Table 2*). In addition, students may highly benefit from the STEM approach in teaching (the positive correlation of Students Benefits and STEM Techniques). The majority of participants stated they put a lot of effort into the process of implementing STEM teaching in primary school curriculum which proves their awareness that the STEM concept should be supported by the integration of 21st century skills, focusing on a student-centered teaching approach where students work on solving problems through various projects and ana-

lytical assignments that require the involvement of critical thinking, collaboration, and cooperation (Breiner et.al., 2012). On the other hand, a minority of participants working in secondary schools believe that their students have low potential for the STEM concept, as stated by one EFL teacher:

> *I have students who have zero STEM affinities, let alone abilities, and who still cannot grasp basic mathematical operations. I try to include problem-solving and critical thinking as much as possible and to enhance their IT skills asking them to use certain applications for project group and individual assignments.*

Standardized regression results prove that predictive variables *21 Teacher*, *place of work*, *gender*, *STEM vision*, *age*, *level of education*, *knowledge about STEM*, *Students Benefits*, *years of experience as EFL teacher*, and *Learning Development* can predict EFL teachers' answers for the dependant variable *STEM Techniques*. Furthermore, EFL teachers' attitudes about *STEM Techniques* can be valued primarily according to the attitudes about Learning Development and Students Benefits and less based on other variables. However, due to the small sample, the possibility of drawing generalized conclusions is low. In order to generalize the results, a bigger sample is needed.

CONCLUSION

Significance

As previously mentioned, this study aimed to explore EFL teachers' beliefs about the possibilities of the STEM approach in regard to interdisciplinary and 21st-century skills development in teaching EFL in primary and secondary school education. The results confirm that their beliefs about professional development are positively linked to teachers' attitudes toward all key principles, whereas several other variables are positively correlated with attitudes toward one or two key principles. The findings of this study are significant since they provide insight into the possible obstacles to the successful implementation of STEM education. The prior research results indicate that in some teaching contexts, 97% of elementary school teachers are ready to implement STEM-based contextual learning and 97% of them have implemented it in their teaching context (Shidiq & Nasrudin, 2021). However, this study was focused on contextual learning with an emphasis on the delivery of knowledge relevant to the concept as well as the student life.

The results of the present study further refine the previous findings. Experienced teachers especially struggle with inquiry-based learning and personalized learning. Therefore, these results indicate that professional development

targeted at improving (attitudes toward) specific key principles and adapted to a person's background experience could be more useful than general professional development for improving teachers' attitudes and ultimately the implementation of STEM. In addition, by using a differential approach to examine teachers' attitudes, the research results also suggest possibilities for improving specific aspects of teachers' attitudes toward STEM. Professional development and access to technical resources are particularly important for improving teachers' attitudes toward the STEM concept. These findings are valuable, as they allow school administrators to pinpoint specific shortcomings in their school's current implementation of STEM and explicitly target these aspects.

REFERENCES

Abdullah, A. H., Hamzah, M. H., Hussin, R. H. S. R., Kohar, U. H. A., Abd Rahman, S. N. S., & Junaidi, J. (2017). Teachers' readiness in implementing science, technology, engineering and mathematics (STEM) education from the cognitive, affective and behavioural aspects. *2017 IEEE 6th International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, IEEE, 6–12.

Akaygun, S., & Aslan-Tutak, F. (2016). STEM Images Revealing STEM Conceptions of Pre-Service Chemistry and Mathematics Teachers. *International Journal of Education in Mathematics, Science and Technology*, 4(1), 56. Available at: https://doi.org/10.18404/ijemst.44833

Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012). What is STEM? A discussion about conceptions of STEM in education and partnerships. *School Science and Mathematics*, 112(1): 3–11.

Cervetti, G. N., Barber, J., Dorph, R., Pearson, P. D., & Goldschmidt, P. G. (2012). The impact of an integrated approach to science and literacy in elementary school classrooms. *Journal of Research in Science Teaching*, 49(5): 631–658.

Clark, L. M., DePiper, J. N., Frank, T. J., Nishio, M., Campbell, P. F., Smith, T. M., & Choi, Y. (2014). Teacher characteristics associated with mathematics Teachers' beliefs and awareness of their Students' mathematical dispositions. *Journal for Research in Mathematics Education*, 45(2): 246–284.

Estapa, A. T. & Tank, K.M (2017). Supporting integrated STEM in the elementary classroom: a professional development approach centered on an engineering design challenge. *International Journal of STEM Education*, 4(6): 1–16.

Fassa, S. M., Tytler, R., Freeman, B., & Roberts, K. (2013). STEM: Country comparisons. Report for the Australian Council of Learned Academies. *The Australian Council of Learned Academies*, 178.

Gresnigt, R., Taconis, R., van Keulen, H., Gravemeijer, K., & Baartman, L. (2014). Promoting science andtechnology in primary education: a review of integrated curricula. *Studies in Science Education,* 50(1): 47–84.

Guzey, S. S., Moore, T. J., Harwell, M., & Moreno, M. (2016). STEM Integration in Middle

School Life Science: Student Learning and Attitudes. *Journal of Science Education and Technology*, 25(4): 550–560.

Han, S., Yalvae, B., Capraro, M. M., & Capraro, R. M. (2015). In-service teachers' implementation and understanding of STEM project-based learning. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(1): 63–76.

Harwell, M., Philips A, Mareno, M., Guzey S. S., & Moore T (2015) A study of STEM assessments in Engineering, Science, and Mathematics Assessments for elementary and middle school students. *School Science and Mathematics*, 115(2): 66–74.

Hedlin, M., & Gunnarsson, G. (2014). Preschool student teachers, technology, and gender: positive expectations despite mixed experiences from their own school days. *Early Child Development and Care*, 184(12): 1948–1959.

Jho, H. (2016). An analysis of STEM / STEAM teacher education in Korea with a case study of two schools from a community of practice perspective. *Eurasia Journal of Mathematics, Science & Technology Education*, 12(7): 1843–1862.

Lam, C. C., Alviar-Martin, T., Adler, S. A., & Sim, J. B. (2013). Curriculum integration in Singapore: teachers' perspectives and practice. *Teaching and Teacher Education*, 31: 23–34.

Lederman, N. G. & Lederman, J. S. (2013). Is it STEM or "S & M" that we truly love? *Journal of Science Teacher Education*, 24(8): 1237–1240.

Madden, M. E., Baxter, M., Beauchamp, H., Bouchard, K., Huff, M., Ladd, B., & Plague, G. (2013). Rethinking STEM Education: An Interdisciplinary STEAM Curriculum. *Procedia - Procedia Computer Science*, 20: 541–546.

Mariani, A. & Ismail, Z. (2013). Pengaruh Kompetensi Guru Matematik Ke Atas Amalan Pengajaran Kreatif. *2nd International Seminar on Quality and Affordable Education (ISQAE 2013)*, 181–187.

Moore, T. J. (2008). STEM integration: Crossing disciplinary borders to promote learning and engagement. Invited presentation to the faculty and graduate students of the UTeach Engineering, UTeach Natural Sciences, and STEM Education program area at University of Texas at Austin, December 15, 2008.

Nadelson, L. S., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfiester, J. (2013). Teacher STEM perception and preparation: Inquiry-based STEM professional development for elementary teachers. *The Journal of Educational Research*, 106(2): 157–168.

National Society of Professional Engineers. (2013). Science, technology, engineering, and mathematics education. (NSPE Position Statement No. 1768). Available at: https://www.nspe.org/sites/default/files/resources/

P21- Partnership for the 21st Century Learning. (2015). *Framework for 21st century learning*. Available at: http://www.p21.org/storage/documents/P21_framework_0515.pdf

Ring, E.A., Dare, E.A. Crotty, E. A., & Roehrig, G.H. (2017) The evolution of Teacher conceptions of STEM Education throughout an intensive professional development experience, *Journal of Science Teacher Education, 28* (5): 444–467.

Roehrig, G. H., Moore, T. J., Wang, H. & Park, M. S. (2012). Is adding the E enough? Investigating the impact of K-12 engineering standards on the implementation of STEM integration. *School Science and Mathematics*, 112(1): 31–44.

Schreiner, C., & Sjøberg, S. (2007). Science education and youth's identity construction—

Two incompatible projects? In: D. Corrigan, J. Dillon, & R. Gunstone (eds.), *The Re-Emergence of Values in the Science Curriculum*, Rotterdam, The Netherlands: Sense Publishers, 231–249.

Yeung, S. Y. S. & Lam, C. C. (2007). Teachers' conception of curriculum integration: a problem hindering its implementation in Hong Kong. *Education Journal*, 35(2): 109–144.

Wagner, T. (2008). Rigor redefined. *Educational Leadership,* 66(2): 20–24.