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Adapting and Validating DigCompEdu for Early Childhood Education Students Through Expert Competence Coefficient

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Abstract: Digital teaching competence (DTC) is key for the teaching profession at any educational level. In early childhood education, DTC poses an important challenge due to the particularities of integrating digital technologies into work with infants. This article proposes an adaptation of DigCompEdu for early childhood education. The construction of this proposal was based on international collaboration, an in-depth literature review, and the expert mediation of the authors, resulting in the adaptation of DigCompEdu's 22 competency descriptors to the field of initial teacher training in early childhood education. Expert competence coefficient K was applied to select 22 experts for the validation process to establish its pertinence, importance, and clarity, who positively evaluated the 22 descriptors of the proposal. The results consist of a DTC proposal in accordance with the DigCompEdu framework for early childhood education students validated by experts, as a starting point for future research for assessing or self-assessment of DTC, and as a guide to define strategies in initial teacher training.

Keywords: digital teacher competence; initial teacher education; digital technologies; higher education; educational technology

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1. Introduction

In a socio-educational context such as the present, Digital Technologies (DT) play a fundamental role in training processes, enabling the construction of training scenarios focused on learning. In the case of Initial Teacher Education (ITE) who are trained as Early Childhood Educators, this need is even more important due to the lack of reference frameworks of competencies in the use of DT relevant to work in formal education contexts with infants (González Tamayo et al. 2023; Su and Yang 2023).

There are different frameworks to define the competencies of teachers with DT in education. Some are defined by international organizations (ISTE 2018; UNESCO 2019), and others by the ministries of education (MINEDUC 2011; Ministerio de Educación Nacional 2013). Worthy of note in the European Union is DigCompEdu (Redecker 2017), used by different governments, even beyond the union itself, to design and implement proposals to develop DTC. DigCompEdu provides ITE with a framework to structure these competencies and guarantee a systematic focus throughout their development (Caena and

Redecker 2019). However, DTC frameworks that are contextualized or that do not consider all teaching levels and environments need to be adapted to local educational contexts and levels (Redecker 2017; UNESCO 2019). This is the case of early childhood education training, for which referents such as DigCompEdu need to be adapted and contextualized for the local reality to respond to the needs of professional performance with infants.

Based on this statement, the objective of this work is to define and validate a model of descriptors to assess DTC for students in the early education training program in the Chilean context, considering the DigCompEdu model as a reference (Supplementary Materials). This is a proposal that guides the development of the DTC in the ITE in early childhood education, based on the adaptation of the DigCompEdu framework to the local reality, carried out by the research team. This work took place within the research project "Assessment of digital teaching competencies to characterize the profile of students in early childhood education programs", funded by the Chilean National Agency for Research and Development of the Chilean Ministry for Science, Technology, Knowledge, and Innovation. To validate the matrix of the descriptors, the expert judgement method was expert competence coefficient (ECC) or expert k, with its two coefficients: knowledge coefficient (KC) and argumentation coefficient (KA).

This article describes and analyzes the processes of definition and validation of DigCompEdu competence descriptors adapted to the context of early childhood education in ITE in the Chilean context, using statistical tools to evaluate the internal consistency and confirmatory validity of the descriptors. The results offer a matrix of descriptors validated by the expert K method, a solid basis to build instruments for self-assessment, perception, and formative evaluation of ITE at this educational level, and to guide the development of these competencies in the formative process.

1.1. Digital Teaching Competence

Teaching mediated by digital technologies is essential in the transition from traditional teaching to knowledge production and student-centered teaching and learning models (Cabello et al. 2020). However, the lack of digital competencies in teachers is one of the major obstacles hindering the use of digital technologies in the classroom (Cañete et al. 2022; Marimon-Martí et al. 2023; Runge et al. 2023). Digital teaching competence is recognized as one of the key competencies for the exercise of the teaching profession at any educational level (Domingo-Coscollola et al. 2020; Inamorato dos Santos et al. 2023) because it implies teachers having the necessary skills, attitudes, and knowledge to promote a learning environment enriched by DTs, improving and transforming their classroom practices and favoring their own professional development (INTEF 2017; Redecker 2017; UNESCO 2019).

DTC is a complex competence, which Verdú-Pina et al. (2023), after a systematic review, arrive at the following definition, as "a complex professional competence that brings together a set of knowledge, skills, and attitudes that teachers must possess and mobilize simultaneously to use DT in their professional practice. DCT is made up of knowledge related to didactic, methodological, space, and resource management, communicative, ethical, and professional development aspects. The positive attitude towards the use of DT in their professional practice and the technical mastery of devices and applications are considered fundamental elements inherent to the development of DTC."

1.2. Reference Frameworks for Digital Competence in Education

A variety of reference frameworks provide the basis of what is expected of a digitally competent teacher, defining dimensions, competencies, knowledge, attitudes, and skills that make up DTC (Cabero et al. 2020). Reference frameworks include the ICT Competency Framework for Teachers (UNESCO 2019), the European Framework for Digital Competence

of Teachers DigCompEdu (Redecker 2017), the Standards for Educators of the International Association for Technology in Education (ISTE 2018), the ICT Competencies for Professional Teacher Development (Ministerio de Educación Nacional 2013), Digital Teacher Competence (INTEF 2017), and ICT competencies and standards for the teaching profession of the Chilean Ministry of Education (MINEDUC 2011). The importance of these frameworks is that they facilitate information design, as they define what is expected of a digitally competent teacher, thus helping to assess their DTC level (Hidalgo 2024).

The effectiveness of a DTC framework relies on its ability to respond to the specific demands of the school context and the initial and continuing teacher education (Cabero and Barroso 2013). These frameworks for DTC tend to focus on the practicing teacher. However, some of the more basic levels expected of a practicing teacher can serve as a basis for what student teachers are expected to develop by the end of their university training (Lázaro-Cantabrana et al. 2019; Silva et al. 2019).

Several of the studies on the DTC of practicing and trainee teachers have been guided by the reference of the European Framework of Digital Competence of Teachers DigCompEdu (Betancur-Chicué and Muñoz-Repiso 2023; Suzer and Koc 2024). This reference considers six areas: professional engagement, digital resources, teaching and learning, assessment and feedback, empowering students, and facilitating students' digital competence. It also contains 22 descriptors and considers six levels: Newcomer, Explorer, Integrator, Expert, Leader, and Pioneer.

1.3. Teaching Digital Competencies in Initial Training in Early Childhood Education

In the initial training of future teachers, DTC is considered a key element for them to effectively integrate DT in their professional practices and in their future teaching practice. Future teachers need to be trained in DTC in areas such as management, collaboration, creation of resources, and reflection on the potential of DT in education (Reisoğlu and Çebi 2020). The teacher in training must also acquire competencies for the development of students' DC so that they integrate DTs in a critical and reflective way in their academic and social life (UNESCO 2019; Caena and Redecker 2019). There is also a relationship between the use of DTs and the improvement of academic performance in teacher training (Gómez-Trigueros et al. 2024).

Subjects and specialized training in education and DT significantly improve the self-perception of the DTC of those who study early childhood education, helping them to move from newcomer to expert levels (Romero-Tena et al. 2020). In a study involving pre-service teachers in early childhood, primary, and secondary education, it was concluded that early childhood education teachers have a lower self-perception of their DTC compared to primary and secondary teachers, highlighting the need for more and better training for early childhood teachers (Verdú-Pina 2024). The level of digital competence among pre-service teachers is low in several areas of the DTC (Katniyon and Duguryil 2024). Research indicates that graduates from early childhood education careers reach basic or medium levels of digital competence, with weaknesses in content creation or in the ethical components for its use (Galindo and Bezanilla 2021; Novella-García and Cloquell-Lozano 2021). Thus, it is necessary to improve DT training processes for learning and strengthen their graduate profiles, especially considering their role in the formation of early digital citizenry and their performance in diverse contexts (Girón Escudero et al. 2019; Lauricella et al. 2020; Pinto-Santos et al. 2022; Undheim and Ploog 2023).

From 2012 to 2018 in Chile, an increase in the percentage of teacher training programs that have at least one ICT subject is observed, showing greater incorporation of DT in training programs (Tapia et al. 2020). However, although these initiatives promote a transversal use of ICT in ITE, a scarce presence of DTC in the plans or graduate profiles of

Pedagogy programs is observed (Cerda et al. 2017; Canales and Silva 2019). These analyses suggest the urgent need to update training programs by incorporating learning outcomes, subjects, and/or the definition of suitable descriptors that favor the development of DTC (Undheim and Ploog 2023). Specific training programs are recommended to improve DTC and strengthen the integration of TDs in teaching practice, thus improving educational outcomes (Nurhayati and Novianti 2024).

2. Materials and Methods

2.1. Adapting DigCompEdu to Early Childhood Education

Based on the areas and competencies of the DigCompEdu framework, descriptors adapted to early childhood education students were formulated. This work was done by a research team made up of national and international experts in education technology and DTC in initial teacher training, and experts in ICT applied to early childhood education who were teaching at this level. A step-by-step methodology of debate and consensus was followed, in which each competency proposal was defined and discussed by the working group until the final formulation was reached. It was organized by areas and competencies, which were maintained, and only the original DigCompEdu descriptors were modified.

2.2. Proposal Validation

The validation of the DTC proposal based on the DigCompEdu framework for early childhood education was carried out through Expert Judgment, which "consists of asking a group of people for an evaluation of an object, instrument, teaching material, or their opinion regarding a specific aspect" (Cabero and Llorente 2013, p. 14). For the selection of experts, the expert competence coefficient (ECC) or expert K method was used (Cabero and Barroso 2013), a strategy strongly associated with Delphi studies (López-Gómez 2018), which has been gaining ground in the field of educational research and evaluation and is widely used in educational research to validate various types of evaluation instruments or constructs (Cabero et al. 2020; Marín-González et al. 2021; Robles and Rojas 2015).

2.3. Selection of Experts

Initial criteria were established for the selection of the experts, which, through expert k, were used to identify the experts included in the sample. Participants had to meet at least two of the following criteria: (i) be teachers of subjects related to digital technologies in early childhood education; (ii) have experience in training teachers in the use of digital technologies; (iii) have done research on teaching digital competence in teacher training; (iv) belong to national or international universities; (v) be members of organizations linked to early childhood education; (vi) have participated in the creation of policies for the integration of digital technologies at this educational level; and (vii) have presented papers in seminars and congresses associated with the insertion of technologies in early childhood education.

The number of experts needed for a reliable estimation of content validity varied according to the authors, ranging from 10 to 35 (Hyrkäs et al. 2003; Malla and Zabala 1978; Witkin and Altschuld 1995). As one of the main challenges in applying expert judgment, different studies propose different figures: between 15 and 20 (Malla and Zabala 1978), between 15 and 35 (Landeta et al. 2002), or between 15 and 25 (Witkin and Altschuld 1995). In this case, it was decided to work with as many experts as possible.

2.4. The Expert Competence Coefficient Method

The expert competence coefficient (ECC), or expert K, is defined as $K = 1/2 (Kc + Ka)$. In this formula, Kc is the "knowledge coefficient", which is obtained from experts' self-

perception of their level of knowledge of the subject under analysis. This knowledge is evaluated on a scale of 0 to 10, where 0 represents absolute ignorance and 10 represents extensive knowledge. In this study, this value is multiplied by 0.1 to obtain the Kc.

To calculate this coefficient, the experts were asked to "Indicate the degree of knowledge you have on the following topics: initial teacher training, early childhood education training, use of digital technologies in teaching, digital competence, and digital teaching competence," on the same scale from 0 to 10.

On the other hand, the argumentation coefficient (Ka) was obtained by adding the scores assigned by the expert to different sources of argumentation of his or her knowledge. The experts were presented with different sources of argumentation and asked to indicate the level of influence of each source on their knowledge of the area, with three options: High = 3, Medium = 2, or Low = 1. Based on the original proposal by Dobrov and Smirnov (1972), adapted for this study, each source of argumentation is assigned a score, and the sum of the scores determines the Ka value.

The values used to determine the expert's position were:

- 0.8 <= K < 1.0 high expert competence coefficient
- 0.5 <= K < 0.8 medium expert competence coefficient
- K < 0.5 low expert competence coefficient

Only experts with competence coefficient values equal to or greater than 0.8 participated in the validation stage of the competency descriptors.

2.5. Instrument

The instrument consists of three sections: (a) participant characterization with general data (gender, country, education, etc.); (b) criteria for estimating the expert K statistic, i.e., Kc and Ka (Table 1); and (c) evaluation of the proposed DigCompEdu descriptors adapted to initial training in education; for each proposed descriptor, the expert had to give an opinion on a scale from 1 = very low to 5 = very high, with regard to pertinence: degree of adequacy of the indicator to evaluate the competence; importance: degree of relevance of the descriptor to evaluate the competence; and clarity: degree of adequacy of the wording of the descriptor to assess the competence.

Table 1. Assessment of the sources of argumentation to obtain the "Coefficient of Argumentation" (Ka).

Source of Argumentation	High	Medium	Low
Your theoretical analysis of digital teacher competencies in initial teacher training.	0.3	0.2	0.1
Your experience gained from practical activity, integrating digital skills into professional practice.	0.3	0.2	0.1
Study/review of works on digital teacher competencies in initial teacher training by Chilean authors.	0.10	0.075	0.025
Study/review of works on digital teacher competencies in initial teacher training by international authors.	0.10	0.075	0.025
Your own knowledge of digital teacher competencies in early childhood education initial training.	0.10	0.075	0.025
Your intuition about digital teacher competencies in early childhood education initial training.	0.10	0.075	0.025

Emails were sent to the selected experts, inviting them to collaborate in this stage of the study through the link https://forms.gle/JeMFrTN5V6WY3dEZ6 (accessed on 25 March 2025). About 80 emails were sent and, after 3 weeks, 32 replies were received.

2.6. Data Processing

The responses provided by the potential experts were analyzed, and only those who obtained ECC values equal to or greater than 0.8 participated in the third stage of validation of the DigCompEdu competency descriptors adapted to early childhood education. The data were analyzed through descriptive and inferential statistics using R 4.4.1 and Jamovi 2.3.28 software. As a validation strategy, two perspectives were used, one referring to the consistency of the experts' evaluations of each of the descriptors of the competencies, using Cronbach's Alpha statistics as estimation mechanisms. On the other hand, a confirmatory factor analysis was performed on the experts' responses in order to search for evidence in the data to justify the dimensions. These two processes were referred to in terms of pertinence, importance, and clarity, after verifying assumptions of sphericity (Bartlett) and sample adequacy (KMO).

3. Results

3.1. Adapting Descriptors

A matrix of descriptors of the DigCompEdu competencies adapted to early childhood education in the Chilean context was designed. The contribution of the proposal is to specify descriptors pertinent to the early childhood education level, given that the general framework is for primary and secondary education and practicing teachers, with the figure of the family emerging, which is ignored at other levels. The matrix was organized according to area, competence, and descriptor (Table 2).

Table 2. Matrix of Competence Descriptors.

Area	Competence	Descriptor
1. Professional engagement	1.1 Organizational communication	Use digital technologies to improve organizational communication with training partners, professional teams linked to the practice, and children's families.
	1.2 Professional collaboration	Explore the possibilities of digital technologies to develop collaborative experiences with fellow students and professional teams linked to the practice, and to share and exchange knowledge, experiences, and innovate pedagogical practices together.
	1.3 Reflexive practice	Reflect on one's own and others' digital pedagogical practice.
	1.4 Continuing Professional Development (CPD) through digital media.	Identify sources of information to improve their knowledge on the use of digital technologies in their professional teacher training.
2. Resources	2.1 Selection of digital resources	Locate, use, and evaluate digital resources for teaching and learning, considering learning objectives, context, pedagogical approach, and educational level.
	2.2 Creating and modifying digital resources	Create, modify, and/or adapt digital resources, individually and collectively, based on the learning objectives, context, methodology, and educational level.
	2.3 Protection, management, and sharing resources	Select and organize resources in order to make them available for use and review by training partners, children, family, and professionals of the practice centers, knowing the use of free licenses, including their correct reference.

Table 2. *Cont.*

Area	Competence	Descriptor
3. Teaching and Learning	3.1 Teaching	Plan the use of digital devices and resources in the teaching-learning process, in order to improve their pedagogical interventions through methodologies that favor an active role of girls and boys.
	3.2 Orientation and support in learning	Use digital technologies to improve individual and collective interaction with the family of children, in order to offer relevant and specific guidance and support.
	3.3 Collaborative learning	Use technologies to develop and encourage children to work collaboratively in order to facilitate communication, cooperation, and learning.
	3.4 Self-regulated learning	Use digital technologies to favor self-regulation processes of children.
4. Assessment and feedback	4.1 Assessment strategies	Use digital technologies for the process of diagnosing, monitoring, and providing feedback on children's achievements and communicating them efficiently and effectively to families.
	4.2 Learning analytics	Use digital technologies to analyze and interpret, in a critical way, the evaluation results for decision making in the planning of the teaching and learning process.
	4.3 Feedback, programming, and decision making	Use digital technologies to process data derived from learning progress and provide specific feedback.
5. Student empowerment	5.1 Accessibility and inclusion	Recognize elements that facilitate accessibility for girls and boys, including those with special educational needs, in pedagogical learning resources and experiences.
	5.2 Personalization	Use digital technologies to meet the diverse learning needs of girls and boys, allowing them to advance at their own learning pace.
	5.3 Active engagement of students with their own learning	Use digital technologies to promote children's interest in learning experiences.
6. Development of students' digital competence	6.1 Information and media literacy	Encourage the use of digital technologies in the search for information by children with the support of their families.
	6.2 Digital communication and collaboration	Incorporate learning experiences with digital resources, tasks, and games that require children to know the rules of use and respect for the work of their peers, for communication, and digital collaboration.
	6.3 Resource creation	Include learning experiences that require children to express themselves using digital technologies.
	6.4 Responsible use	Adopt measures to ensure the physical, psychological, and social well-being of children when using digital technologies.
	6.5 Digital problem solving	Incorporate learning experiences that require children to identify and solve simple technical problems derived from the use of digital technologies.

3.2. Expert Competence Coefficient

First, the knowledge coefficient (Kc) was determined for each of the 32 potential experts invited to participate in the study, each of whom rated their knowledge of topics associated with DTC and early childhood education on a scale of 0 to 10, with 0 being the

most disadvantaged level and 10 being full knowledge, for subsequent standardization. The Kc reached for the group of potential experts a mean of 0.82 with a standard deviation of 0.086. On the other hand, Ka represents the valuation that the researcher assigns to the potential expert according to a series of questions referring to sources of argumentation about DC in Higher Education and in IDF in early childhood education (Table 3).

Table 3. Assessment of sources of argumentation.

Source of Argumentation	Media	SD
Your theoretical analysis of digital teacher competencies in initial teacher training.	2.24	0.740
Your experience gained from practical activity, integrating digital skills into professional practice.	2.57	0.552
Study/review of works on digital teacher competencies in initial teacher training by Chilean authors.	2.06	0.814
Study/review of works on digital teacher competencies in initial teacher training by international authors.	2.09	0.793
Your own knowledge of digital teacher competencies in early childhood education initial training.	1.94	0.894
Your intuition about digital teacher competencies in early childhood education initial training.	2.06	0.736

Note: M: mean, SD: Standard deviation. The assessment scale is low = 1, medium = 2, high = 3.

In general terms, the source of argumentation can be described with a mean of 2.44 and SD = 0.66. The sources of argumentation with the highest means are "Your experience gained from your practical activity integrating digital competencies in your professional practice" (M = 2.57, SD = 0.552) and "Theoretical analysis carried out by you on digital competencies in initial teacher education" (M = 2.24, SD = 0.740). The descriptors with the lowest means are "Your own knowledge of digital competencies in initial teacher education in early childhood education" (M = 1.94, SD = 0.736), "Your intuition about digital competencies in initial teacher education in early childhood education" (M = 2.06, SD = 0.736), and "Study/review of works on digital competencies in initial teacher education by national authors" (M = 2.06, SD = 0.814). The low standard deviations suggest consistency in the responses of the survey participants.

The Kc and Ka estimates show that the self-assessments assigned by the experts could be considered high and significant. This suggests a sample of experts with high validation potential. Table 4 presents the frequency and percentages achieved for each of the sources of argumentation.

Table 4. Frequencies of assessment of the sources of argumentation.

Source of Argumentation	Low		Medium		High	
	f	%	f	%	f	%
Your theoretical analysis of digital teacher competencies in initial teacher training.	6	18.8	12	37.5	14	43.8
Your experience gained from practical activity, integrating digital skills into professional practice.	1	3.1	11	34.4	20	62.5
Study/review of works on digital teacher competencies in initial teacher training by Chilean authors.	10	31.3	10	31.3	12	37.5
Study/review of works on digital teacher competencies in initial teacher training by international authors.	9	18.1	12	37.5	11	34.4
Your own knowledge of digital teacher competencies in early childhood education initial training.	9	28.1	16	50.0	7	21.9
Your intuition about digital teacher competencies in early childhood education initial training.	8	25.0	14	43.8	10	31.3

It is observed that the experts give high value to "Their experience obtained from their practical activity . . ." 62.5% and "Theoretical analysis conducted . . ." 43.8% as key sources for understanding DTC in early childhood education. On the other hand, they give low value to "Their own knowledge of teaching digital competencies . . ." 28.1% and "Study/review of works on teaching digital competencies . . ." 31.3%. The results show that own knowledge and practical experience are key to knowledge construction in this area of DTC in early childhood education; on the other hand, external sources and intuition play a secondary role.

Based on the expert competence coefficient K, i.e., (Ka + Kc)/2, it is possible to indicate that the results of the CCE (Table 5) suggest that 22 potential experts exceed the decision, i.e., being higher than 0.8, characterizing the group that participated in the third stage of the expert validation of the descriptors associated with the DigCompEdu competencies adapted for early childhood education.

Table 5. Knowledge coefficient (Kc), argumentation coefficient (Ka), and expert competence coefficient (K) obtained by each of the experts.

Person	Knowledge Coefficient (Kc)	Argumentation Coefficient (Ka)	Expert Competence Coefficient (K)
1	0.92	0.8	0.86
2	0.78	0.8	0.79
3	0.78	0.9	0.84
4	0.84	0.8	0.82
5	0.92	0.7	0.81
6	0.78	0.6	0.69
7	0.76	0.7	0.73
8	0.78	0.7	0.74
9	0.90	0.8	0.85
10	0.83	0.7	0.77
11	0.85	0.7	0.77
12	0.85	0.9	0.87
13	0.92	0.9	0.91
14	0.91	1	0.96
15	0.83	0.8	0.81
16	0.70	0.5	0.60
17	0.90	1	0.95
18	0.77	0.8	0.78
19	0.84	0.9	0.87
20	0.90	0.8	0.85
21	0.91	1	0.96
22	0.92	0.8	0.86
23	0.83	0.7	0.77
24	0.55	0.5	0.53
25	0.92	1	0.96
26	0.91	0.8	0.85
27	0.91	0.8	0.85
28	0.75	0.6	0.68
29	0.78	0.7	0.74
30	0.78	0.7	0.74
31	0.70	0.5	0.60
32	0.75	0.6	0.68

The average value of the CCE was 0.79 with a standard deviation of 0.106. The Kc reached for the group of potential experts a mean of 0.82 with a standard deviation of 0.086. The mean of the Ka coefficient reached 0.76 with a standard deviation of 0.142. The distri-

bution of the experts (Table 6) in the three coefficients of knowledge and argumentation consulted in the questionnaire to define the level of expert competence shows a total of 22 selected experts.

Table 6. Values of achieved ranges.

Competence Level		N	AP *	SM **
Knowledge	Medium Level (<0.8)	29	0.112	1.12
	High Level (≥0.8)	3	0.117	2.588
	Total	32		
Argumentation	Medium Level (<0.8)	4	0.125	1.259
	High Level (≥0.8)	18	0.129	2.851
	Total	32		
Expert Competence	Medium Level (<0.8)	10	0.117	1.174
	High Level (≥0.8)	22	0.119	2.225
	Total	32		

Note: * AP = Average Range; ** SM = Sum of Ranges.

A test for paired samples based on Friedman's statistic was performed to establish whether the differences between Ka and Kc are significant, which led to the conclusion that there are no significant differences; therefore, the selection of experts took both components into account in a balanced proportion.

The selected experts holding a doctorate were 40.9% (f = 9), while 59.1% (f = 13) held a master's degree. Most of them work in private or public universities, 86.4% (f = 19); the remaining percentage refers to public institutions and other options. Forty-five percent (f = 10) have a teaching, research, and management role, 4.5% (f = 1) are dedicated only to research, and 9.1% (f = 2) only to teaching. The experience of these experts (Table 7) is higher in teaching and publications both with 50% (f = 11) and in generating policies 63.3% (f = 14), in contrast to where they have less experience in research projects 68.2% (f = 15) and knowledge of DTC frameworks 77.3% (f = 17).

Table 7. Experience of the judges selected based on the ECC ≥ 0.8.

Experience	Frequency
Has undergraduate teaching experience in Educational Technology in early childhood education.	Yes 50% (f = 11) No 50% (f = 11)
Has participated in research or innovation projects related to early childhood education and/or digital technologies in education.	Yes 31.8% (f = 7) No 68.2% (f = 15)
Has participated in publications related to early childhood education and/or digital technologies in education.	Yes 50% (f = 11) No 50% (f = 11)
Has theoretical knowledge of the Digital Competencies frameworks for teachers.	Yes 22.7% (f = 5) No 77.3% (f = 17)
Has participated in the generation of public and/or institutional policies on Education, early childhood education, and/or digital technologies.	Yes 63.3% (f = 14) No 36.4% (f = 8)
Has experience in pedagogical practices in early childhood education.	Yes 31.8% (f = 7) No 68.2% (f = 15)

The knowledge of DTC frameworks among teachers is low; in the Chilean context, teachers know other frameworks such as UNESCO (2019), ISTE (2018), and ICT standards in initial teacher training Ministerio de Educación Chile (2011) (MINEDUC 2011). Table 5 shows that experts perform theoretical analysis on teachers' digital competencies. Therefore,

they are familiar with references, but not under the label of the digital teaching competencies framework, in addition to handling the structure of areas, competencies, and descriptors concerning the scarce participation in research projects on digital technologies and early childhood education. In relation to low participation in research projects, in Chile, there are scarce resources for research, and even fewer for education. Only 2% of the research projects financed by the state correspond to education, which includes teacher training. However, the selected experts do keep up to date by reading national and international research (Table 5).

3.3. Assessment of the Proposal

The result of the assessment of pertinence, importance, and clarity assigned by the experts, with a value >0.8 in the SCC, to the descriptors of the competencies of the six areas of DigCompEdu adapted for Early Childhood Education in the Chilean context (Table 8) shows a high assessment in all areas.

Table 8. Assessment by Area.

Area		Pertinence		Importance		Clarity	
		M	SD	M	SD	M	SD
1.	Professional Engagement	4.31	0.730	4.37	0.746	4.31	0.684
2.	Resources	4.20	0.875	4.24	0.800	3.96	0.871
3.	Teaching and Learning	4.13	0.835	4.17	0.839	3.99	0.923
4.	Assessment and Feedback	4.46	0.665	4.41	0.665	4.35	0.829
5.	Empowerment	4.31	0.859	4.34	0.827	4.25	0.991
6.	Digital Competence Development	4.15	0.770	4.17	0.722	4.14	0.893

Note: M: Mean, SD: Standard Deviation, scale of 1 to 5, where 1 = very low and 5 = very high.

In pertinence, the best evaluated area is "Professional Engagement" (M = 4.31, SD = 0.730), while the lowest rated is "Teaching and Learning" (M = 4.13, SD = 0.835). In importance, "Professional Engagement" is also the best-scoring area (M = 4.37, SD = 0.746), and the lowest-rated areas are "Teaching and Learning" (M = 4.17, SD = 0.839) and "Digital Competence Development" (M = 4.17, SD = 0.722).

In terms of quality, the best evaluated area is "Assessment and Feedback" (M = 4.35, SD = 0.829), and "Resources" has the lowest score (M = 3.96, SD = 0.871). In terms of variability and considering the standard deviation, homogeneity is observed in the scores, which brings consistency to the summary in terms of centrality.

In relation to the descriptors (Table 9), it is observed that all are highly rated in terms of pertinence, importance, and clarity. In terms of pertinence, the highest rated descriptor is 6.4 "Responsible use" (M = 4.72, SD = 0.581), while the lowest rated is 3.4 "Self-regulated learning" (M = 3.63, SD = 1.362). In terms of importance, the most prominent descriptor remains 6.4 "Responsible use" (M = 4.75, SD = 0.508), and the one with the lowest rating is again 3.4 "Self-regulated learning" (M = 3.69, SD = 1.378). Finally, in terms of clarity, the highest rated descriptor is 6.4 "Responsible use" (M = 4.63, SD = 0.833), while the lowest rated is 2.3 "Protection, management, and sharing of resources" (M = 3.34, SD = 1.494).

In some cases, the experts made observations and proposals for improving the wording of some descriptors, which were evaluated and integrated according to their contribution to a better re-drafting and understanding of the descriptors in the version. Table 10 shows the internal consistency analysis of the ratings, operationalized by means of Cronbach's Alpha statistic for the descriptors grouped into competencies and areas.

Table 9. Assessment by Descriptor.

Area	Competence	Pertinence		Importance		Clarity	
		SD	M	SD	SD	M	SD
1. Professional engagement	1.1 Organizational communication	4.19	0.859	4.44	0.716	4.31	0.738
	1.2 Professional collaboration	4.41	0.837	4.47	0.761	4.41	0.756
	1.3 Reflective practice	4.31	0.998	4.22	1.128	4.22	1.008
	1.4 Continuing professional development through digital media	4.34	0.865	4.34	0.865	4.31	0.896
2. Resources	2.1 Selection of digital resources	4.5	0.88	4.59	0.712	4.5	0.803
	2.2 Creation and modification of digital resources	4.13	1.100	4.13	1.008	4.03	0.967
	2.3 Resource protection, management, and exchange	3.97	1.332	4.00	1.320	3.34	1.494
3. Teaching and learning	3.1 Teaching	4.31	0.821	4.38	0.833	4.13	0.942
	3.2 Orientation and support in learning	4.47	0.718	4.50	0.718	4.13	0.976
	3.3 Collaborative learning	4.09	1.254	4.13	1.289	4.16	1.194
	3.4 Self-regulated learning	3.63	1.362	3.69	1.378	3.56	1.343
4. Assessment and feedback	4.1 Assessment strategies	4.5	0.842	4.5	0.762	4.41	0.946
	4.2 Learning analytics	4.56	0.669	4.47	0.718	4.44	0.801
	4.3 Feedback, programming, and decision making	4.31	0.931	4.25	0.95	4.22	1.039
5. Student empowerment	5.1 Accessibility and inclusion	4.25	0.914	4.47	0.879	4.31	1.061
	5.2 Customization	4.31	0.931	4.34	0.902	4.25	1.016
	5.3 Active engagement of students with their own learning	4.19	0.998	4.22	1.008	4.19	1.091
6. Digital competence development of students	6.1 Information and media literacy	3.84	1.298	3.97	1.282	4.09	1.118
	6.2 Digital communication and collaboration	4.13	1.008	4.13	0.976	3.97	1.177
	6.3 Resources creation	3.84	1.110	3.88	1.070	3.81	1.091
	6.4 Responsible use	4.72	0.581	4.75	0.508	4.63	0.833
	6.5 Digital problem solving	4.22	1.008	4.16	0.954	4.22	1.099

Table 10. Scale Reliability Statistics based on Cronbach's α.

Area	Pertinence	Importance	Clarity
1. Professional engagement	0.782	0.845	0.718
2. Resources	0.770	0.709	0.707
3. Teaching and learning	0.836	0.819	0.767
4. Assessment and feedback	0.725	0.740	0.833
5. Empowerment	0.926	0.902	0.913
6. Digital competence development	0.802	0.779	0.889
General	**0.961**	**0.955**	**0.949**

For all areas, an estimate between acceptable and very good is established for pertinence, importance, and clarity, being evidence, supported by data for internal consistency both in each area and for each competence. Supporting positive metric characteristics of the matrix of descriptors as judged by the experts.

In relation to the statistical validation of the assessment of importance, pertinence and clarity, given by the experts for each descriptor, after verification of Bartlett's sphericity assumptions and the sample adequacy statistic KMO (higher than 0.5 in all cases), which justifies the factor analysis, it is possible to indicate that the data (Table 11) support evidence in favor of the six areas.

Table 11. Factor loading for Importance, Pertinence, and Clarity by descriptor.

Descriptor	Importance		Pertinence		Clarity	
	Estimator	*p*	Estimator	*p*	Estimator	*p*
1.1 Organizational communication	0.520	<0.001	0.5263	0.003	0.530	<0.001
1.2 Professional collaboration	0.760	<0.001	0.7681	<0.001	0.775	<0.001
1.3 Reflective practice	0.890	<0.001	0.8976	<0.001	0.908	<0.001
1.4 Continuing professional development through digital media	0.300	0.062	0.3109	0.068	0.306	0.077
2.1 Digital resource selection	0.810	<0.001	0.8074	<0.001	0.826	<0.001
2.2 Creation and modification of digital resources	0.840	<0.001	0.8455	<0.001	0.857	<0.001
2.3 Resource protection, management, and exchange	0.550	0.026	0.5407	0.026	0.561	0.016
3.1 Teaching	0.660	<0.001	0.6550	<0.001	0.673	<0.001
3.2 Orientation and learning support	0.600	<0.001	0.5974	<0.001	0.612	<0.001
3.3 Collaborative learning	0.910	<0.001	0.9122	<0.001	0.928	<0.001
3.4 Self-regulated learning	0.750	0.012	0.7523	0.003	0.765	<0.001
4.1 Assessment strategies	0.730	<0.001	0.7392	<0.001	0.745	<0.001
4.2 Learning analytics	0.180	0.265	0.1775	0.286	0.184	0.278
4.3 Feedback programming and decision making	0.740	<0.001	0.7453	<0.001	0.755	<0.001
5.1 Accessibility and inclusion	0.880	<0.001	0.8917	<0.001	0.898	<0.001
5.2 Customization	0.970	<0.001	0.9792	<0.001	0.989	<0.001
5.3 Active engagement of students with their own learning	0.900	<0.001	0.9041	<0.001	0.918	<0.001
6.1 Information and media literacy	1.060	<0.001	1.0570	<0.001	1.081	<0.001
6.2 Digital communication and collaboration	1.030	<0.001	1.0412	<0.001	1.051	<0.001
6.3 Resources creation	0.840	<0.001	0.8371	<0.001	0.857	<0.001
6.4 Responsible use	0.070	0.067	0.0627	0.076	0.071	0.079
6.5 Digital problem solving	0.640	<0.001	0.6380	0.003	0.653	0.009

4. Discussion

The objective of this study was to design and validate a matrix of descriptors of DigCompEdu competencies adapted to early childhood education training in the Chilean context using expert coefficient competence. To this end, the team designed a proposal to validate the matrix and formed a panel of 22 experts from Chilean and Latin American universities. These experts were selected rigorously, using the expert coefficient competence (ECC), evaluating their knowledge coefficient (Kc) and their argumentation coefficient (Ka). The expert assessment of their knowledge regarding ECC in early childhood teacher education was high, indicating that the selection of the experts was adequate. However, the concentration of values in the lower range of the data for the argumentative coefficient (Ka) related to knowledge of the DTC in initial teacher training in early childhood education shows that even among experts, it is a topic that requires deepening. It is an area where research has been less than in other areas of teacher training, such as basic or secondary education. The ECC method proved to be an appropriate strategy to identify experts who could validate the proposal. The use of this methodology is expanding in the scientific community because it gives greater rigor to expert judgment.

The expert K method, in agreement with other studies (Cabero et al. 2020; Fernández et al. 2023), proved to be effective in selecting experts and in giving greater volatility and reliability to the assessment instruments or constructs designed. Particularly, García-

Valcárcel et al. (2020) elaborated and validated a model of descriptors (INCODIES) using expert K, following the structure of the European framework of DIGCOMP, in line with this study, producing similar results.

DTC should be a central component of initial teacher education programs to face the challenges of education in a highly technological society (Tondeur et al. 2020). Having a proposal validated by experts and adapted to the local context thus provides better chances to integrate technology into the formative processes. This study has demonstrated, as indicated by other authors, that DigCompEdu is a robust and flexible framework that can be adapted to a variety of levels and contexts (Redecker 2017; UNESCO 2019). As indicated by (Caena and Redecker 2019) for ITE, DigCompEdu provides a framework to structure these competencies and guarantee a systematic focus, which, for the Chilean case, was effective for ITE in early childhood education. This proposal can contribute towards the responsibility of universities to incorporate frameworks such as DigCompEdu in their ITE programs to guarantee the preparedness of future teachers in the ethical, critical, and pedagogically relevant use of DT (European Commission 2020).

The proposal has been satisfactorily validated by experts in terms of pertinence, importance, and clarity, and can serve as a reference for the development of various instruments associated with DTC in early childhood education, according to the framework of DigCompEdu, such as assessment tools, self-assessment instruments, and self-perception instruments. This proposal is of vital importance given that the DigCompEdu framework, currently the most widely used, is mainly used for the primary and secondary education system, and it has been adapted for higher education. The particularity of early childhood education is that teachers not only work with children, but also with the family. Expert judgment and the use of expert K have been important to provide validity of the assessments of the descriptors.

The adaptation of DigCompEdu to the initial training of teachers in early childhood education provides a valuable tool that allows trainers and those responsible for the initial training policies of institutional educators to make decisions to plan improvements to the development of DTC. Additionally, it could be used to create or improve those undergraduate courses that address, as a central object of knowledge, the use of digital technologies in teaching and learning. At the curriculum level, in a transversal way, it could help to incorporate the digital technologies in the subjects so that they can contribute to improving the level of DTC, being the responsibility of the entire teaching staff, not only of technology and education teachers. Additionally, it can be used to guide new research aimed at evaluating or self-evaluating the DTC in teacher training in early childhood education, under the DigCompEdu framework.

Supplementary Materials: In DigCompEdu for Early Childhood Education. Zenodo. https://doi.org/10.5281/zenodo.15115813 the following supporting information can be downloaded, DigCompEdu expert judgment validation instrument for early childhood education; Adaptation DigCompEdu for early childhood education.

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