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T-MOOC for Initial Teacher Training in Digital Competences: Technology and Educational Innovation

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Massive open online courses (MOOCs) are perceived as emerging technologies for training and innovation in the educational context. They have become approaches for distance education in the face of the new challenges, changes, and crises experienced by the COVID-19 pandemic. They represent, in turn, new emerging opportunities as a response to the United Nations recommendations for open education and the development of sustainable goals. The presence of technologies in the development of educational tasks means that the acquisition of Digital Competences (DC) by teachers and students in training goes beyond the mere mastery of content and teaching methodologies. The research presented aims to analyze the educational possibilities of T-MOOCs for the development of DC in teachers, and as resources that favor autonomous and collaborative learning in innovative scenarios. The study sample is made up of 313 students of the Primary Education Degree at the University of Seville (Spain). For this purpose, two online questionnaires (Google Forms) were applied at the beginning of the course: the Digital Teaching Competence Questionnaire (DigCompEdu), and the Content Questionnaire: Digital Resources and Digital Pedagogy. The results obtained show that the students' level of both digital competences and subject content is low to medium, so that training in educational technology is required for the acquisition of key digital competences. Based on the data obtained, the following actions are proposed: (a) The concretion of the contents structured by means of a learning guide and e-activities to be developed by the student body, taking into account the United Nations guidelines with regard to the Development of Sustainable Objectives; (b) The creation of a training and innovative environment under the T-MOOC architecture, based on open and distance learning due to the current health situation of COVID-19, which, on the one hand, empowers students to use digital tools, and on the other hand, facilitates the acquisition of the SDGs; and (c) The evaluation of the T-MOOC designed as a resource for autonomous, collaborative, guided learning in emerging contexts in which technologies and educational innovation play an important role for sustainable development.

Keywords: digital competences, T-MOOC, initial training, educational innovation, e-activities, undergraduate

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INTRODUCTION

The economic, political, technological, social, and educational changes raise the need to look for other ways of: relating, communicating and organizing, disseminating information, generating resources, creating alternative and innovative pedagogical models, with methodologies that deploy other methods that favor the teaching-learning processes. Creativity, knowledge, and technology are key to achieving the SDGs in all contexts. The incorporation of technologies in institutions in general, and in the educational system in particular, involves responding to current demands, requirements and trends. In these transformation processes, higher education institutions play an important role in the promotion of knowledge, the acquisition of competencies, the development of innovation and digital metamorphosis, which invite to adapt to new times, crossing time, and space boundaries (Tang, 2017; Gudmundsdottir and Hatlevic, 2018; Ithurburu, 2019; Martínez-Pérez and Rodríguez-Abitia, 2021).

In this sense, MOOCs (Massive Open Online Courses) emerge from the open educational resources movement (Pilli and Admiraal, 2016), for lifelong learning, and can be seen as a disruptive innovation (Al-Imarah and Shields, 2019) and a technology that have been gaining ground, increasing their practices and transforming teaching and learning processes (Gordon and Wiltrout, 2021). They also emerge as a new pedagogical approach to address diversity and interculturality with the purpose of promoting an inclusion of opportunities for more active participation, and meeting learning needs in an open and distributed way (Boaler et al., 2018; Beltrán and Ramírez-Montoya, 2019; Khalid et al., 2020; Cabero-Almenara et al., 2021b). Moreover, they have the potential to contribute to innovation under pedagogical strategies, enabling co-creation, knowledge acquisition, and fostering professional and competence development (Gudmundsdottir and Hatlevic, 2018; Ruiz-Palmero et al., 2021). As proposed by Kady and Vadeboncoeur (2013), Watson et al. (2017), García-Peñalvo et al. (2018); Zawacki-Richer et al. (2018), Cornelius et al. (2019), and Deng et al. (2020), these can: (a) Generate global learning opportunities, where student participation and engagement are key, (b) Provide access to open and shared content, leading to emergent knowledge; (c) Have a significant impact on Higher Education; and (d) Foster educational quality and instructional design. MOOCs therefore represent an impetus to enhance and promote the 2030 Agenda and the SDGs (Hueso, 2022).

Doherty et al. (2015), Drake et al. (2015), and Raposo-Rivas et al. (2017) pointed out that, for the development of MOOCs and to avoid possible dropout and abandonment, the pedagogical design (autonomy, diversity, openness, and interactivity), which in turn has to be attractive, and the principles by which they are governed (meaningful, engaging, measurable, accessible, and scalable) are key elements that pivot on the students and their learning process; especially when outlining materials, providing resources and planning activities, seeking a shared construction based on autonomous, self-regulated, rhizomatic, situated and collaborative mediated learning, and horizontal communication between peers and teachers (Escudero-Nahón and Núñez-Urbina, 2020). In this sense, the study by Albelbisi et al. (2018) highlights the relevance of taking into account 12 main factors for a successful implementation of MOOCs "earner characteristic with sub -factors (learner demographics, learner motivation, and interactivity), instructor, pedagogy, pattern of engagement, instructional design, assessment, credit, plagiarism, sustainability, learning analytics, student dropout rate, and MOOC quality" (p. 3006).

Taking all these elements into account, it should be noted that MOOCs have resulted in the emergence of several variants: xMOOC (visualized as traditional courses, focused on the acquisition of content by students), cMOOC (referring to connectivism, to the connections that students are able to establish in training environments), hMOOC (hybrid models between xMOOCs and cMOOCs), bMOOCs (combining the advantages of online learning and face-to-face interaction), sMOOC (the "s" of social and seamless, enhancing interactions in learning and without breaks, are constantly accessible), tMOOC (transfer massive open online courses, the participants, through collaborative work, acquire competences to put into practice tools, learning methods, co-evaluations in relation to the theme chosen for their course), and SPOCs (small private on-line courses, maintaining the structure and methodology of MOOCs but with restrictions on the number of students and their access) (Aguayo and Bravo, 2017; García-Peñalvo et al., 2018; Osuna-Acedo et al., 2018; Zhao and Song, 2020; Cabero-Almenara et al., 2021b). In this line, Pilli and Admiraal (2016) performed a taxonomy of different MOOCs according to two dimensions: massiveness (number of participants) and openness (degree of accessibility and flexibility); classifying them into four classes according to these dimensions: (i) Small scale and less open, (ii) Small scale and more open, (iii) Large scale and less open, (iv) Large scale and more open.

Among the MOOC typologies, the tMOOC is selected for this study. These are based on the transfer of learning, pedagogical transformation, and the development of different tasks that students must perform to continue advancing in the course and to be able to demonstrate that they have mastered the competencies that are deployed in the tMOOC (Osuna-Acedo et al., 2018; Cabero-Almenara et al., 2021a). Along the same lines, Pilli and Admiraal (2016) affirm that these types of MOOCs are supported by instructivism and constructivism, whose student body presents an active participation in the educational process. For their part, Albelbisi et al. (2018) point out that a key element of success of MOOCs is evaluation. This assessment becomes a critical variable in this MOOC format so that the subject progresses in the training action (Cabero-Almenara et al., 2021b).

Thus, taking into account the different authors, MOOCs are an excellent strategy for the development of e-activities and the training of future teachers in digital competences under the Digital Teaching Competences Framework "DigCompEdu."

UNESCO (2018) defines a key competence as the "combination of knowledge, skills, and attitudes adapted to the context" (p. 7). Being competent is related to everything that society requires overcoming the obstacles of the time in which it develops; one of the fundamental competencies of today's society

is digital competence. In this sense, teacher training is considered of great importance. For the European Union (2019), a Digital competence "involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (including digital wellbeing and competences related to cybersecurity), intellectual property related questions, problem solving, and critical thinking" (p. 10).

To assess the importance of a Digital Competences Framework for teachers, in the studies conducted by Cabero-Almenara and Palacios-Rodríguez (2020) and Cabero-Almenara et al. (2020) to 179 national and international experts on digital competences, it was concluded that the DigCompEdu Framework was the most highly valued, making it the most suitable for use in the university context, hence its importance and having taken it as the object of study in this research. The study values very positively its pedagogical component, the main advantage over other frameworks. In contrast, the other frameworks analyzed pay special attention to the technological dimension of digital competence, leaving aside the pedagogical competence.

The DigCompEdu framework (Redecker and Punie, 2017; Ghomi and Redecker, 2019) focuses, as shown in **Figure 1**, on three broad dimensions of competencies: educators' professional, educators' pedagogical, and student competences. DigCompEdu is a digital competence model with six differentiated competence areas: (i) Professional engagement, (ii) Digital resources, (iii) Teaching and learning, (iv) Assessment, (v) Empowering learners, and (vi) Facilitating learners' digital competence. Each area has a series of competencies that "teachers must have in order to promote effective, inclusive and innovative learning strategies, using digital tools" (Redecker and Punie, 2017, p. 4). In addition, the DigCompEdu framework proposes six progressive levels of competence: A1 (newcomer), A2 (explorers), B1 (integrators), B2 (experts), C1 (leaders), and C2 (pioneer).

Focusing on the development of tasks by students to continue advancing in the course and to be able to demonstrate that they have mastered the competencies that are deployed in the tMOOC, Cabero-Almenara and Palacios-Rodríguez (2021), taking into account the above, emphasize the need to perform e-activities, defining them as all the tasks developed by the student individually or collectively in a digital environment, whose purpose is the acquisition of specific learning. The difference between virtual and face-to-face activities lies in the possibilities offered by virtual environments, since these can be more motivating and less frustrating, to promote an interactive context between information and participants (students and teachers) (Gómez-Rey et al., 2018); and, in turn, promote reflective and collaborative learning, and acquire the competence of learning to learn (Luo et al., 2017).

Furthermore, Gros (2018) points out the importance of the pedagogical design of the tasks, and states that the success of e-activities will depend on "the student's ability to direct and manage their own learning process, establishing objectives, and appropriate strategies to achieve their goals" (p. 74). In this sense, Maina (2020) lists different types of e-activities to be deployed in MOOCs: (i) Analysis and synthesis, (ii) Research and/or problem solving, (iii) Interaction and communication,

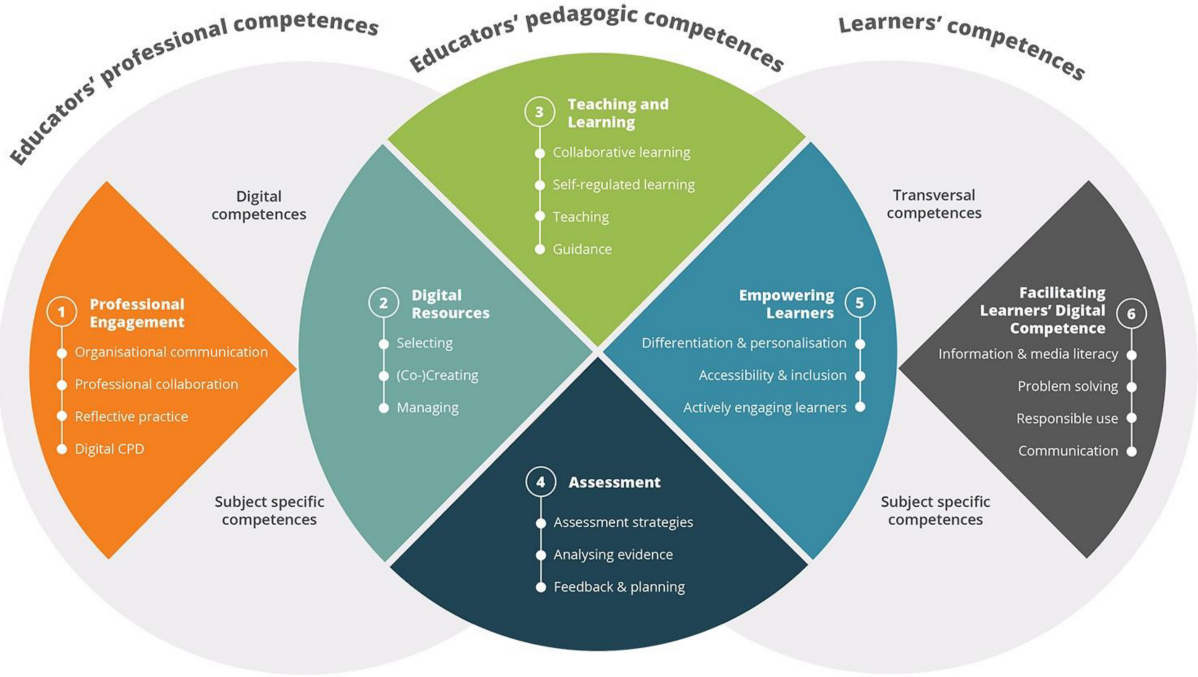

FIGURE 1 | The European Framework for the digital competence of educators (DigCompEdu).

(iv) Collaborative construction of knowledge, and (v) Reflection. In addition, Cabero-Almenara and Palacios-Rodríguez (2021) emphasize the relevance of incorporating meaningful elements for all students, with quality e-activities, designed with technical and pedagogical criteria, adapted to the context.

This paper aims to analyze the educational possibilities of T-MOOCs for the formation of digital competences of teachers, as resources that favor the concretion of the contents structured in e-activities, and the autonomous and collaborative learning in innovative scenarios under the T-MOOC architecture.

MATERIALS AND METHODS

Research Aims

In order to analyze the educational possibilities of T-MOOCs for the development of Digital Competences in teachers, and as resources that favor autonomous and collaborative learning in innovative scenarios. The research objectives being pursued are as follows:

- To analyze the level of Digital Teaching Competence in initial teacher training.
- To elaborate a training proposal to improve the level of Digital Teaching Competence of the trainee teachers.

Participants

The sample was made up of 313 students (23,3%, f = 73 were male and 76,7%, f = 240 were female) of the Primary Education Degree at the University of Seville (Spain), of the basic training course "Information and Communication Technologies Applied to Education," which is taught in the first year of the Degree, second quarter (February–June). The average age of the students was 20 years old.

Data Analysis Procedure

A cross-sectional descriptive research design is proposed that takes into account the participation of the students of the Primary Education Degree. The reliability, discriminate validity, and convergent validity of the Digital Teaching Competence questionnaire (DigCompEdu Check-In) were calculated using the coefficients: Cronbach's Alpha, McDonald's Omega, Composite Reliability (CR), Average Variance Extracted (AVE), and Maximum Shared Variance (MSV). The construct validity of the test was obtained by means of an exploratory factor analysis (EFA). The method used for factor selection is the principal components method. The factors obtained are orthogonally rotated using the Varimax method with Kaiser Normalization. Once the number of factors has been determined, a confirmatory factor analysis (CFA) is performed. Confirmatory factor analysis is used to check whether the theoretical measures of the model are consistent through the modeling of diagrams and the use of structural equations (Ruiz et al., 2010). In other words, it is tested whether the data fit the hypothetical measurement model yielded by the exploratory factor analysis. The method used to test the theoretical model was weighted least squares (WLS), which provides consistent estimates in samples that do not fit normality criteria (Ruiz et al., 2010). For the latter procedure, the AMOS software has been used, capable of revealing hypothetical complex relationships between variables, using structural equation modeling (SEM). At the same time, it has been verified that the data are not normally distributed through a descriptive study in which skewness and kurtosis have been taken into account. The Kolmogorov-Smirnov goodness-of-fit test confirmed this finding, with significance (p-value) equal to 0.000 for all items, a non-normal distribution according to Siegel (1976). Consequently, in response to the first research objective, the means and standard deviations of the questionnaire items, dimensions, and total values are presented.

Instruments

The data collection instruments are Digital Teaching Competence Questionnaire "DigCompEdu" (Cabero-Almenara and Palacios-Rodríguez, 2020) and the Content Questionnaire: Digital Resources and Digital Pedagogy. Regarding the first questionnaire, it is an adaptation of the DigCompEdu European Framework for Digital Teaching Competence analysis instrument validated by Ghomi and Redecker (2019). This competency framework is selected as the most appropriate for assessing the Digital Teaching Competence of university faculty by means of expert judgment (Cabero-Almenara et al., 2020).

The first questionnaire is composed of 7 items/dimensions, which refer to the 2 competency areas worked in the subject: digital resources (3 items) and digital pedagogy (4 items). Each of the items measures the different competencies that make up the competency framework: B1–selecting digital resources; B2–creating and modifying digital resources; B3–managing, protecting and sharing digital resources; C1–teaching; C2–guiding; C3–collaborative learning; C4–self-directed learning.

The instrument lacked analyses to confirm exploratory and confirmatory validity, because this was performed and checked. The exploratory factor analysis (EFA) was used under the maximum likelihood method with varimax rotation. The KMO test (Kaiser–Meyer–Olkin) was 0.924 and Bartlett's test was significant ($p < 0.05$). The final version explained 85.65% of the true variance of it. On the other hand, the confirmatory factor analysis (CFA) showed that the teachers' data fitted correctly to the theoretical model proposed by Cabero-Almenara and Palacios-Rodríguez (2020). The coefficients were correct and respected the thresholds established by Schumacker and Lomax (2004) and Bentler (2006). This model supported the factorial structure formulated in the CFA, formed by two correlated latent variables. The structural equation model was performed with AMOS V.24 software. In addition, the reliability of the selected items was examined through Cronbach's Alpha (α = 0.949) and McDonald's Omega coefficient (Ω = 0.945), for each of the instrument's scales. Both coefficients obtained very satisfactory values.

The values for the different dimensions analyzed through the instrument were also obtained; presenting the results of both Cronbach's Alpha and McDonald's Omega remained sufficiently high and significant. All coefficients are shown in **Table 1**.

The second questionnaire consists of 20 a multiple-choice question (**Table 2**) in which only one option is correct (test).

TABLE 1 | Exploratory and confirmatory factorial results and reliability of the instrument.

Model fit summary	χ^2	*p*	CFI	TLI	IFI	NFI	RMR	RMSEA
	3.014	**0.001**	**0.925**	**0.942**	**0.926**	**0.936**	**0.049**	**0.077**
	Dimensions	**Dim. 1**	**Dim. 2**					
Validity analysis	CR	0.919	0.929					
	AVE	0.798	0.812					
	MSV	0.502	0.552					
Test reliability	α	0.919	0.901					
	Ω	0.929	0.908					

Both instruments were administered online, through the Google Forms platform. The anonymity of the participants is assured at all times. The following links show the general structure of the data collection instruments: https://cutt.ly/IUnEyCg (DigCompEdu Check-In) and https://cutt.ly/5UnEssX (questionnaire content).

RESULTS

The results obtained from the two questionnaires: DigCompEdu Check-In and questionnaire content are shown below. Results that subsequently help, on the one hand, to demonstrate the knowledge, content, and skills acquired by the students of the Primary Education Degree of the University of Seville; and subsequently, to respond to the second objective of this study, to design a training proposal to improve the level of Digital Teaching Competence of teachers in training under the architecture of the T-MOOC.

DigCompEdu Check-In

The results obtained after administration of the DigCompEdu Check-In questionnaire provide the frequencies and percentages (valid and cumulative) (**Table 3**) for each of the items comprising the seven key dimensions: (i) Use different internet sites (web pages) and search strategies to find and select a wide range of digital resources; (ii) Create my own digital resources and modify existing ones to adapt them to my needs as a future teacher; (iii) Able to securely protect sensitive content. For example: photographs, videos, files, exams, grades, personal data.; (iv) Consider how, when, and why to use digital technologies in the teaching-learning process, to ensure that their added value is exploited; (v) Consider the supervision of the activities and interactions of my future students with ICT in my educational proposals; (vi) Consider cooperative work with ICT to acquire and document knowledge in my educational proposals; and (vii) Consider the use of digital technologies to allow my future students to plan, document, and evaluate their learning by themselves.

It should be noted that the first three dimensions are included in area 2 "digital resources/content"; and the remaining four dimensions in area 3 "teaching and learning" of the "Digital competence of teachers in training (DigCompeEdu)" questionnaire. As can be seen in **Table 3**, the results show that in the first dimension, "use different internet sites (web pages) and search strategies to find and select a wide range of digital resources", 38% (f = 119) of the students indicate that they use search engines (e.g., Google) and/or educational platforms to find educational resources; followed by 30% (f = 94) who state that they evaluate and select the digital resources I find based on their suitability for my needs as a student and future teacher. The most significant data is found in the item: "rarely use the Internet to find resources," with only 0.6% (f = 2) of the participants.

As regards the second dimension, create my own digital resources and modify existing ones to adapt them to my needs as a future teacher, the item: "I create digital slideshows. For example: Power Point, Prezi." with 56.5% (f = 177); as opposed to 3.5% (f = 11) and 4.5% (f = 14) of the items: "I create activity sheets with the computer and then print them out" and "I configure and adapt complex and interactive resources," respectively. The third and last dimension within the area "digital resources," able to securely protect sensitive content, we find, as significant data regarding the secure protection of sensitive content, that 31.3% (f = 98) and 31.9% (f = 100), respectively, protect their personal data and their own passwords; only 2.2% (f = 7) indicate that they do not need to do so. This fact leads us to think about the little importance that some students give to pedagogical competencies as future teachers, competencies such as protection, creation and collaboration, and protection, management and exchange of digital content.

In relation to the second area "teaching and learning," the three dimensions to be analyzed are. First, the dimension: carefully consider how, when and why to use digital technologies in the teaching-learning process, to ensure that their added value is exploited, it is striking how only 0.6% (f = 2) do not consider the use or rarely use technology in future teaching-learning strategies; that in contrast, 30.7% (f = 96) and 26.5% (f = 83) consider the use of digital tools as an opportunity to implement innovative pedagogical strategies in their teaching practices, and as key elements to systematically improve their own educational proposals. The results converge with the "teaching" competency of the DigCompEdu framework, "program and implement digital devices and resources in the teaching process to improve the effectiveness of teaching interventions; manage and coordinate adequately digital didactic interventions; experiment with and develop new formats and pedagogical methods for teaching" (Redecker and Punie, 2017; Ghomi and Redecker, 2019).

TABLE 2 | Transfer massive open online courses content questionnaire.

Item/question	Multiple-choice
1. What is NOT a tool used in gamification?	- Kahoot. - Quizizz. - Mentimeter. - Padlet.
2. Among the different possibilities that the teacher has for the use of technological resources, the one that best adapts to the characteristics of the material produced and the needs of the students is the following.	- Imitative. - Creative. - Adaptive. - None of the above possibilities meets the stated objective.
3. What is NOT an emerging educational strategy?	- Gamification. - Cooperative Learning. - Flipped Classroom. - Educational robotics.
4. If I detect a security gap in my context, how should I act?	- I try to work it out for myself. - I do not communicate anything to anyone. - I notify both the university institution and the Data Protection Agency. - None of the above actions is correct.
5. Taking into account your knowledge about the possibilities of technologies and their correct integration in educational contexts, it is interesting that:	- The teacher does not have a large number of technologies at his or her disposal. - The teacher has at his/her disposal a large number of technologies. - The teacher has access to the latest technologies available on the market. - The teacher is an expert in the use of technologies.
6. Among the following programs, which would be the best option if we want to make a collective presentation?	- Google Slides. - Bing. - Microsoft Teams. - Edmodo.
7. The TLK are. . .	- Information and Communication Technologies. - Technologies for Learning and Knowledge. - Technologies for Cooperative Learning. - Technologies for Continuous Learning.
8. In order to carry out the tutorial function, the teacher must rely on different synchronous and asynchronous communication tools.	- True. - False.
9. What is NOT an online collaborative learning environment?	- Moodle. - Blackboard. - Google Classroom. - Mentimeter.
10. Among the basic rules that can help us to mitigate the risks of identity theft are:	- Knowing with whom information is shared, personally investigating the identity of the person with whom I share information, storing and disposing of information securely. - Store and delete information securely, know with whom information is shared, ask questions before deciding to share information, and maintain an appropriate level of security on our devices. - Do not share information as a general rule and know with whom the information is shared. - None of the above options is correct.
11. In order to achieve an effective search, it is advisable to contemplate some rules such as, for example:	- Do not use more than 10 words because some search engines do not consider them. - The order in which you put the words is important. - Generally, search engines do not identify short words, except for "AND" and "OR." - All options are correct.
12. If you intend to search for information on the web about the rankings of soccer teams in the 1979 and 2019 league championships. What term would you place to refine your search?	- Soccer league standings 1979–2019. - Soccer league standings 1979 2019. - Soccer league standings 1979 OR 2019. - Soccer league standings 1979 AND 2019.
13. Which is NOT a blogging tool?	- Blogger. - Blogia. - Weebly. - Blogly.
14. Which is NOT one of the chat planning stages?	- Planning. - Production. - Development. - Completion.

(Continued)

TABLE 2 | (Continued)

Item/question	Multiple-choice
15. What is a characteristic of collaborative learning?	- Individual responsibility of the person in the participation in the project, as well as group responsibility in the acquisition of the objectives and in the configuration of quality educational actions. - Individual responsibility of the person in the participation in the project. - Group responsibility in the acquisition of the objectives and in the configuration of quality educational actions. - Learning is only achieved through interaction.
16. Among the general principles to be taken into account for the selection and use of ICT in education we find:	- The learner is a passive processor of information. - ICTs work in the same way in any context and are not conditioned by it. - ICTs are vicarious transformers of reality. - The main task of the teacher is to find the supertechnology that will help him/her to solve his/her educational problems.
17. When it comes to the curricular integration of any resource, we have to consider:	- Learning objectives, context, pedagogical approach and characteristics of the group of students. - Technical characteristics of the resource, learning objectives, context, pedagogical approach, and characteristics of the learner group. - Learning objectives and technical characteristics of the resource. - Context, pedagogical approach, characteristics of the learner group and technical characteristics of the resource.
18. Bauman (2010) points out that we live in a society that is.	- Modern. - Post-modern. - Liquid. - Liberal.
19. A PLE is.	- Personal Learning Environment. - Personal Development Environment. - Virtual Learning Environment. - Online Learning Environment.
20. What evaluation strategy requires a final version of the program:	- Self-assessment by producers. - Consultation with experts. - Evaluation "by" and "from" the users. - Illuminative evaluation.

In second place, the dimension "consider the supervision of the activities and interactions of my future students with ICT in my educational proposals," the most significant data is found in the item: "regularly consider the intervention with comments to motivate or correct the activity proposed online" with 44.1% (f = 138), compared to the 1.6% (f = 5) found in the item "do not offer educational proposals that contemplate the use of ICT" in contrast to the competence "guidance and support in learning, oriented to: "use digital technologies and services to improve individual and collective interaction with students inside and outside the teaching sessions; use digital technologies to provide relevant and specific guidance and assistance; and experiment with and develop new ways and formats to offer guidance and support" (Redecker and Punie, 2017; Ghomi and Redecker, 2019).

In third place, the dimension "consider cooperative work with ICT to acquire and document knowledge in my educational proposals," yields significant data showing high values for the items "collaborative work proposals, I always contemplate the use of the Internet to find information and present the results in digital format" and "consider the exchange and creation of group knowledge in different online collaborative spaces, e.g., class blog, virtual platform, wiki" with 41.2% (f = 129) and 37.4 (f = 117), respectively. At the other extreme, low values can be found in the response of two students with 0.3% (f = 1), respectively, to the items: "my educational proposals do not contemplate group work" and "I do not feel able to integrate digital technologies in group work." Both participants consider or do not contemplate the importance of group work and, consequently, the added value of collaborative learning; perhaps a first reading could be found in the lack of training of some students to use technologies as part of collaborative tasks and the joint creation of knowledge.

Finally, the fourth dimension, consider the use of digital technologies to allow my future students to plan, document and evaluate their learning by themselves, shows data of 75.4% (f = 236) in relation to the competence "self-regulated learning," in which the importance of using digital technologies to promote and encourage learning processes, where students can plan, document, and reflect on their own learning, is expressed. In this sense, the student body apparently presents certain abilities to share ideas and creative solutions through the use of digital tools. Only 3.5% (f = 11) do not feel trained or qualified to deploy the variety of digital tools available to them.

Table 4 shows the average (m) and deviation (SD) achieved for each of the dimensions analyzed. The values range from 1.96 (basic level) to 3.15 (intermediate level). Specifically, the students present a basic level in the use different internet sites (web pages) and search strategies to find and select a wide range of digital resources; a fact that leads us to think about the relevance of promoting and enhancing competences oriented to

TABLE 3 | Digital teaching competence questionnaire check-in item results (response percentage).

Frequency	Percentage	Valid percentage	Cumulative percentage	
I use different internet sites (web pages) and search strategies to find and select a wide range of digital resources.				
- I advise colleagues on appropriate digital resources and search strategies.	14	4,5	4,5	4,5
- I compare resources using a series of criteria relevant to my needs as a student and my future educational practice. For example: quality, pedagogical fit, design and interactivity.	84	26,8	26,8	31,3
- I evaluate and select the digital resources I find based on their suitability for my needs as a student and future teacher.	94	30,0	30,0	61,3
- I rarely use the Internet to find resources.	2	6	6	62,0
- I use search engines (e.g., Google) and/or educational platforms to find educational resources.	119	38,0	38,0	100,0
Total	313	100,0	100,0	
I create my own digital resources and modify existing ones to adapt them to my needs as a future teacher.				
- I configure and adapt complex and interactive resources.	14	4,5	4,5	4,5
- I create activity sheets with the computer and then print them out.	11	3,5	3,5	8,0
- I create digital slideshows. For example: Power Point, Prezi.	177	56,5	56,5	64,5
- I create and modify different types of digital resources.	74	23,6	23,6	88,2
- I do not create my own digital resources.	37	11,8	11,8	100,0
Total	313	100,0	100,0	
I am able to securely protect sensitive content. For example: photographs, videos, files, exams, grades, personal data.				
- I avoid storing personal data electronically.	61	19,5	19,5	19,5
- I don't need to do that.	7	2,2	2,2	21,7
- I protect some personal data.	98	31,3	31,3	53,0
- I password protect files with personal data.	100	31,9	31,9	85,0
- I protect personal data thoroughly. For example: combining hard-to-guess passwords, encrypting files, performing frequent software updates.	47	15,0	15,0	100,0
Total	313	100,0	100,0	
I carefully consider how, when and why to use digital technologies in the teaching-learning process, to ensure that their added value is exploited.				
- I consider the basic use of the equipment available in the classroom. For example: audio equipment, television, projector, digital whiteboard.	60	19,2	19,2	19,2
- I consider the use of digital tools to systematically improve my educational proposals.	83	26,5	26,5	45,7
- I consider the use of digital tools to implement innovative pedagogical strategies in my future educational proposals.	96	30,7	30,7	76,4
- I consider a wide variety of digital strategies in my future educational proposals.	72	23,0	23,0	99,4
- I do not consider the use or rarely use technology in future teaching-learning strategies.	2	6	6	100,0
Total	313	100,0	100,0	
I consider the supervision of the activities and interactions of my future students with ICT in my educational proposals.				
- I regularly consider the intervention with comments to motivate or correct the activity proposed online.	138	44,1	44,1	44,1
- I occasionally consider the review and keep in mind.	54	17,3	17,3	61,3
- I do not consider monitoring student activity in the online environments we use.	11	3,5	3,5	64,9
- I do not offer educational proposals that contemplate the use of ICT.	5	1,6	1,6	66,5
- I regularly consider the supervision and analyze the online activity of my students.	105	33,5	33,5	100,0
Total	313	100,0	100,0	
I consider cooperative work with ICT to acquire and document knowledge in my educational proposals.				
- I consider the exchange and creation of group knowledge in different online collaborative spaces. For example: class blog, virtual platform, wiki.	117	37,4	37,4	37,4
- I consider searching for information online or presenting results in digital format in my cooperative work proposals.	65	20,8	20,8	58,1
- In my collaborative work proposals, I always contemplate the use of the Internet to find information and present the results in digital format.	129	41,2	41,2	99,4
- My educational proposals do not contemplate group work.	1	3	3	99,7
- I do not feel able to integrate digital technologies in group work.	1	3	3	100,0
Total	313	100,0	100,0	
I consider the use of digital technologies to allow my future students to plan, document, and evaluate their learning by themselves. For example: self-assessment tests, digital portfolios, blogs, forums.				
Sometimes I use, for example, tests for self-evaluation, blog, portfolio. . .	103	32,9	32,9	32,9
- I systematically integrate different digital tools to plan and reflect on progress.	54	17,3	17,3	50,2
- I don't feel qualified to use these kinds of digital tools.	11	3,5	3,5	53,7
- They reflect on their learning, but not with digital technologies.	12	3,8	3,8	57,5
- I use a variety of digital tools to plan, document or reflect on learning.	133	42,5	42,5	100,0
Total	313	100,0	100,0	

TABLE 4 | Digital teaching competence questionnaire check-in items results (Likert scale 0–4).

Item	Average	Deviation
- I use different internet sites (web pages) and search strategies to find and select a wide range of digital resources.	1,96	0,924
- I create my own digital resources and modify existing ones to adapt them to my needs as a future teacher.	2,05	0,961
- I am able to securely protect sensitive content. For example: photographs, videos, files, exams, grades, personal data.	2,38	1,031
- I carefully consider how, when and why to use digital technologies in the teaching-learning process, to ensure that their added value is exploited.	2,67	1,122
- I consider the supervision of my future students' activities and interactions with ICT in my educational proposals.	3,15	0,937
- I consider cooperative work with ICT to acquire and document knowledge in my educational proposals.	3,15	0,776
- I consider the use of digital technologies to allow my future students to plan, document and evaluate their learning by themselves. For example: self-assessment tests, digital portfolios, blogs, forums.	2,66	0,927

The scale of values is between 0 and 4 points, where the values between 0 and 1 represent a low level of competence, 2 and 3 points an intermediate level, and 4 a high level.

the selection, creation, protection, management, and exchange of digital resources and contents. As for the competencies that stand out (intermediate level), they are focused on teaching and learning, and mainly refer to orientation and support in learning, whether autonomous, self-regulated, or collaborative. That is to say, the student body indicates (m = 3.15) that as teachers they have to contemplate and carry out educational proposals using technologies in their teaching-learning processes.

In closing, **Table 5** shows the average and deviation with respect to the level of digital competence in initial teacher training with respect to two key axes: resources and the pedagogical nature of all training.

The table shows that the student body is at an intermediate level in terms of resources (m = 2.13; D = 0.972) and pedagogy (m = 2.91; D = 0.941), Through the implementation of the T-MOOC, the objective would be for students to reach all levels, until they reach a high level (leaders or pioneers) in terms of digital competencies.

Content Questionnaire

The purpose of this questionnaire was to inquire about the students' knowledge of digital resources, emerging educational strategies, and the use and possibilities of technologies in educational contexts in accordance with the contents of the subject "Information and Communication Technologies Applied to Education." And in this way, to design the contents of the T-MOOC for the development of digital competence in teaching, which is presented in the following section.

TABLE 5 | Digital teaching competence questionnaire check-in dimensions and total results (Likert scale 0–4).

Digital kind	Average	Deviation
Digital resources	2,13	0,972
Digital pedagogy	2,91	0,941
Total	2,52	0,957

The answers obtained are shown as a percentage of correct answers (% hits) to the 20 questions asked (**Table 6**).

A high percentage of correct answers was observed in the questions/items: 8 "To carry out the tutorial function, the teacher must have different synchronous and asynchronous communication tools," 95.9% answered correctly; 4 "If I detect a security gap in my context, how should I act?" with 87.6%; 9 "What is NOT an online collaborative learning environment?" with 80.7%; and 11 "To achieve an effective search, it is advisable to contemplate some rules" with 77.9%. In contrast, the questions/items with the lowest percentage of correct answers were 17 (15.5%) "When integrating any resource into the curriculum, it is necessary to consider"; 3 (19.7%) "Which is NOT an emerging educational strategy?"; 2 (28.6%) "Among the different possibilities that the teacher has for the use of technological resources, the one that best suits the characteristics of the material produced and the needs of the students is the following"; 14 (32.1%) "Which is NOT one of the planning stages of the lecture?"; 13 (32.4%) "What is NOT a blogging tool?"; 1 (35.9%) "What is NOT a tool used in gamification?" and 12 "If you intend to search for information on the web about the rankings of soccer teams in the 1979 and 2019 league championships. What term would you place to refine your search?" (36,2%)." The percentage of correct answers for the rest of the items/questions answered by the students ranged from 44.1 to 66.2%.

T-MOOC Design

After obtaining the results from the students of the DigCompEdu Check-In and content questionnaires, and taking into account the responses of the students, we proceed to create a training and innovative environment under the tMOOC architecture. The purpose is to promote the acquisition of digital competences by the teachers, in our case, for the initial training of the teachers of

TABLE 6 | Test results content (% hits).

Item/question	% hits
1. What is NOT a tool used in gamification?	35,9
2. Among the different possibilities that the teacher has for the use of technological resources, the one that best adapts to the characteristics of the material produced and the needs of the students is the following.	28,6
3. What is NOT an emerging educational strategy?	19,7
4. If I detect a security gap in my context, how should I act?	87,6
5. Taking into account your knowledge about the possibilities of technologies and their correct integration in educational contexts, it is interesting that:	51
6. Among the following programs, which would be the best option if we want to make a collective presentation?	54,1
7. The TLK are. . .	66,2
8. In order to carry out the tutorial function, the teacher must rely on different synchronous and asynchronous communication tools.	95,9
9. What is NOT an online collaborative learning environment?	80,7
10. Among the basic rules that can help us to mitigate the risks of identity theft are:	64,8
11. In order to achieve an effective search, it is advisable to contemplate some rules.	77,9
12. If you intend to search for information on the web about the rankings of soccer teams in the 1979 and 2019 league championships. What term would you place to refine your search?	36,2
13. Which is NOT a blogging tool?	32,4
14. Which is NOT one of the chat planning stages?	32,1
15. What is a characteristic of collaborative learning?	64,8
16. Among the general principles to be taken into account for the selection and use of ICT in education we find:	44,1
17. When it comes to the curricular integration of any resource, we have to consider:	15,5
18. Bauman (2010) points out that we live in a society that is.	52,4
19. A PLE is.	65,5
20. What evaluation strategy requires a final version of the program:	44,8

FIGURE 2 | Transfer massive open online courses for the acquisition of digital teaching competencies.

the University of Seville. For this purpose, the platform chosen for the design and development of the t-MOOC was Moodle (**Figure 2**).

To access the T-MOOC, each user is assigned an identifier and a password. Once inside, students are presented with the structure of the course. First, there is a presentation of the course

and the DigCompEdu Framework through two animations: one with instructions on how to proceed through the course, and the other with the DigCompEdu model with its different areas and competencies. After viewing the videos, the different areas are shown (**Figure 3**). Each competency area is composed by its respective competencies and each competency by its corresponding level (beginner, intermediate, and advanced). Each competency with its corresponding presentation for its correct procedure, levels, tasks and forums (**Figure 4**).

The T-MOOC has a diversity of programs (ExeLearning, VYOND, Genially, Photoshop, Adobe Premiere, and Audacity), distributed as follows: two general animations (one with navigation instructions and use of the t-MOOC, and the other on DigCompEdu); 22 animations specific to each DigcompEdu competency; 16 animations integrated in the different learning modules; 66 learning modules, 230 e-activities distributed in the different modules; 24 infographics and 11 multimedia, both resources integrated in the different learning modules.

The presentation of the tasks (e-activities) is done through a guide that incorporates aspects such as: their identification, recommendations for their completion, a checklist for the user to check the quality of the delivery, and an evaluation rubric that is used by t-MOOC tutors.

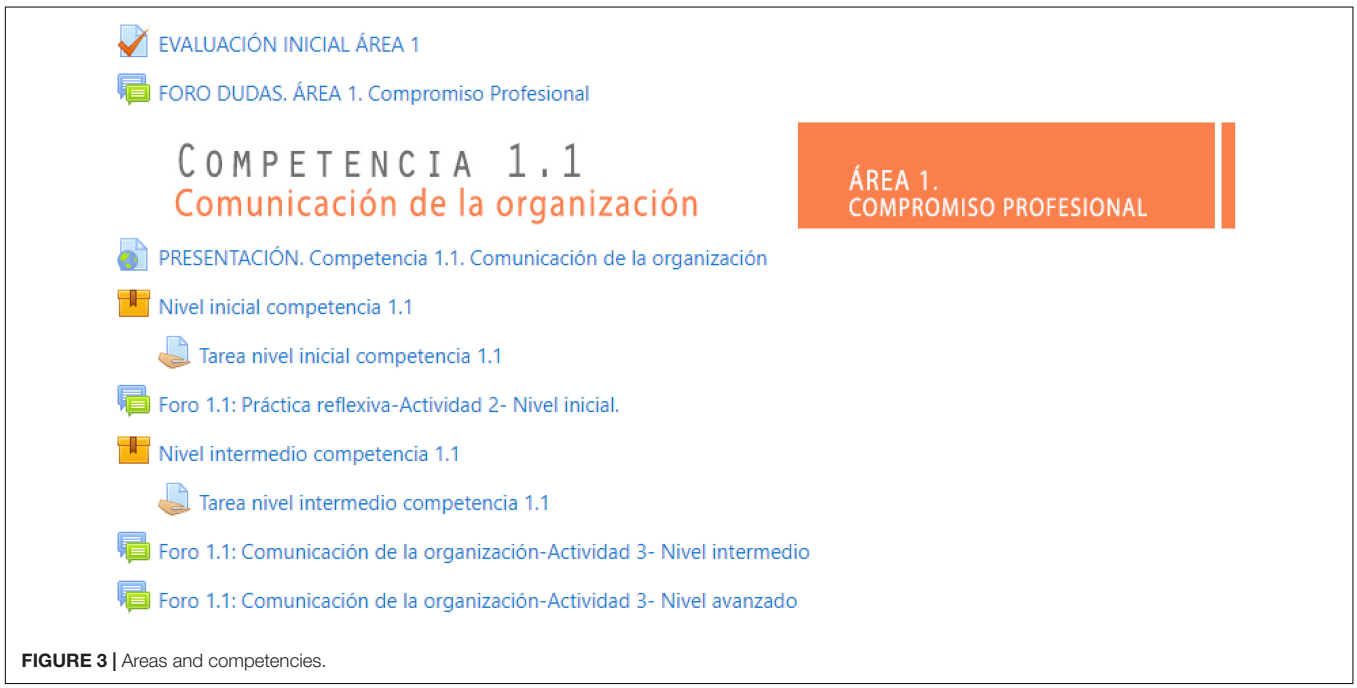

FIGURE 3 | Areas and competencies.

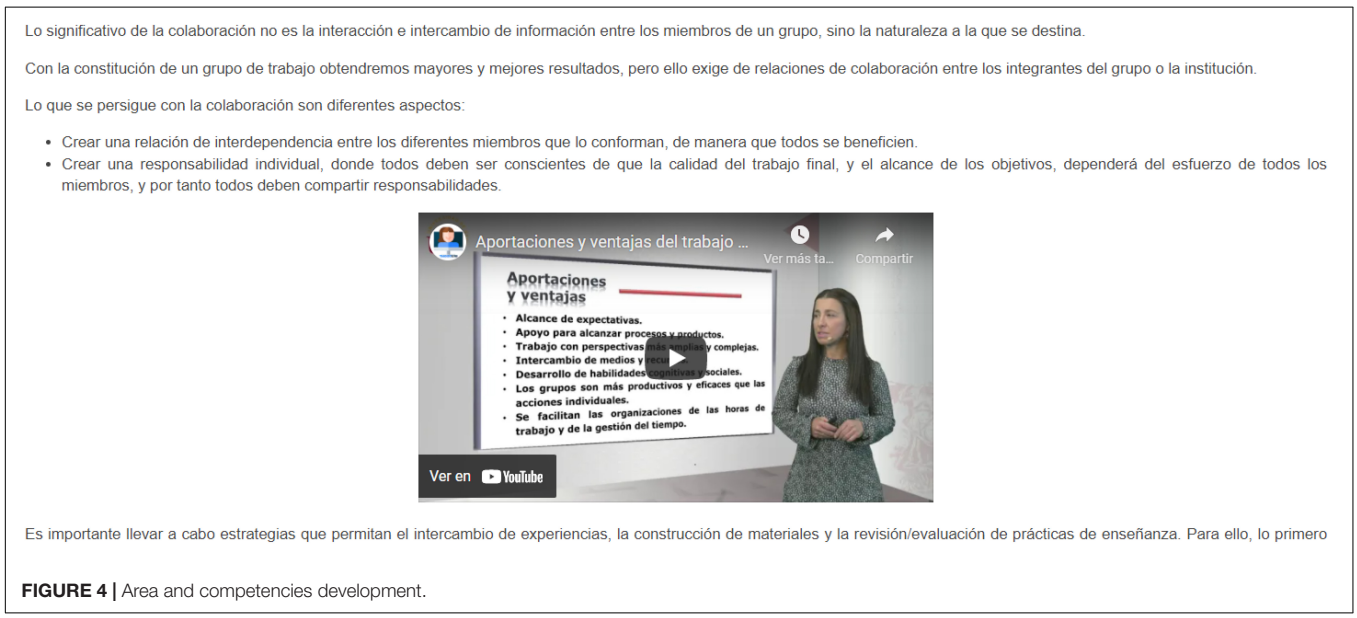

FIGURE 4 | Area and competencies development.

It should be noted that the e-activities proposed are of various types: making concept maps, participating in forums, building a blog, creating a PLE with certain tools, creating learning communities, among others. As for the resources used in the learning modules: didactic animations, polimedia recordings, videos, infographics, web addresses, and complementary documents. In addition, several forums have been designed: for general doubts about how t-MOOC works, for doubts about each competency area and specific forums for activities.

DISCUSSION AND CONCLUSION

Based on the results, we can corroborate those presented by Luo et al. (2017) and Gudmundsdottir and Hatlevic (2018), and which highlight the concern on the part of teachers about their training in digital competencies. The presented research implies a transformation in traditional training and educational structures, methods, and assumptions. This is why, as Cabero-Almenara and Palacios-Rodríguez (2020) pointed out in their research, there is a need to rethink other ways of approaching teacher training in order to promote authentic competence development for the current demands of society.

It should be noted that the period of data collection and the results obtained present an overview of the initial training of future teachers in reference to digital competencies at a time when the pandemic situation generated by COVID-19 led us to teach in virtual mode (February–June 2021). These results are similar to those of another study (Cabero-Almenara et al., 2021a), showing teachers in training with a moderate level (basic-intermediate) in terms of digital competencies (Redecker and Punie, 2017; Ghomi and Redecker, 2019).

In order to analyze the educational possibilities of T-MOOCs for initial teacher training in digital competencies, and as resources that favor autonomous and collaborative learning in innovative scenarios, the results of the different analyses carried out provide answers to the two objectives presented: (i) To analyze the level of Digital Teaching Competence in initial teacher training through the DigCompEdu Check-In and content questionnaires; (ii) To develop a training proposal, under the innovative architecture of the T-MOOC, to improve the level of Digital Teaching Competence of teachers in training.

In relation to the implementation of online courses for teachers, and taking into account the research of Drake et al. (2015), Boaler et al. (2018), Beltrán and Ramírez-Montoya (2019), and Escudero-Nahón and Núñez-Urbina (2020), we consider, after the results obtained from the participating students, that for the acquisition of digital competencies, a change of mentality, methodologies, strategies and pedagogical resources is important; whose principles are the use of the Internet in order to access digital resources and content, networked learning and horizontal communication. And, in turn, they are envisioned as a means of opportunities for effective teaching and for the involvement of teachers in training, as pointed out by Cornelius et al. (2019) in their study; not to mention the entire organizational structure and pedagogical design, as pointed out by Raposo-Rivas et al. (2017) and Gros (2018) in their research. It is hoped that with the implementation of the T-MOOC presented in initial teacher education, the inclusion of opportunities for more active participation will be promoted.

It is understood that the conclusion presented should be interpreted with caution. The type of non-experimental design and the size of the sample imply some restrictions for the generalization and application of the results. Future research could consider larger samples and carry them out in other subjects and university careers. Therefore, the purpose is to continue improving and expanding the characteristics of this study, in order to contract results.

In view of the above, it is considered that the present research adds value to the field of educational innovation and technologies, as it opens new perspectives for further research in future studies related to the T-MOOC phenomenon in terms of the acquisition of digital teaching skills, both for teachers who are currently working as well as for those who are undergoing initial training (students). It may also be of interest to educational administrations in order to structure and evaluate training plans and improve the level of digital competencies of teachers.

DATA AVAILABILITY STATEMENT

The datasets generated during the current study are not publicly available because the identities of some participants are visible, undermining privacy protection. Requests to access the datasets should be directed to SM-P, smartinezperez@us.es; JC-A, cabero@us.es; JB-O, jbarroso@us.es; AP-R, aprodriguez@us.es.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SM-P and AP-R wrote the first draft. All authors listed have made a substantial, direct, and intellectual contribution to the work, read and edited each draft, and approved it for publication.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.