

Towards the Development of a Digital Competency Framework for Digital Teaching and Learning

Petros Lameris
School of Computing, Electronics & Mathematics
Coventry University
Coventry, UK
ab3430@coventry.ac.uk

Nektarios Mousmoutzis
School of Electronic & Computer Engineering
Technical University of Crete
Crete, Greece
nektar@ced.tuc.gr

Abstract—Cognizant use of technology is essential in offering a pedagogically rich, inclusive, creative and equitable digital learning experience to students. Teachers may need to develop digital skills and competencies that would propagate a constructive and cultural inclusive digital learning environment for orchestrating flexible and activity-oriented learning through synchronous and asynchronous learning tools. This study presents a digital competency framework discerned from a qualitative study on teachers' understandings of digital competencies for digital teaching and learning. Thirty-eight (n=38) teachers completed an online questionnaire as means to elicit beliefs on what constitutes digital competency development for digital teaching and learning. The results revealed six (6) digital competencies and associated sub-competencies that may be perceived as a point of departure for teachers to build on new or extend existing competencies. A reflection on implications around digital content, data and information, pedagogy, creativity and inclusion is perpetuated for optimising and leveraging teaching and learning in a connected and networked digital learning ecosystem.

Keywords—digital competencies, teachers, digital literacies, digital education, inclusive digital learning

I. INTRODUCTION

It is evident from school education commentators and European policy digital education reports that digital competencies development is key for teachers to learn and persevere in their journey towards using technologies in education especially during an unprecedented and challenging era we are experiencing with the COVID-19 pandemic. To this end, teachers need to develop existing and new digital skills that would help them to teach in different modes of teaching including blended, distance or face-to-face. There are challenges and risks that teachers need to tackle from different design and teaching orchestration perspectives such as digital resources, quality, equity, ethics, pedagogy and digital inclusion to be considered in rethinking digital teaching and learning. It is recognised that for achieving this, processes, practices, strategies and policies may need to be reinvigorated in a way that teachers would be able to comprehend the skills, competencies, institutional and policy regimes that would render a flexible and open technology-based instantiation of teaching.

As school environments experience digital demands, the capacity and capability for digitally competent teachers requires an increasingly detailed account of what skills and competencies would be relevant to and aligned with practice and context. In particular, the need for adopting approaches to teaching that combine the use of a plethora of digital technologies to deliver digital learning activities is a sine-qua-

non-intervention for helping students to develop their own digital competencies for learning in online or blended learning environments. The overarching question that this research study attempts to address is “What digital competencies and capabilities are increasingly relevant for enabling schoolteachers to design and deliver digital teaching and learning with the use of technology?” We have developed a digital competency framework that may be used by teachers and practitioners alike for reflecting on existing and new digital competencies that are relevant to be constructed and optimised as a means of scaffolding the process of designing and delivering teaching and learning with the use of technology in a plethora of teaching modes commensurate to teachers' ways of teaching.

To situate the study in a context, we start by presenting the background on investigating digital competencies and frameworks for designing and orchestrating teaching and learning. Then we elucidate on the research method adopted, encompassing data collection and analysis for investigating teachers' understandings on what digital competencies would be most likely relevant to them. The results are presented along with a discussion on implications for digital competencies skill development and future research.

II. TEACHERS' DIGITAL COMPETENCIES AND CAPABILITIES

The overarching assumption to investigating digital competencies for designing and delivering digital teaching and learning activities is that the way teachers develop digital skills and competencies may influence student's online or blended approaches to learning. The integration of technology in education has been a wide area of research and discourse in schools, but there are a number of arguments, which support the lack of effort to efficiently intergrade technology with curriculum delivery (e.g. [1]; [2]; [3]; [4]).

Digital competency development may be understood as an inter-connected set of skills or competencies for enabling the design and orchestration of teaching and learning through the use of digital technology [5]. In this study we will use the term digital competency development to align with the European terminology and to uphold consensus with the Digital Competencies Framework (DigiCompEdu) [20]. Different terms have been gauged to denote the development of digital learning skills such as: digital literacy (e.g. [5]), ICT literacy and ICT competence (e.g. [4]) and digital capabilities (e.g. [6]). There is differentiation in meaning when these terms are used from more technical-centred instantiations (e.g. ICT literacy) to more knowledge-centred and integrated (e.g. ICT competence) focusing on the information, knowledge and pedagogical strategies, tools and processes employed to foster learning with the aid of technology (e.g. [7]).

Commentators argue that the purpose of acquiring digital competencies is also distinguished in two types of competencies: (a) for helping students to use ICT in the classroom and (b) for designing a rich mediated ICT-enabled learning environment [e.g. 5, 6, 8]. As a third type of competencies complementing the two, we propose competencies that promote inclusive, creative, meaningful and personalised teaching and learning for ideating, designing, orchestrating, assessing and reflecting on teaching and learning with the use of digital technologies. The third type of ICT competence is in line with the DigCompEdu [20] and it also alludes to the premise that digital competency development should not only focus on how to use technology but also to deliberate how pedagogy and context shape the way teaching and learning is designed, delivered and assessed. This echoes European Commission's view of competence as the twinning of knowledge, skills and attitudes to successfully develop and practice for instigating life-long learning [9]. In turn, this informs European Commission's view of digital competencies as the confident and critical use of Information Society Technology (IST) for acquiring basic skills in ICT as means to retrieve, access, store, produce, present and exchange information and to communicate and participate in online collaborative networks. Decomposing this view, we can distil certain digital competencies as central in teachers' digital competency development. As such, the DigCompEdu identifies 22 competencies categorised in six thematic areas focusing on different aspects of teachers' professional activities.

A. Meanings and understandings of digital competencies

Research studies have attempted to conceive and define digital competencies from different cultural, contextual and socio-technical backgrounds. For example, [2] presented the design of a survey instrument to collect data on how teachers perceive their digital competencies. Instefjord & Munthe, [1] investigated the development of pre-service teachers' digital competencies in Norway and amongst the findings, was that the use of ICT in learning and teaching was not part of the intended learning outcomes in subsequent teacher education programmes making an explicit inference that digital competencies may not be as much emphasised as other areas of professional development. Gunes & Bahcivan [10] conducted a study with 979 science teachers on digital literacy and found that teachers' self-beliefs on and prior experiences of digital literacy skills influence the level of expertise and dexterity on specific digital competencies, and that their overall epistemology for teaching and learning was affected from their digital literacy views. A central digital competency is associated to the creation and use of digital learning resources. Ramirez-Montoya & Mena [11] study aimed to understand teachers' self-perceptions of digital competencies affect in a deeper understanding of how to create and use Open Educational Resources (OERs). Similarly, to [10] study, self-beliefs on previous knowledge, skills and capabilities with technologies influence their level of competency in creating, using and sharing OERs. The study also highlighted the correlation between high-skill competency levels with the ability to create and use digital resources. Garcia-Martin & Garcia-Sanchez [13] carried out a study with 483 pre-service teachers' competencies dimensions of digital literacy and showed a tendency for teachers to use social networks and their desire to further develop their digital competencies by focusing on increasing or updating their knowledge on learning theories, concepts and paradigms as well as

increasing their communication skills. Taimalu and Luik [14] conducted a study about the impact of teachers' beliefs on technology adoption for teaching and learning and confirmed results from previous studies that found teachers with more behaviourist conceptions of teaching held more naïve conceptions of technology integration whilst teachers with more constructivist beliefs of teaching were more likely to have more cohesive conceptions of technology integration.

B. Strategies deployed for digital skills development

Strategies reported in previous studies for developing teachers' digital competencies include digital skills development, instructional development and field experience courses (e.g. [15]). However, there seems to be a disjunction between theory and practice when teachers are participating in such digital skills development courses. Although teachers may learn the theoretical foundations of different technological tools and increase their self-efficacy, there is no evidence that they implement the acquired knowledge into the classroom [16]. To alleviate this discrepancy between theory and praxis, commentators have suggested to change the curriculum content, whilst retaining the structure of the courses, by placing more emphasis on pedagogical, design-like, technological and content problems under the principle of learning-by-design (e.g. [17]) and thereby focusing on creative and hands-on processes and strategies in developing digital skills. A plethora of strategies that could be employed in digital skill development programmes include having trainers acting as role models (e.g. [18]), collaboration and group-work (e.g. [19]), authentic educational technology (e.g. [20]) and meaningful feedback [21]). There is no empirical evidence however on the relationship between digital skill-competencies with more artistic and creative curriculums as a contextual influence to developing digital competencies. It will be pertinent to investigate creative-based competencies teachers may need to develop and how such competencies may help teachers to design and orchestrate digital teaching and learning in more imaginative and creative ways.

III. RESEARCH DESIGN

The aim of this study was to understand how teachers experienced digital competencies for enabling the use of technology in designing and orchestrating teaching and learning. The research question we sought to investigate was: "What are teachers' beliefs, understandings and actions of digital competencies for enhancing teaching and learning with the use of technology?"

We have recruited thirty-eight (n=38) school-teachers for completing a questionnaire as means to elicit views, opinions and conceptions of what constitutes digital competencies development for teaching and learning. All participants were teachers from primary (n=21) and secondary education (n=17) teaching varied topics from science subjects (n=19) to social (n=10) and artistic (n=11) subjects. We were interested in gaining multiple perspectives from teachers with diverse backgrounds and experiences in teaching and learning with the use of technologies and hence permeating rich variations on the phenomenon in question. Twenty (20) participants were male, and eighteen participants were female with teaching experience using technology spanning from one to fifteen years (1-15 years). All participants found it useful to develop digital skills for improving their digital teaching and learning skillsets. Participants sought to demarcate conceptions of digital skills competencies being relevant to

them and to particular teaching context practice therefore we attempted to recruit teachers from diverse geographical locations originating from Sweden (n=10), UK (n=9), Greece (n=14) and Cyprus (n=5).

The data collection process was primarily based through completing an online questionnaire with semi-structured questions designed to encourage participants to highlight and reflect on rich inferences and interpretations of how digital competencies are experienced. The online questionnaire could be completed in 30-40 minutes. Questions were focused on the digital competencies skills that teachers felt important to develop when teaching with the use of technology. For example, questions such as “Could you please explain what do you mean by digital competencies for teaching and learning? To probe specifically on the digital competencies that felt important to teachers, questions such as “What particular digital competency would help you to improve teaching and learning using technology? To follow-up on existing digital competencies that teachers felt they needed to improve or expand, questions like “What aspects of your existing digital competencies you think may be improved as part of your professional development strategy?” To explicitly deriving inferences on the purposes of developing a particular digital competency questions along the lines “What are you trying to achieve by developing this particular digital competency?” would encourage teachers to perpetuate ‘praxis’ in their conceptualisations of the development of specific digital competencies contextualised in practice. All ethical procedures were articulated well in advance before participants started to complete the questionnaire. Ethical considerations such as rights to withdraw at any time, data management and the voluntary nature of participating to this study was explicitly mentioned and required the consent of the participants to be able to engage with the questionnaire.

Data analysis was discerned from a qualitative and data-driven perspective as means to delimit themes of digital competencies as experienced from the participating teachers. We used a qualitative software analysis package for developing and associating codings with meanings, inferences and nuances of varied ways teachers experience digital competencies for technology-enabled teaching and learning. The analysis process started with the primarily analysing ten (10) questionnaires and delineating an overarching set of digital competencies. We then analysed the remaining twenty-eight (28) questionnaires that complemented the initial set with meanings that constituted elements of a particular digital competency and thereby gaining a holistic composition of the perceived digital competency. Although the initial focus was on the qualitative aspects of the digital competency formation, we endeavoured to map the frequency of the digital competencies that were highlighted from the participants as to pinpoint any patterns, occurrences and manifestations that prevailed. Such a symbiosis between patterns and meanings entailed a rigorous and evidenced-based way to highlight digital competencies as experienced, in a holistic way, from the participating teachers.

IV. RESULTS

We present the results of this study on the basis of discerning a set of digital competencies rendered as themes and sub-themes of teachers’ views of how they conceptualised and approached digital competencies for teaching and learning with the use of technology. We elaborate on each them to present the meaning and structure and to contemplate

on the basic principles and characteristics that define the digital competency and the overarching sub-domains that it resembles. We inculcate an overarching focus in each theme and then we perpetuate associated sub-themes that make the periphery of the competency.

Table 1 presents the themes and subthemes of the digital competencies as perceived and understood from the participating teachers along with the number of references that denoted the occurrences of a particular competency and sub-competency across the entire sample. Table 2 shows the each digital competency with representative quotations from the participants concomitant to the meaning and focus of each theme.

TABLE I. THE THEMES AND SUB-THEMES OF TEACHERS’ DIGITAL COMPETENCIES FOR TEACHING AND LEARNING USING TECHNOLOGY

Themes and sub-themes	Number of references
A: Designing, developing and delivering digital content	30
Designing digital content	5
Developing digital content	10
Representing digital content	15
B: Acquiring data, information and media literacy skills	27
Understanding and tracking student’s progress through gathering and analysing data	6
Finding, accessing, using and sharing information	11
Producing and editing digital media	10
C: Developing skills in employing digitally and activity-led pedagogies	27
Collaborative learning	10
Inquiry and problem-based learning	5
Activity and digitally-led assessment	5
Providing multiple modes of feedback	3
Reflection	4
D: Becoming ICT proficient in digital learning environments, devices, applications, software and services	25
Technical use of software and hardware for tracking, recording and representing progress and performance	5
Applying knowledge to solve technical problems with software and hardware	7
Selecting software, hardware and services based on learning and technical requirements	13
Basic understanding of computing, coding and systems thinking	1
E: Developing digital creativity skills, empathy and a do-it-yourself culture	20
Ideating, brainstorming and designing digital learning activities	12
Personalising, sharing and re-mixing digital learning activities	3
Empathising with students needs and interests for a custom activity design	3
Producing tangible digital learning resources	2
F: Fostering student digital inclusion, social influence and relatedness	10
Embedding equal digital learning opportunities into the digital learning environment	7
Acting as role models offering best practice examples in implementing technology	2
Designing digital learning resources that are related to students’ past experiences, feeling and emotions for increasing engagement and motivation	1

A. Designing, developing and delivering digital content

In this theme, digital skills development was focused on content creation and use for digital content access and delivery for students to access. Design of digital content was felt as

important for structuring and determining what and how content will be available to students through a designated digital content system. Designing content was distinctive from developing content in a sense that the teacher first had to learn what content needs to be provided, how it will be visualised and represented, how it will be associated with the learning outcomes, activities, feedback and how it will be sequenced with content, activities and outcomes from different subject topics. Selecting and learning how to use a system focused on storing, using and sharing information and learning material was perceived as a critical digital skill. Designing content was connected with personalising the learning experience to students and therefore, designing content was also associated, not to just mere content design, but also designed in way that would be suited to student's needs and interests and as such the identification of students needs through collecting information on student's prior knowledge, performance and misconceptions was part of the content design process. Active engagement and differentiation were also mentioned as processes that may be achieved and supported by learning how to design digital learning content. Creativity and planning ahead was felt that could be strengthened by learning how to design digital learning content. Developing digital content felt like being a natural continuation of the design phase. Once the design parameters and students' information are consolidated and established, then teachers were putting into practice their design plans to produce digital content considering the properties of the digital content system, the students' level and the mode of teaching. Once the content development phase completed then the representation content stage started as means to deliver, visualise and provide content to students. Protecting sensitive learning content and student's personal information and the processes that need to be followed for ensuring that content is safely created and distributed to students was a high concern in terms of the skills and capabilities needed for creating a secure environment for students to access, retrieve, access and share subject content.

B. Acquiring data, information and media literacy skills

Developing skills, competencies and capabilities to access, find and retrieve data, information and media was a central aspect of digital competency development. Teachers felt that they had to develop their skills on how to find and use information. Learning about current trends in digital teaching through finding online information was also key for keeping abreast with ongoing developments in processes, practices and tools for digital education development. Sharing information about digital teaching with students and other teachers was also perceived as part of being information literate. The use of different media for designing digital learning was perceived as becoming media literate in terms of how different media may be used to attain particular learning dexterities. The essence was to get an understanding of digital media as artefacts for learning and teaching and of digital media production as a way of connecting learning outcomes with particular applied skills. Data literacy was perceived as the ability to track, record and analyse student's performance as means to help students to improve their performance as well as making the necessary adjustments to lesson planning, content, assessment and feedback for tailoring the lesson and topic to student's needs. Data literacy was also viewed as gathering data from research evidence on a subject topic of interest as to present and discuss topics from a research-based standpoint.

C. Developing skills in employing digital and activity-led pedagogies

Key in this theme is having the skills to employ digital pedagogies that would afford the use of technology for digital teaching. Reported pedagogies that may allow for more activity-based learning with the use of technologies included collaborative-learning, problem-based and inquiry-based learning as means to instigate creativity, research and online communities of practice. Activity-led pedagogies were seen as key for enriching teaching strategies but especially in terms of deploying a particular paradigm aligned with personal conceptions of teaching and beliefs about how activity-led teaching may enhance learning with the use of technologies. Developing meaningful assessment and feedback following the principles of activity-led practices and helping students to reflect on feedback received for understanding and applying it for improving performance was key aspect to be developed as part of developing rich-mediated feedback strategies. Pedagogical development in digital teaching and learning was perceived as important, although related with conventional teaching and learning, it required a reinvigoration of teaching is designed and orchestrated to afford the use of digital technologies in more autonomous, self-directed and engaging ways as most of the learning is directed and initiated by students.

D. Becoming ICT proficient in digital learning environments, device, applications, software and services

Central to this category is developing the skills necessary to learn how to use different online learning management systems, software, tools, services and applications related with digital leaning in general and with digital learning activities in particular. Learning how to use specific devices for recording, tracking and sequencing progress was an example of becoming ICT proficient. Applying knowledge to solve technical problems and analysing what are the benefits and challenges for selecting devices or services tied with a specific learning objective was the focus. The capacity to solve technical problems that students are experiencing across platforms, devices tools and services along with basic understanding on computing, coding and systems thinking was highly valued. The general premise was that by having a technical capacity to assist students in technical problems, students would feel confident in using school-enabled technology but also would feel more confident to use or bring their own devices in the school for pertaining intimacy and familiarisation with technology. Teachers felt that adopting such skills would be central in increasing the rates of technology acceptance.

E. Developing digital creativity skills, empathy and a do-it-yourself culture

It was prevalent from participants' responses that there is an internal need to develop skills that focus on digital creativity competences. Ideating, brainstorming and designing activities and lesson plans felt a key creativity skill for aligning student's prior knowledge and experiences to the intended learning activities, feedback and assessment as digital resources to be designed and orchestrated for a subject-topic. It was also perceived that there is room for plenty of editing, personalisation, sharing and re-use / repurposing / re-mixing of learning activities. Participants craved that they had the skills to select and use design for learning authoring environments that afforded the design, orchestration, sharing,

use and re-use of digital learning integrated to their taught curriculum standards. Developing feelings and understandings of what students require whilst considering their learning and personal situations was also felt as a creative aspect in terms of making a conscious effort as part of a holistic and custom-design for learning process. Participants were keen on producing their own digital resources for learning and teaching (digital prototypes, games, simulations, instructional software, widgets, educational robots, tangible interfaces) and being part of the Do-It-Yourself (DIY) and establishing an identity culture and thereby acting as role models for empowering students to emulate DIY for crafting their own tangible products.

TABLE II. DIGITAL COMPETENCIES THEMES WITH REPRESENTATIVE QUOTATIONS

Themes	Representative quotation
A: Designing, developing and delivering digital content	<i>"knowledge in content design "</i> (Teacher 10). <i>"identifying and selecting content"</i> (Teacher 15). <i>"...developing content related to specific technology tools such as whiteboards or a learning management system"</i> (Teacher 09). <i>I want to have skills in designing content that can be delivered through different media like a video, or via slides or through a static animation</i> (Teacher 30)
B: Acquiring data, information and media literacy skills	<i>"To learn how to understand, record and analyse data about students"</i> (Teacher 11). <i>To know how to find and make available information about students"</i> (Teacher 7)
C: Developing skills in employing digital and activity-led pedagogies	<i>"to be able to use collaborative tools for co-creation and solving problems together"</i> (Teacher 02). <i>"I need to give careful thought on how to integrate assessment via using technology"</i> (Teacher 05)
D: Becoming ICT proficient in digital learning environments, devices, applications, software and services	<i>"learning how to use a learning analytics tool, how to track performance how to filter based on parameters and organise them"</i> (Teacher 06). <i>"learning how to select appropriate software and hardware for managing content, learning and student needs"</i> (Teacher 21). <i>"if I don't know how to handle technical issues students will be disengaged"</i> (Teacher 33)
E: Developing digital creativity skills, empathy and a do-it yourself culture	<i>"making the design relational to student interests"</i> (Teacher 12). <i>"creating a bond and a relation to learn habits and then try to apply in the design"</i> (Teacher 38)
F: Fostering student digital inclusion, social influence and relatedness	<i>"Equal learning opportunities should be embedded into the design of digital material, activities, etc"</i> (Teacher 4). <i>"being able to use technology in an exemplar manner might help students to use technology in the same way"</i> (Teacher 18).

F. Fostering student digital inclusion, social influence and relatedness

It was clear from participants responses that the way digital inclusion is fostered is a process that may be inherently designed in the learning content, materials, activities and tools designed and developed by teachers. Digital inclusion was about learning how to design digital learning environments that foster knowledge and learning to students with different backgrounds, learning preferences or to provide the means, adapted technology and choices for students with learning difficulties to learn through using technology alongside with their peers. Social influence is connected with best practice examples of digital technology use from the teacher and other stakeholders (e.g. parents, fellow-students) to act as role

models and scaffolders in implementing technology for digital-based learning. Relatedness is the capacity to help students to be engaged and motivated through relating past experiences, knowledge, places, people or events to current digital learning experiences emanated from the use of technology. The underpinning capability is to design and represent digital learning that is engaging and allows students to be self-directed, autonomous and independent in their learning journey hence would trigger positive memories, feelings and emotions that would likely increase engagement and motivation and thereby learning.

V. DISCUSSION

There is an increasing perception that the extent to which teachers choose to use technology in designing and orchestrating teaching and learning may influence students' perceptions, attitudes and dispositions towards exploiting technology for enhancing their learning experience (e.g. [1], [16], [17]). However, there is a misalignment and disjunction in professional development programmes and digital technology training support sessions on how technology and digital development skills may be conceptualised, supported and cultivated beyond technocentric and linear representations neglecting pedagogical, emotional and socio-cultural aspects that may influence how digital learning may be designed, represented and transferred to different contextual realities.

This study provided a data-driven analysis on and reflection of a digital competency framework (see Figure 1) that may be used from educators and practitioners alike for understanding and acting upon the digital competencies they envisage to practice to contextualised teaching realities. We investigated the research question: "What are teachers' beliefs, understandings and actions of digital competencies for enhancing teaching and learning with the use of technology?" The results revealed six themes of digital competencies along with subthemes that constituted teachers' perceptions of digital competencies from a subjective viewpoint.

The first theme "Designing, developing and delivering digital content" is strongly focused on content with associated variations in terms of designing and delivery content. The emphasis on digital learning content closely resembles other studies that reported the prevalence of creating systems, methods, capabilities and skills for teachers to be able to design and deliver digital learning content to students (e.g. [10], [11]). It is high likely therefore that teacher professional development programs may provide training activities with particular focus on tools, resources and methods that help teachers to develop competencies in designing, creating and presenting content. For example, content-delivery enabled tools such as receiving training on how to present subject content through whiteboards could be a targeted intervention for teachers who may be interested to develop skills in content design and delivery through using whiteboards. In line with [1] digital competence skills in designing digital content via whiteboards received the lowest mean score meaning that teachers had a low competence on how to present content through a whiteboard system and thereby we may argue that this may serve as a barrier for teachers to present and visualise subject content using dedicated learning technology. As part of content design process, it is central for teachers to identify and evaluate a plethora of digital learning resources in terms of their quality as to decide which will be efficient and effective for student's learning. The evaluation and assessment of digital content requires teachers to possess

analytical and high-order skills in digital content evaluation (e.g. [21]). This may have immediate effects on placing particular attention on cultivating digital competencies in relation to digital content evaluation and teachers' technological pedagogical content knowledge as means to design, represent and visualise content.

In the second theme "Acquiring data, information and media literacy skills" there is a prolific digital skill-based understanding inclined to adopt a more data, information and media literacy-based conceptualisation necessary for analysis and processing data, information and media. As such, deconstructing data, information and media to a set of individual and monolithic components that enable teachers to manage, analyse and use data, information and media in more nuanced but also research-based ways (e.g., collecting and analysing data and information on student's performance and then representing data and information via graphs, text, figures, dashboards and other media uncovers a dual set of skills relevant for teachers to master: The first renders the use of data and information as a research-driven skills for understanding and acting upon student's evidence on progress, misconceptions and prior knowledge that can be derived from gathered data and information; and the second is about developing skills that correspond to media literacy, as identified by [5]. The data, information and media skill development aspects were predominantly focused on the acquiring the skill as an individual capability rather as a sociocultural skill in terms of sharing information and data with colleagues as means to reflect on research or media literacy skills with the objective to co-develop such skills with the community.

A central digital competency discerned was "Developing skills in employing digital and activity-led pedagogies" alluding to the significance of developing skills on student-centred and activity-led pedagogies for designing and representing digital teaching and learning. This is in line with [22] as part of creating pedagogical digital skills and alignment with learning objectives, digital learning activities, assessment and feedback and activity sequence. It seemed that there is a connection between activity-based pedagogies and technology integration in terms of adopting teaching strategies and processes that would afford the use of technology systems in a more flexible, open and participatory way. It would be presumed that digital competency development aspects would focus on teacher preparation of making activity-based mediated choices in terms of designing digital learning activities, lesson planning and pedagogical content knowledge based on overarching purposes of teaching using technology [e.g., 15]. Another relevant instantiation of digital and activity-led pedagogy skill development is in conjunction to producing digital learning objects that would integrate a holistic and dynamic activity-led approach providing support to the student digital learning experience. Such digital learning objects could be represented as Open Educational Resources (OERs) via open licenced digital media and thereby granting accessibility to pedagogically rich and specialised material and sustainability of a body of process-based knowledge for digital education, particularly expedient to students attempting to be digitally educated in socio-economically disadvantaged contexts. A rigorous skill competency development on activity-oriented OER design and usage would most likely leverage teachers' digital skills in relation to digital and activity-led pedagogies.

"Becoming ICT proficient in digital learning environments, devices, applications, software and services" denotes the technical orientation and applied interventions that teachers may need to develop as a digital skill competency for resolving simple technical issues (e.g. registering students in a virtual learning environment) to more complex and ill-defined problems such as identifying glitches or addressing troubleshooting in relation to particular digital software or hardware. Pondering on digital skills development from a technical perspective is emphasised as a result of teachers' prolonged experiences in attempting to resolve technical problems without the need of a dedicated information technology in-house specialist team. It seems therefore that there is a predominant skill that would help teachers to provide technical support to students in an instant and rapid way not only in terms of institutional software and hardware but also in terms of personal devices (mobiles, computers, multimedia) that students would choose to use to accommodate their digital learning journey (e.g. [2], [4]). There may be a misalignment however between teachers' experiences of what constitutes technical skills development that students expect from schools and teachers to possess and teachers' own views of technical skills. It may be necessary therefore that a common set of technical skills would be discerned and delimited that would entail common technical problems that students are facing and be resolved promptly by teachers.

Developing creativity skills, empathy and a do-it yourself culture is a digital skill that it is not widely emanated in other digital competency frameworks. For example, in the prominent EU's DigiCompEdu framework [20] there is no direct reference on the premise that creativity, empathy and making are skills that need to be nurtured and developed by teachers and then emulated or mimic by students during a digital learning activity. The essence of creativity as a skill that may be learned and practiced is complex and ill-defined by its nature, but creating a set of capabilities and processes for teachers to be able to embed creativity and empathy in lesson planning and in designing online learning activities to enable a more systematic and viable way for students to understand the importance of being passionate and caring on digital projects and online activities whilst learning how to sustain creative mindsets through making and creating their own prototypes and products. There is a shift from digital natives to digital creatives raise substantial questions in terms "which creativity skills should be prioritised?" and "how do we scale creativity in digital teaching and learning? We have proposed particularly for teachers' creativity skills development to having the capacity to create an environment for students to learn how to ideate, brainstorm and cultivate creative ideas; and to design learning activities that are personalised to student's needs by creating collaborations and partnerships with teachers and peers for producing tangible prototypes and products, especially, but not exclusively, for more engineering and computing oriented subject domains. Encouraging students to create and make simple projects from a single sensor prototype to a fully-fledged electric car will help students to understand the technical nuances but also it will instigate a feeling of achievement, empowerment and care. A teacher therefore may design and carefully implement the process and the structure for the creative activity to engender in the classroom and embroiling the resources, tools,

scenarios and a holistic creative environment for igniting students' creative mindsets.

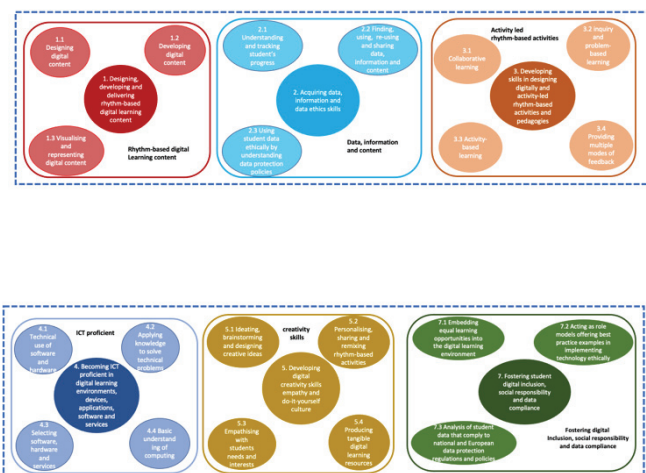


Fig. 1. The Six Digital competencies and relationships with associated sub-competencies

Inclusive and equitable quality education is a top priority for UNESCO's sustainability development goals especially when technology is employed for enhancing learning and teaching in equitable and transparent ways. Fostering student digital inclusion, social responsibility and relatedness is substantial and must be viewed as a priority skill for teachers to master. Learning Management Systems (LMSs) are commonly used as learning environments and require changing perceptions, attitudes, practices and beliefs as to support students' diverse cultural perspectives to be encouraged and reflected upon during the digital learning process. To this end, teachers should have an understanding and expertise in designing learning permeated in LMSs that would respond to and underpinned by student's cultures especially in synchronous and asynchronous communication, interactive content, digital resources and activities. This cultural equity should respect and complement other cultures and would require teachers to be culturally responsive as to create and maintain a collective, situated and dialogic digital learning experience.

VI. CONCLUSION

This study discerned and demarcated a digital competency framework for teachers to develop and reflect existing and new competencies for teaching and learning. The formation of digital teaching and learning competencies is fundamental for teachers that are interested to design and orchestrate practice with the use of technology. This empirically based digital competency framework provides a point of departure for educators at all levels of education who wish to understand and employ a set of digital competency skills in their own context and practice whilst strategically plan their next developmental stage towards their journey into amplifying and optimising methods, practices and processes of enacting teaching and learning with the use of technology. Future research encompasses the design, implementation and assessment of a progression model to help teachers to assess and self-reflect on their digital competencies.

ACKNOWLEDGEMENT

This research study was supported by the Erasmus + KA2 project Rhythm4Inclusion with agreement number 2018-1-SE01-KA201-039032.

REFERENCES

- [1] Instefjord, E.J., and Munthe, E.: 'Educating digitally competent teachers: A study of integration of professional digital competence in teacher education', *Teaching and Teacher Education*, 2017, 67, pp. 37-45
- [2] Svensson, M., and Baelo, R.: 'Teacher Students' Perceptions of their Digital Competence', *Procedia - Social and Behavioral Sciences*, 2015, 180, pp. 1527-1534
- [3] Kay, R.H.: 'Evaluating Strategies Used To Incorporate Technology Into Preservice Education', *Journal of Research on Technology in Education*, 2006, 38, (4), pp. 383-408
- [4] Tondeur, J., Aesaert, K., Prestridge, S., and Consuegra, E.: 'A multilevel analysis of what matters in the training of pre-service teacher's ICT competencies', *Computers & Education*, 2018, 122, pp. 32-42
- [5] List, A.: 'Defining digital literacy development: An examination of pre-service teachers' beliefs', *Computers & Education*, 2019, 138, pp. 146-158
- [6] 'Building digital capability | Jisc'. <https://www.jisc.ac.uk/rd/projects/building-digital-capability> (accessed Nov. 30, 2020).
- [7] Margaryan, A., Littlejohn, A., Vojt, G.: 'Are digital natives a myth or reality? University students' use of digital technologies', *Computers & Education*, 2011, 56, (2), pp. 429-440
- [8] Tondeur, J., van Braak, J., Siddiq, F., and Scherer, R.: 'Time for a new approach to prepare future teachers for educational technology use: Its meaning and measurement', *Computers & Education*, 2016, 94, pp. 134-150
- [9] European Commission: 'Recommendation 2006/962/EC of the European Parliament and of the Council of 18 on key competencies for lifelong learning', *Official Journal of the European Union* 2006, 10, (18)
- [10] Güneş, E., and Bahçivan, E.: 'A mixed research-based model for pre-service science teachers' digital literacy: Responses to "which beliefs" and "how and why they interact" questions', *Computers & Education*, 2018, 118, pp. 96-106
- [11] García-Martín, J., and García-Sánchez, J.-N.: 'Pre-service teachers' perceptions of the competence dimensions of digital literacy and of psychological and educational measures', *Computers & Education*, 2017, 107, pp. 54-67
- [12] Taimalu, M., and Luik, P.: 'The impact of beliefs and knowledge on the integration of technology among teacher educators: A path analysis', *Teaching and Teacher Education*, 2019, 79, pp. 101-110
- [13] Mouza, C., Karchmer-Klein, R., Nandakumar, R., Yilmaz Ozden, S., and Hu, L.: 'Investigating the impact of an integrated approach to the development of preservice teachers' technological pedagogical content knowledge (TPACK)', *Computers & Education*, 2014, 71, pp. 206-221
- [14] Kay, R.H.: 'Evaluating Strategies Used To Incorporate Technology Into Preservice Education', *Journal of Research on Technology in Education*, 2006, 38, (4), pp. 383-408
- [15] Koehler, M.J., and Mishra, P.: 'What Happens When Teachers Design Educational Technology? The Development of Technological Pedagogical Content Knowledge', *Journal of Educational Computing Research*, 2005, 32, (2), pp. 131-152
- [16] Lee, Y., and Lee, J.: 'Enhancing pre-service teachers' self-efficacy beliefs for technology integration through lesson planning practice', *Computers & Education*, 2014, 73, pp. 121-128
- [17] Tearle, P., and Golder, G.: 'The use of ICT in the teaching and learning of physical education in compulsory education: how do we prepare the workforce of the future?', *European Journal of Teacher Education*, 2008, 31, (1), pp. 55-72
- [18] Valtonen, T., Kukkonen, J., Kontkanen, S., Sormunen, K., Dillon, P., and Sointu, E.: 'The impact of authentic learning experiences with ICT on pre-service teachers' intentions to use ICT for teaching and learning', *Computers & Education*, 2015, 81, pp. 49-58
- [19] Ryan, T., Henderson, M., and Phillips, M.: 'Feedback modes matter: Comparing student perceptions of digital and non-digital feedback modes in higher education', *British Journal of Educational Technology*, 2019, 50, (3), pp. 1507-1523
- [20] European Commission. Joint Research Centre., *European framework for the digital competence of educators: DigCompEdu*. LU: Publications Office, 2017.