
METHODOLOGY FOR THE DEVELOPMENT OF A COMPETENCE FRAMEWORK FOR STE(A)M EDUCATORS

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Abstract

The STE(A)MonEdu Project aims to increase the adoption and impact of STE(A)M education by investing in the community of stakeholders and the professional development of educators. Focusing on the professional development of educators, it aims firstly to compile a competence framework for STE(A)M educators and then design appropriate training offers. In this paper, we first discuss the competency-based perspective, alongside with the related work regarding competence frameworks for STE(A)M education. Subsequently, the proposed methodology for the development of a STE(A)M educator competence framework and profile are described, based on a modified Delphi technique and taking advantage of the European Framework for the Digital Competence of Educators (DigCompEdu).

Introduction

STEM-related careers are considered as “the jobs” of the future; the European Parliament forecasts around 7 million new STEM jobs by 2025 (UNESCO, 2017). However, although students who participate in STEM-related programs may have more experiential learning opportunities, the contemporary advanced world requires much more than a mere understanding of these areas; it requires application, creation and ingenuity. STEAM education allows students to connect their STEM learning with arts practices and elements, design principles and standards so as to have the whole pallet of learning at their disposal (Sanger & Gleason, 2020). However, combining STEM and non-STEM subjects requires a lot of content knowledge for educators. In addition, with the adoption of STE(A)M in classrooms, new teaching methods have emerged, in which educators have multiple roles (e.g. manager, technician, educator etc.).

The EU-funded Erasmus+ project “STE(A)MonEdu: Competence development of STE(A)M educators through online tools and communities” aims to increase the adoption and impact of STE(A)M education by investing in the professional development of all kind

of educators (teachers, trainers, tutors etc.). In this context, STE(A)MonEDU will research how to strengthen STE(A)M education, providing an online environment with an assorted toolset to support the development of an evolving STE(A)M education eco system, where different stakeholders work collaboratively to design, develop and implement STE(A)M educational content, practices, projects and policies. The overall approach of STEAMonEDU is to nominate educators as the pillars of the implementation of STE(A)M education and support their professional development either by blended training or by their participation in a community of stakeholders. In this context, the core project outcome is the STE(A)M Competence Framework (STE(A)MComp), which will detail the competences necessary to design and implement STE(A)M education activities. Based on it, the STE(A)M educator profile will be designed, in which the competencies will be compatible with ESCO (European skills/competences, qualifications and occupations) and the job profile will be mapped to European Qualification Framework (EQF).

In this paper we focus on the STE(A)M Educator Competence Framework, the first result of the STE(A)MonEdu project. At first, the competency-based perspective is discussed, alongside with the related work regarding competence frameworks for STE(A)M education. Subsequently, the proposed methodology for the development of the competence framework together with first results are presented, illustrating the different phased of this process.

Challenges of STE(A)M educators

There is widespread recognition that teaching separate subjects divorced from practical problems and real world practice is not meeting the needs of the 21st century (Xun, Dirk, & Spector, 2015). Therefore, there has been a growing interest in cross-curricular and integrated learning over the past years. STEAM education grew out of STEM educational approach and utilizes the following main pillars: Natural Sciences (S), Technology (T), Engineering Sciences (E), Arts (A) and Mathematics (M). This interdisciplinarity allows for a holistic approach to enhance the cultivation of the skills of educated citizens of the 21st century (Yakman & Lee, 2012). It consists of learning experiences that help students realize how to focus and learn by putting emphasis on logical, mathematical, experimental, and scientific thinking (Bybee, 2013). At the same time, STE(A)M approach enables the recognition of the diversity of learners' learning needs and enhances the teaching of STEM fields, by utilizing common skills in the STEM and Arts disciplines (Allina, 2018). Integrating aspects that emphasize on the arts and humanities can transform the current emphasis on STEM jobs and domain specific skills to inquiry-centred knowledge development appropriate for STE(A)M-based curricula (Xun et al., 2015). In many advanced countries, mostly in United States and Asia, efforts to integrate various STEM disciplines and subjects in curricula at different levels have been recorded (Anisimova,

Sabirova, & Shatunova, 2020). However, these initiatives create the need for an education system reform in order to support STE(A)M education. Better preparation of educators is one of the main challenges of this required reform, because still there is limited consideration of the challenges that educators face in implementing an integrated STE(A)M curriculum effectively (Ng, 2019). Although what an educator needs to know and be able to do in general for effective teaching and learning has been a subject of scholarly research, relatively less effort has been put into articulating the knowledge educators need for effective STEM teaching (Chan, Yeh, & Hsu, 2019).

The results of the a experimental work with future teachers confirmed that support and active implementation of STE(A)M education should be carried out through targeted development programs.(Anisimova et al., 2020). The results of another study (Nadelson et al., 2013) consistently revealed that the participants' years of teaching experience were not associated with knowledge and comfort with teaching STEM or a greater feeling of effectiveness for teaching STEM. Thus, professional development that attends to STEM knowledge may be needed by educators at multiple stages in their careers. On the other hand, the implementation of STE(A)M education is feasible at all levels of education, ranging from pre-school to professional, often in close cooperation and cooperation of educational and extracurricular organizations (Anisimova et al., 2020). Thus, because educators may have different academic backgrounds, the current content knowledge may different, as the result training needs for STE(A)M education may differ based on the educators' characteristics (Spyropoulou & Kameas, 2020). In the literature, there are several works regarding design and implementation of Professional Development Programs for specific topics of STEM or STEAM education (e.g. problem based learning in STEM), mostly for science teachers (Ahmad, Yakob, & Ahmad, 2018; Ring, Dare, Crotty, & Roehrig, 2017), however, little research has investigated variations of STE(A)M education teaching needs and practices by their background characteristics (Park, Byun, Sim, Han, & Baek, 2016). As a result there is a need for further research on educators needs so that they can effectively teach STE(A)M-related courses (Margot & Kettler, 2019; Stohlmann, Moore, & Roehrig, 2012).

A competency-based perspective

A competence is a broad concept that describes individual's ability and it involves a set of knowledge, skills, values and attitudes that is critical in producing key outputs (Yar, Asmuni, Abu, & Silong, 2008). According to U.S. Department of Education "Competency-based strategies provide flexibility and personalized learning opportunities with a better learner engagement due to the content is relevant to each learner and tailored to his/her unique needs" (U.S. Department of Education, 2017). Depending on the strategy pursued, competency-based systems also create multiple pathways to education and help identify

opportunities to target interventions to meet the specific learning needs of learners (Bartram, 2005). This learning method allows learners to acquire at their own pace individual skills that they find challenging, practicing and refining as much as they need and move rapidly to other skills to which they are more adept (Gervais, 2016). Educators' competencies are descriptions of what a qualified teacher/educator should know and be able to do. To maximize student learning, educators must have expertise in a wide-ranging array of competencies in an especially complex environment where hundreds of critical decisions are required each day (Gump & Jackson, 1969).

A competence profile is an assessment tool that consists of a list of tools that an employee needs to possess to be successful in a position. Competence profiles assist in effective learning and development by identifying the behaviours, knowledge, skills and abilities that are necessary for successful performance in a job (Fletcher & Campbell, 2018). Educators' competence profiles are used to promote "best practices", provide educators with a clear focus of goal setting for professional growth and efficiency, and help guide educator training and institutionalization of professional development activities. UNESCO (2009) has developed a competence profile for educators, which includes a description of the necessary knowledge, skills and perceptions with which an educator should be equipped to efficiently integrate different innovative digital technologies and systems in educational practice. The digital technologies that are approached mainly concern technically the use of mobile computing systems and smart boards, while in terms of applications, the effort focuses mainly on the exploitation of Web 2.0 applications for teaching and learning. European Committee for Standardisation (CEN) has developed the European e-Competence Framework (e-CF), which provides a reference of competences applied within the ICT sector, and understood by ICT user and supply companies, ICT practitioners, managers and human resources departments, the public sector, educational and social partners across Europe. In 2016 the e-CF framework has become a European standard for the ICT competences (e-CF, 2016). In addition, European Commission (Redecker & Punie, 2017) has developed the European Framework for the Digital Competence of Educators (DigCompEdu), which describes a set of digital competences that enable educators to seize the potential of digital technologies for enhancing and innovating education. The DigCompEdu framework addresses educators at all levels and forms of education (formal, informal, non-formal).

On the other hand, there is not much literature for educators' competencies and competency profiles for STE(A)M education, especially across Europe. Corbett et al. (2014) in a report from Pennsylvania Department of Education about a Program Endorsement to certify educators, present 19 types of STEM competences that candidates will acquire by completing their program, including the domains of contents, skill and ability,

instructional practice and assessment, as guidelines for the qualifications of STEM education instructors. However, they apply the specific competencies required based on the Pennsylvania School Code and the report did not describe how they were developed and whether their formulation has been validated. Kim and Kim (2016) developed, through behavioural event interviews and literature review and validated evaluation, indicators of teaching competency in STE(A)M education in Korea. The final evaluation indicators of teaching competency in STE(A)M education were composed of 35 items in 7 areas: Understanding of Subjects, Teaching-Learning Methods, Inducing Learners to Participate in Learning, Understanding of Learners, Learning Environments and Circumstances, Evaluation of Learners and Individual Qualification. However, this work focuses on Korean needs and, as the authors commented, these indicators are limited as they did not establish a hierarchy of importance among evaluation areas, criteria, and indicators and further studies to elaborate them are needed.

Methodology for developing a Competence Framework for STE(A)M Educators

According to the National Academies of Sciences, Engineering, and Medicine (2017), although educators are at the centre of education's expansion into integrated STEM approaches, many of the policies shaping education are formed with little to no input from educators (Shernoff, Sinha, Bressler, & Ginsburg, 2017). In addition, during the research on teaching competency, most studies conducted a literature review to establish factors of teaching competency but did not reflect the opinions of educators in the field (Kim & Kim, 2016).

Our methodology utilizes a modified Delphi technique, a chief methodology to construct core competency models (Green, 2014). More specifically, Delphi has been used for the development of competency models and to identify the needs of teaching community in educational research (Tough, 2009). It refers to multiple rounds of surveys, with groups of participants, which are usually geographically dispersed, and allows them to deal systematically with a complex problem or a task, with the use of quantitative and qualitative data. This section presents the different phases of the methodology.

At first, based on the literature review and our research regarding STE(A)M educators' perceptions about challenges, difficulties, training needs and the role of STE(A)M educator (Spyropoulou & Kameas, 2019; 2020), a draft STEAMComp Profile has been developed. The draft profile contains the following areas:

	Areas
1. Content	1.1 Understand STE(A)M Education 1.2 Content Knowledge 1.3 Selecting content 1.4 Creating and modifying content 1.5 Managing and sharing content
2. Teaching and learning	2.1 Teaching 2.2. Design 2.3 Guidance 2.4 Collaborative learning 2.5 Self-regulated learning
3. Organization and Management	3.1 Classroom management 2.2 Content management 2.3 Teaching organization
4. Professional Engagement	4.1 Communication and cooperation 4.2 Professional Collaboration 4.3 Reflective activities
5. Assessment	5.1 Assessment strategies 5.2 Feedback and Planning
6. Empowering Learners	6.1 Accessibility and inclusion 6.1 Active engagement of learners 6.2 Differentiation and personalization

Figure 1.

Currently, in order to validate this proposal version and identify areas of possible improvement, we are designing a questionnaire-driven online survey, in which participants will be asked to answer some self-reflective questions regarding their expertise level in each area, and to share their opinions for the predefined categories and dimensions, by ranking, adding and/or deleting or rewriting them. By analysing quantitative and qualitative data, a revised STEAMComp Profile will be produced. In the third phase, the mapping of each competence with the European Qualification Framework will be designed. A second round of survey, with semi-structured interviews will be carried out (phase four), where participants will discuss about their opinion for the mapping with the EQF, in order to validate and to revise the alignment. Finally, at the final stage of the methodology, a synthesis of the STEAMComp framework and profile will be developed based on the results. Table 1 illustrate the phases of the proposed methodology.

Table 1: Phases for the Development of the STE(A)M Educator Competence Framework

Phases	1	2	3	4	5
Procedure	Literature review, Interviews /focus group	Online survey	Mapping the competence profile with EQF	Semi-structured interviews	Synthesis of STE(A)MComp Framework and profile
Results	Draft STE(A)M Comp Profile	Validation of STE(A)M Comp Profile	Draft alignment of the STE(A)MComp profile with EQF	Validation of the mapping with EQF	STE(A)MComp Framework and profile

Conclusion and Future Work

In this paper, a brief overview concerning the competency-based perspective was presented, in order at first, to identify the challenges of and the current research within this topic for STE(A)M education and then to provide the proposed methodology for the development of the Competence Framework for STE(A)M Educators. We adopted a bottom-up approach, by nominating educators as the pillars of our research, in order to develop a STE(A)M educator Competence Framework. Mapping the required skills and competences a STE(A)M educator needs and investigating how he/she may enhance these skills and competences, will lead to more structured training programs with the broader aim to enhance scientific and technological dexterity in fighting exclusion in the forthcoming technology-intensive society and to develop technologically savvy citizens. This competence framework will be designed following a modified Delphi technique, with five different phases along the example of DigComp for Edu framework, including different competence areas and competences that are compatible with ESCO (European skills/competences, qualifications and occupations) and the job profile will be mapped to European Qualification Framework (EQF).

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