# Teachers Professional Development Framework: Challenges and Achievements Implementing E-Learning Course for STEAM

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**Abstract**

*The study aims to present the main challenges and achievements, which we faced seeking to implement teachers' professional development framework for the STEAM with educational robotics integration in MOOCs. The Erasmus+ project "Fostering STEAM Education in Schools (EDUSIMSTEAM)" WP2 conceptual and empirical results were used in this research.*

*The study consists of three stages: at first, a comprehensive framework for teachers' professional development in STEAM was designed; second, an e-learning environment together with the curriculum for e-learning course was prepared; third, piloting of e-learning course, evaluation, and improvement was conducted in MOOCs.*

*Following the comprehensive literature review, we were able to identify 13 components that are crucial for STEAM teacher professional development: six main components and seven supporting components.*

*The curriculum was developed: Unit 1. Introduction to integrated STE(A)M teaching & relevant teaching methods; Unit 2. STEAM subjects and how STEM careers are contextualized at school; Unit 3. Subject-specific details for teachers; Unit 4. Robotics.*

*Although 466 K12 teachers from Spain and Turkey expressed interest in attending this e-learning course, but only 129 trainees were awarded certificates. For the course evaluation we used qualitative and quantitate methods. The piloting was conducted in Spain and Turkey.*

*In this study was used systemic and comparative literature analysis; for the piloting of the e-learning course evaluation were used qualitative and quantitive methods.*

*The main challenges of this study are related to a holistic approach for the teachers' professional development seeking to reflect the 21st-century needs implementation. As the biggest achievement, we can emphasize the conceptual framework implementation in the STEAM for educational robotics in e-learning course.*

**Keywords:** *Teacher Professional Development, E-Learning, Curriculum Development, MOOCs, STEAM, Educational Robotics*.

## 1. Introduction

Effective education for future generations relies heavily on appropriate teachers' preparation. Thus, ensuring that young learners acquire essential 21st-century skills necessitates substantial investment in the professional development of educators. Investing in teachers' professional development not only enhances the individual competencies of young people but also contributes significantly to the overall advancement and efficacy of educational systems in every country where these changes were implemented.

The endeavour to incorporate the STEAM (science, technology, engineering, arts, and mathematics) approach encounters diverse challenges. Integrating STEAM across different disciplines prompts a reconsideration of teaching methods and pedagogies, the adaptation of instructional practices to contemporary educational landscapes, the development of innovative and engaging curricula, the integration of technology, and the redefinition of the roles of both learners and educators, among other considerations.

With the integration of A into the STEM subjects, we involve such components as arts. This aspect event raises more challenges: how to be creative in the STEAM field. Robots can be assessed as an art element, which inspires students to adopt their creativity. Since the use of robots in the classroom increases student engagement and benefits, traditional teaching methods are being replaced with more creative and efficient ones. Students learn in a more tangible and understandable way when they are able to handle and manipulate various robotics kits for real-world problems solutions.

This study presents the Erasmus+ project "Fostering STEAM Education in Schools" (EDUSIMSTEAM) aimed to promote an effective STEAM approach in education and to develop appropriate teachers' skills and curriculum. During the project WP2 was developed a framework for teachers' professional development in STEAM; was designed e-learning environment together with the curriculum for e-learning course; was organised e-learning course piloting, assessment and improvement.

In this study was used systemic and comparative literature analysis; for the piloting of the e-learning course evaluation were used qualitative and quantitive methods.

## 2. Literature Analysis for Teachers Professional Development Framework

### *2.1. Study Analysis*

In order to prepare an appropriate Framework for Teachers' Professional Development in STEAM with educational robotics, the analysis of existing models was conducted with the purpose to identify the key elements.

One of the main models – Digital Competence Framework for Educators (DigCompEdu) – highlights how important it is for instructors to develop their professional competencies as educators, often known as pedagogical or learners' competencies, and how important these skills are in the STEAM field [1].

The Model involves the main domain and sub-domain. The Main domain emphasizes the importance of professional engagement, digital resources, teaching and learning, assessment, empowering learners, facilitating learners' digital competence. Sub-domains disclose digital competencies, subject-specific competencies, and transversal competencies as educators and learners' competencies.

A Highly Structured Collaborative STEAM Program: Enacting a Professional Development Framework [2]. In the context of educational robotics, the approach seems to ignore teachers' abilities to use certain technological tools, digital tools, and learner preferences. According to [3], using computational tools and activities in mathematics and science classes helps students understand these subjects more realistically and better prepares them for careers in these professions.

In this A Highly Structured Collaborative STEAM Program the design and development involve a common vision and design, targets, individual and organizational; the implementation phase involves whole group engagement, classroom implementation and four phases of active implementation; evaluation related to the design, contexts, cycles, connections, measures and assessment, outcomes; research involves teacher's capability to measure of these components.

Kolb's Experiential Learning Cycle as a Base of Teacher Training Framework [4,5]. In this framework, the capacity to reason abstractly and break down broad viewpoints into smaller parts shows correlations with computational thinking [6]. In this model four phase were emphasised such as abstract conceptualizing, active experimenting, concrete experience, reflexive observation.

In STEM-driven conceptual model [7], [8] such components were emphasized as pedagogy driven activities, technology-driven processes, knowledge transfer channels, educational learning outcomes.

As well we involved such theories and models as the Meaningful Learning Model [9] and Activity Theory [10, 11] in our analysis [12].

### *2.2. Framework*

Based on the literature analysis and using layered learning design provided by Boyle (2009) was developed the framework [13]. The framework consists of two circles (Fig 1).

The first cycle covers the main elements of the STEAM-driven Learning Content (curriculum) and involves pedagogy-driven activities, educational environment (tools, STEAM content library, etc.), knowledge transfer channels, technology-driven processes, learning outcomes, and etc. The elements of the first cycle are connected by the arrows which show direction to one and another side.

The second cycle involves instructional elements such elements as voluntary work, a community of learning, steam learning types, digital assessment, STEAM competencies, observable outcomes, learners identity and needs.

The important aspect that the Framework for Teachers' Professional Development in the STEAM field, includes learner's (students) role and related to students / learners preferences, needs that impact learning motivation and identity [12].

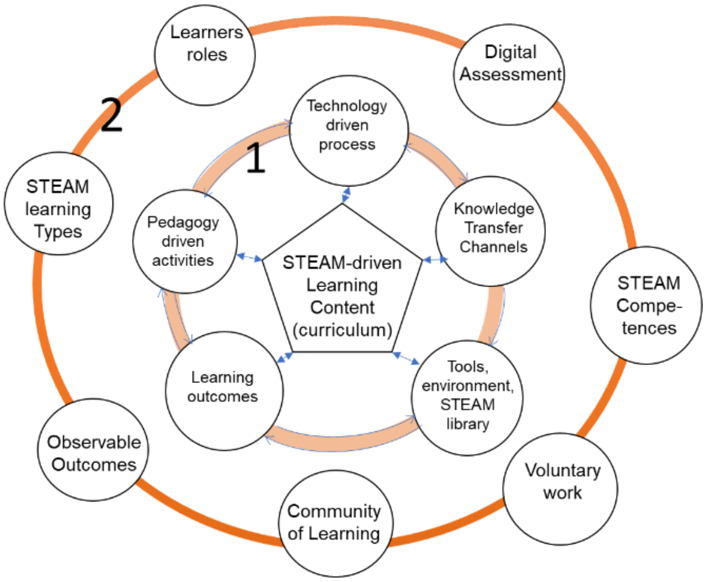


**Fig. 1.** Proposed Framework for Teachers Professional Development in STEAM: 2CSTEAM.

In this section was proposed the Framework for Teachers' Professional Development. The main challenge in this stage was to identify essential components appropriate in STEAM.

In the next part, the e-learning environment together with the curriculum for e-learning course will be presented.

## 3. E-learning Course Design

### *3.1. Curriculum development*

In order to build appropriate teachers skills and promote an effective STEAM approach, the 4 weeks training course was designed (Fig 2).

The first unit "Introduction to integrated STE(A)M teaching & relevant teaching methods" provides a main understanding of STEAM essence and the difference between STEAM and STEM. The second unit "STEAM subjects and how STEM careers are contextualized at school" gives knowledge on how to build authentic STEAM scenarios and lessons, how to adopt students' knowledge assessment methodology and models. The third unit "Subject-specific details for teachers", gave knowledge how to create scenarios for a particular course. The learners had to create scenarios and upload them for the assessment. The fourth unit "Robotics in practice" provided "hands on activities". The tasks were proposed in three levels: basic, intermediate and advanced.


Fig. 2. STEAM curiculum with the integration of educational robotics.

### *3.2 E-learning Environment*

The course design in MOOC (Moodle) aimed to provide learners with access to learning materials and ensure the assessment of their knowledge.

Designed the e-learning platform, the elements from Framework for Teachers Professional Development in STEAM where integrated (Table 1).

**Table 1.** First cycle components implementation e-learning course.

| No | Model components | Components |
|---|---|---|
| 1 | STEAM driven content curriculum | 4 week e-learning course about STEAM with educational robotics integration |
| 2 | Pedagogy driven activities | Pedagogical approaches (inquiry-based, project-based)<br>Motivation (mentors supervision, help, support)<br>Assessment (H5P assessment tool integration, Bloom's taxonomy) |
| 3 | Technology driven activities | Software and hardware (Unit 4. Arduino / Thinkercad; Moodle environment) |
| 4 | Knowledge transfer channels | Capability to upload the curriculum to teachers personal Moodle and to use it personal course |
| 5 | Tools, Environment, STEAM library | Discussion forum; Page; Book; 4 H5P interactive presentations; Files and URL |
| 6 | Learning outcomes | Assignments results; Questionnaire; Certificate |

The correlations second cycle components with the e-learning content were identified as well ICIST.

Before the piloting trainings trainees received foundational information about the MOOC (Moodle), including guidance on navigation, progress tracking, review status of learning materials, completion of tasks, and avenues for discussing course-related challenges. Learning resources and activities were structured to automatically register completion based on predefined conditions, such as viewing, answering questions, submitting results, and fulfilling activity requirements, with practical tasks requiring manual marking as completed.

## 4. Empirical Research

### *4.1. Methodology*

Examining the e-learning course using the Framework for Teacher Professional Development in STEAM . The target group of this study was learners (teachers) in Turkey and Spain, who took part in a project piloting.

It is noteworthy that the training sessions were conducted during the COVID-19 pandemic and were structured in several stages. Initially, the mentors reviewed and analyzed the training content. Following their reflections and suggestions, the training materials were refined. Subsequently, K-12 teachers were invited to register on the platform and engage in the training.

In the course "STEAM Course Oriented Toward R-Learning" were enrolled 466 trainees (teachers) Spain and Turkey. 129 trainees received certificates. 227 of trainees from 252 completed the questionnaire. The participants were required to respond to closed-ended questions as well as binary and Likert scale questions, ranging from 1 = strongly disagree to 7 = strongly agree.

In this research participated 157 (69 %) females and 70 (31 %) males. The highest number of respondents 109 (48 %) work in secondary school; in primary school 39 (17%); teacher in training 39 (17%). In this trainings participated as well English language teachers, teachers of children with special needs, teachers of vocational studies, preschool assistant principal, higher education teachers, creative drama engineering, vocational training teachers, science teachers for gifted students, and etc.

The training in Turkey was organised between the 27th of September 2021 and the 25th of October 2021; the training in Spain was conducted between the 3rd of November 2021 and the 5th of December 2021. In both countries the piloting trainings were organised on the Moodle platform (https://steam.eba.gov.tr/).

We collected quantitative data via survey at the end of course. Approximately 466 trainees attended the course, and 227 trainees filled out the questionnaire to complete the course.

Mentors reflections where observed using qualitative methods. From Turkey participated 18 mentors and from Spain and 24 mentors.

### 4.2. Quantitative Research Results

In this part, we will present the main results related to STEAM course integrating educational robotics assessment.

165 (73 %) respondents answered 'Yes', the platform was easy to use, but 62 (27 %) of the respondents answered "No". This answer directed us to the E-learning course improvement.

101 (44%) respondents answered "Yes" they take a break from the course, 126 (56%) learners answered "No". This number shows that the curriculum required previous preparation and knowledge.

To the question "what was it simple to use the platform?" 165 (73%) of the trainees answered "Yes", 62 (27%) of the trainees "No".

To the question "Did you have clear instructions on how to navigate through the platform? 146 (64%) of the trainees answered 'Yes', and 81 (36%) of the trainees answered "No".

To the question "Did you feel like learning how to use the platform took time away from your training?" 124 (55%) trainees answered "Yes", 103 (45%) trainees answered "No".

According to Fig. 3 the course provided knowledge to respondents "STEAM teaching scenarios creation" 143 (62%) got knowledge, STEAM knowledge of teaching 141 (61%), STEAM knowledge 129 (56%), knowledge of robotics integration into the subject 122 (53%), and participants got some other knowledge 15 (7%).

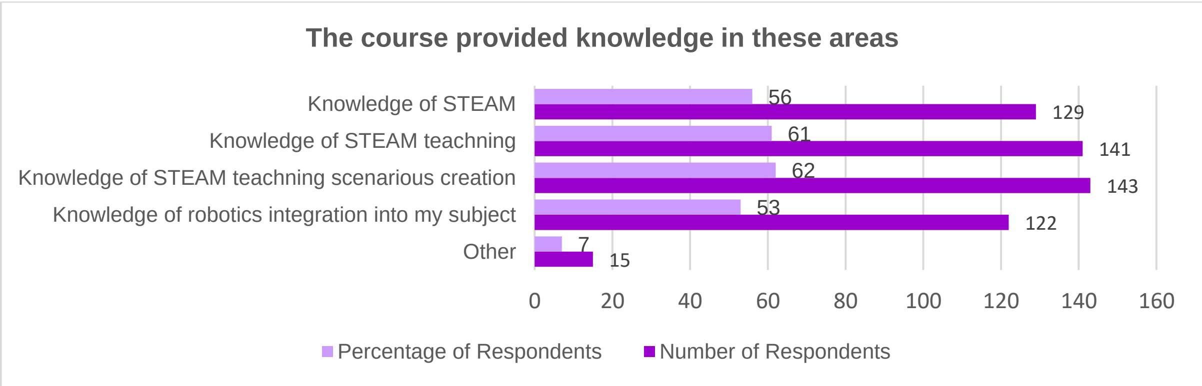


Fig. 3. Main aspects in which course provided knowledge.

The biggest number of respondents 140 (61%) mentioned, that creating ~~of~~ STEAM learning scenarios helped to obtain teaching practice (see Fig. 4). 112 (49) of respondents got knowledge of robotics integration into the subject.

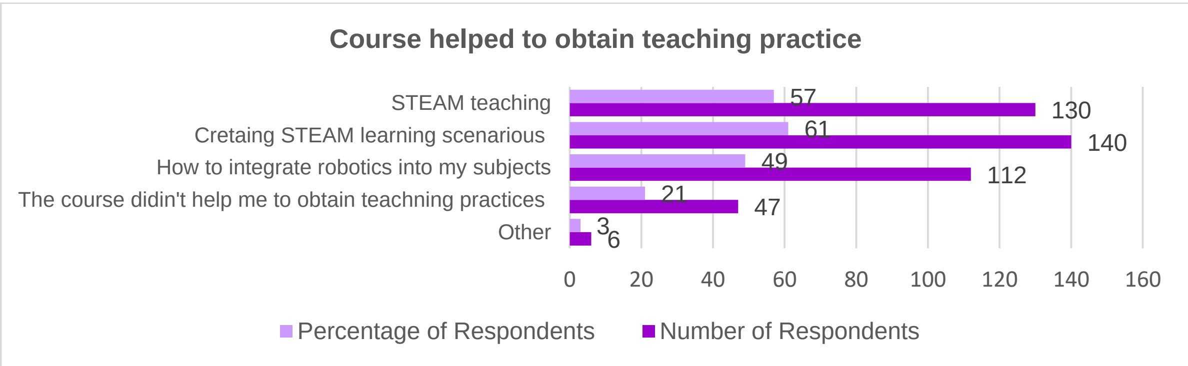


**Fig. 4.** The aspects in which the course helped to obtain teaching practice.

The 64 respondents (28%) the statement "I have gained practical ideas on how I can improve my professional practice in STEAM learning scenarios and robotics" was evaluated with 7 points (Table 2).

**Table 2.** Practical ideas on how I can improve my professional practice in STEAM learning scenarios and robotics.

| I have gained practical ideas on how I can improve my professional practice in STEAM learning scenarios and robotic | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Number of Respondents | 14 | 8 | 23 | 34 | 47 | 37 | **64** |
| Percentage of Respondents | 6 | 4 | 10 | 15 | 21 | 16 | **28** |

The significant problems which prevented from the completing the tasks were named as technical issues (98 respondents, 43 %), time issues and lack of information related on course organisations (71 respondent, 31 %) (Fig. 5).

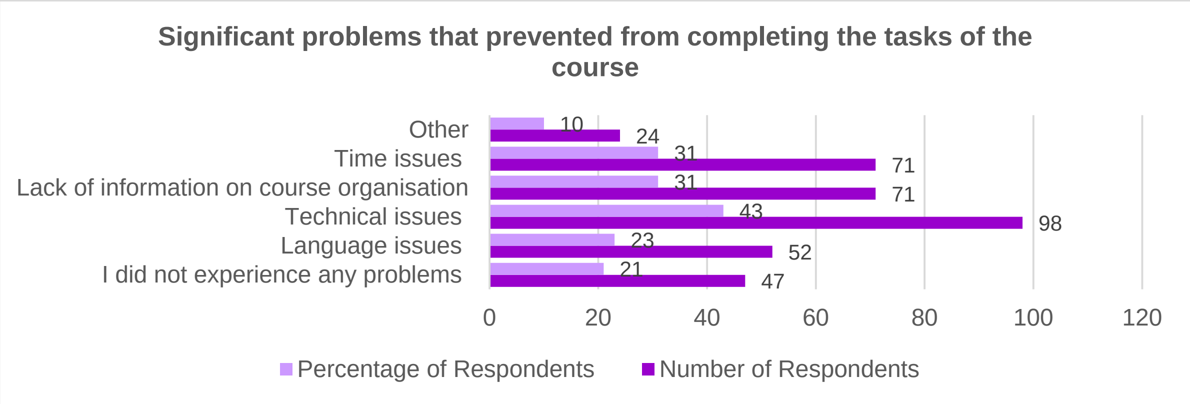


Fig. 5. Significant problems that prevented from completing the tasks of the course.

63 (28%) respondent mentioned that they will recommend the course to colleague or friend (Table 3).

Table 3. The number of trainees who will recommend the course to colleagues and friends.

| I will recommend this course to a colleague or friend. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Trainees Number | 22 | 16 | 12 | 25 | 48 | 45 | 63 |
| Percentage of Trainees | 10% | 7% | 5% | 11% | 19% | 20% | 28% |

The trainees has opportunity to provide suggestions/remarks/reflections related to the training course. 51 (22 %) trainees expressed their gratitude and positive evaluation of the course. Other trainees proposed some suggestions for the improvement.

The main suggestions were related to:

- Adaptation of the content to those who don't have previous knowledge of coding;
- Make the platform easy to use;
- Reduce the duration of the trainings;
- Provide more detailed information, what to do in the platform,
- Provide content for different trainee levels: beginners, intermediates, advanced;
- Ensure appropriate communication.

For education robotics it is necessary to combine tangible and intangible aspects of the learning process to provide appropriate knowledge for the learners.

### 4.3. Qualitative research results

#### *4.3.1. Spanish mentors evaluation results*

In this section, we present the opinions of the Spanish and Turkey mentors about the training course and emphasized the difficulties and strengths of each unit.

The Spanish teachers evaluated every Unit separately. The main remarks related to the e-training course are presented in Table 4.

Table 4. Units evaluation.

| Numer of Units | Difficulties | Strengths |
|---|---|---|
| Unit 1 | Too much information.<br>More practical examples are missed.<br>Some of the materials are too technical for an introduction<br>Focused on secondary education. | The information is really useful for solving the tasks; The platform. It your own achievement; The simplicity of tasks; Forums allows communication with other teachers |
| Unit 2 | Previous knowledge is required; The ideas are not clear enough; Too theoretical; Lack of feedback. | The support of mentoring teachers<br>The theoretical bases are really good with interesting data and information |
| Unit 3 | Previous knowledge is required; More tracking; Video-tutorials for supporting the task performing; Team-work could be included. | Flexibility of working schedule and workload |
| Unit 4. | Programming addressed is not really STEAM; More materials are needed; Modules 3 and 4 would be better face to face; Timing; More feedback and tracking are needed; Lack of awareness of the competences needed for the STEAM approach. | Mind opening content makes teachers think of creating new tasks for the students; Well-designed tasks show the expertise of the creators; The platform it's intuitive and easy |

#### *4.3.3. Turkish mentors evaluation results*

The Turkish mentors answered 7 questions related to the trainings (Table 5). Some of the answers from teachers and mentors contradicted each other. For example, some teachers expressed their opinion that Units 2 and 3 were very complicated for them, but the mentors disclosed that the mentioned units were the most interesting. The mentors had knowledge in the training field; therefore, it was easy for them to accept the content. Some teachers mentioned that they didn't see content related to art integration, but the mentors emphasized that it helped them better integrate art with other disciplines.

**Table 5.** Mentors from Turkey answers to the survey questions.

| No.1 | Question | Positive aspects |
|---|---|---|
| 1 | What aspects of the training do you like most? | Platform is user friendly; The most interesting 2nd and 3rd module; Good interaction; Positive user experience; Refresh knowledge; The difference between STEM and STEAM is well explained; Good examples of learning scenarios |
| 2 | What aspects of the training do you like least? | Interface of the platform can be improved; 1 unit was lacking; Difficult unit 4; More visuals and videos; Section tabs could be horizontal; Expectations for face-to-face training; Switching between pages in the course |
| 3 | What aspects did the training contribute to your teaching practice? | To integrate art better with other disciplines; Some cases shared in the class; Plans to improve the robotics field; Integrate different disciplines; More efficient usage of technology; To include learning models; To remember Arduino |
| 4 | What would you like to change related to training? | Simultaneous sessions; More videos; Face to face trainings; To support course with videos, teachers' explanations; Workshops |
| 5 | What do you suggest for the training platform to be more user friendly? | A gamified interface; Effective usage of uploaded documents; More descriptive steps of education; To open units when the time comes; To extend course time |
| 6 | What was the most challenging issue in this training? How did you deal with it? | Robotics; Technical issues; English language skills; Interface of the course |
| 7 | What was the most motivating issue in this training? | Scratch; Module 4 division into two parts; STEAM content; Course content; Information resources |

## 5. Conclusion and Findings

Seeking to ensure appropriate teachers professional development in STEAM, it is important to apply the holistic approach for Teachers' Professional Development.

During the project “Fostering STEAM Education in Schools (EDUSIMSTEAM)” WP2, after careful literature analysis the Framework for Teachers' Professional Development was justified. The framework consists of two circles.

The project aimed to provide e-learning course for a big number of learners, therefore Moodle was choosen as an appropriate platform. In order to be successful in STEAM with education robotics its important to understand the first environment, i.e. platform characteristics and to give awareness to the learners about the platforms features.

The training content was designed from 4 units and provided conceptual knowledge and practical lessons. The piloting evaluation results disclosed the strength and the weakness of the training course.

The big number of teachers (466) from Spain and Turkey who were enrolled into the training course reflects the need for similar trainings, but just 129 of trainers got certificates. 227 of trainees from 252 completed the questionnaire.

The main challenges in this course were related to the understanding of the transformative teachers role in STEAM landscape and to provide appropriate content to the learners (teachers). During the course, the learners were enrolled in the course by themselves and they were responded by themselves for the results: if they wanted to get certificate, they had to finish the tasks, upload the tasks and to do practical tasks. The importance of learners previous knowledge was emphasized as well, therefore after piloting was made some improvements and Unit 4 training content was divided into three levels: basic, intermediate and advanced. The content in other units was simplified as well.

Another crucial aspect is related to the understanding that robotics kits are tangible and intelligible material, therefore even designing course online its important to take into consideration the users experience aspects and to make lessons as simple, as possible.

The necessity to provide content in different forms was emphasized, therefore the content was enriched by videos.

It was made some improvements of the platform as well: to show the learners’ progress in every stage; provide detailed information about every task, differentiate content according to the levels of learners, ensure the appropriate communication, integrate different types of material, and provide different tools for evaluation.

**Limitations**

The piloting of e-learning course was organised just in two countries Turkey and Spain. The platform piloting in other countries can provide with valuable insights about MOOC design for teachers professional continual development in STEAM Education. However, the other countries can have distinctive needs in STEAM education.

We involved educational robotics as part of A integrating in STEAM, other elements of integration may provide us with broader insights.

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**REFERENCES**

[1] Punie, Y., editor(s), Redecker, C., European Framework for the Digital Competence of Ed-ucators: DigCompEdu , EUR 28775 EN, Publications Office of the European Union, Lux-embourg, ISBN 978-92-79-73718-3 (print),978-92-79-73494-6 (pdf), doi:10.2760/178382 (print),10.2760/159770 (online), JRC107466 (2017).

[2] Bush, S. B., Cook, K. L., Ronau, R. N., Rakes, C. R., Mohr-Schroeder, M. J., & Saderholm, J. A highly structured collaborative STEAM program: Enacting a professional development framework. Journal of Research in STEM Education, 2(2), 106-125 (2016).

[3] Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., &Wilensky, U. De-fining Computational Thinking for Mathematics and Science Classrooms. Journal of Sci-ence Education and Technol-ogy, 25(1), 127-147. DOI: 10.1007/s10956-015-9581-5 (2016).

[4] Kolb, A. Y., & Kolb, D. A. The learning way: Meta-cognitive aspects of experiential learn-ing. Simulation & gaming, 40(3), 297-327 (2009).

[5] Kolb, D. Experiential learning: Experience as the source of learning and development. Pren-tice-Hall (1984).

[6] Selby, C., & Woollard, J. Computational thinking: the developing definition (2013).
[7] Štuikys, V., Burbaite, R., Blažauskas, T., Barisas, D., & Binkis, M. Model for introducing STEM into high school computer science education. The International journal of engineer-ing education, 33(5), 1684-1698 (2017).
[8] Burbaitė, R., Drąsutė, V., & Štuikys, V. (2018, April). Integration of computational thinking skills in STEM-driven computer science education. In 2018 IEEE Global Engineering Edu-cation Conference (EDUCON) (pp. 1824-1832). IEEE.
[9] Jonassen, P., & Peck, K. L. Wilson. Learning with technology: a constructivist perspective (1999).
[10] Engestrdm, Y. Learning by expanding: An activity-theoretical approach to developmental research. Helsinki: Orienta-Konsultit (1987).
[11] Engeström, Y. Making expansive decisions: An activity-theoretical study of practitioners building collaborative medical care for children. In Decision making: Social and creative dimensions (pp. 281-301). Springer, Dordrecht, (2001).
[12] Burbaitė, R., Zailskaitė-Jakštė, L., Narbutaitė, L., Ostreika, A., Urbaitytė, A., Kommers, P., ... & Koç, Ş. (2022, October). Designing MOOC Based on the Framework for Teacher Professional Development in STEAM. In International Conference on Information and Software Technologies (pp. 315-330). Cham: Springer International Publishing.
[13] Boyle, T. (2009, March). Generative learning objects (GLOs): design as the basis for reuse and repurposing. In First International Conference of e-Learning and Distance Education.