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"*T-CoRe*": a new instrument for studies on Technological Pedagogical Content Knowledge and for technological teacher education

Pércia Paiva Barbosa[1]

Gabriela dos Santos Brito[2]

Suzana Ursi[3]

Abstract: Competencies related to the use of technologies are essential for today's citizens, justifying their implementation in educational environments. However, teacher education is crucial for effective learning with these resources. Thus, research on teachers' Knowledge Bases, including Technological Pedagogical Content Knowledge, becomes highly relevant. This article presents "*T-CoRe*", an instrument designed to support teachers' technological education and facilitate research in this field. Inspired by Loughran and collaborators, "*T-CoRe*" consists of eight questions regarding using technological resources in teaching, enabling access to teachers' Knowledge Bases, particularly their technological knowledge. The instrument was tested with future Biology teachers, revealing promising aspects of "*T-CoRe*" for research purposes. The results also emphasize the instrument's capacity to identify gaps in Knowledge Bases throughout teacher education.

Keywords*:* Qualitative research instrument. teacher education. Knowledge Bases.

"*T-CoRe*": un nuevo instrumento para estudios sobre Conocimiento de Contenidos Tecnológicos Pedagógicos y para la formación tecnológica de docentes

Resumen**:** Competencias acerca del uso de las "tecnologías" son exigidas a los ciudadanos modernos, justificando su uso en ambientes educativos. Para que el aprendizaje con estos recursos suceda correctamente, la formación de los docentes es esencial. Así, pesquisas sobre la enseñanza de los Conocimientos Base (incluidos Conocimientos Tecnológicos Pedagógicos de Contenido) demuestran relevancia. Por ello, este artículo presenta el "*T-CoRe*", instrumento que auxilia la formación tecnológica de los docentes, como la investigación en este campo. Inspirado por Loughran y colaboradores, el "*T-CoRe*" tiene ocho preguntas sobre el uso de recursos tecnológicos en la enseñanza y, a partir de ellas, es posible acceder al Conocimiento Base docente, en particular, al conocimiento tecnológico del educador. El instrumento fue probado con futuros profesores de Biología, detectando aspectos prometedores del *T-CoRe* para fines de investigación. Además, los resultados resaltaron la capacidad del instrumento para identificar posibles brechas en el Conocimiento Base durante la formación docente.

Palabras clave: Instrumento de investigación cualitativa. formación docente. Bases de Conocimiento.

[1] Universidade de São Paulo — São Paulo, Brasil. ✉ percia@alumni.usp.br Orcid: https://orcid.org/0000-0002-0063-5730. Lattes: http://lattes.cnpq.br/5637681823503751.

[2] Universidade de São Paulo — São Paulo, Brasil. ✉ gbrito.gabriela@gmail.com Orcid: https://orcid.org/0000-0001-7695-8731. Lattes: http://lattes.cnpq.br/6956827926104757.

[3] Universidade de São Paulo — São Paulo, Brasil. ✉ suzanaursi@usp.br Orcid: https://orcid.org/0000-0002-1493-2496. Lattes: http://lattes.cnpq.br/2908921158400085.

"*T-CoRe*": um novo instrumento para os estudos sobre o Conhecimento Tecnológico Pedagógico do Conteúdo e para a formação tecnológica de professores

Resumo: Competências relacionadas ao uso das tecnologias são exigidas dos cidadãos hodiernos, justificando o uso destas nos ambientes educativos. Contudo, para que a aprendizagem com tais recursos aconteça de maneira adequada, a formação docente é fundamental. Assim, investigações sobre os Conhecimentos Base docentes (incluindo Conhecimento Tecnológico Pedagógico do Conteúdo) tornam-se relevantes. Assim, este artigo apresenta o "*T-CoRe*", um instrumento capaz de auxiliar a formação tecnológica de professores, assim como as pesquisas nesse campo. Inspirado em Loughran e colaboradores, o "*T-CoRe*" possui oito questões sobre a utilização de recursos tecnológicos no ensino sendo que, a partir delas, é possível acessar os Conhecimentos Base docentes, em especial, os conhecimentos tecnológicos do educador. Realizou-se um teste do instrumento com futuros professores de Biologia, detectando-se aspectos promissores do "*T-CoRe*" para fins de pesquisa. Os resultados ainda apontam a capacidade do instrumento para identificação de possíveis lacunas dos Conhecimentos Base ao longo da formação de professores.

Palavras-chave: Instrumento qualitativo de investigação. formação docente. Conhecimentos Base.

1 Introduction

Society is experiencing profound changes, and citizens must develop skills different from those of past centuries. Studies by Unesco (2011) show the importance of modern societies building workforces with Information and Communication Technologies (ICT) skills to enable citizens to manage their lives effectively and participate in society. At the time of these studies, it would have been impossible to imagine how critical this issue would become a decade later, in 2020, with the COVID-19 pandemic, which forced the implementation of *emergency remote teaching/ ERT*. Despite the catastrophic situation brought on by the pandemic, a positive outcome was the increased knowledge and skills in technology among both teachers and students, as demonstrated by Brianza *et al.* (2024) – specifically, in the Brazilian context, it was possible to identify some good experiences (e.g., Ursi, 2017; Ursi and Lima, 2021; Ribeiro and Piedade, 2023).Thus, education could be an option to develop them, and it should help students (and teachers) become qualified users of technologies and be able to search, analyze, evaluate, and solve problems that arise in their lives.

Despite this scenario, it is known that the insertion of technologies in classrooms often does not happen satisfactorily. Teachers' actions can be related to this phenomenon, which is evidenced by a study by the 2014 IEA (International Association

for the Evaluation of Education Achievement). This study pointed out that teachers did not feel confident about their ability to use technologies: less than 50% considered themselves self-sufficient to use computers for more complex tasks. Other research has shown similar conclusions: Petko (2012) indicates that teachers use computers and Internet applications more often in class when they consider themselves competent to use ICT for teaching. Moreover, the author affirms that teachers use ICT when they are convinced that computers improve learning and when they have conceptions of centered learner forms.

In this context, Costa *et al*. (2008) focus on the role of teachers' education, affirming that the inadequate preparation of teachers is a barrier that harms the effective use of computers in the educational context. Particularly about teachers' continuing education, the authors say that courses focusing on computer use are not enough to qualify teachers to use technologies effectively. Teachers must have concrete experiences capable of stimulating their reflections and increasing their confidence in using technological resources in teaching. To prepare teachers for effective technology integration, teacher education programs must help them build knowledge of sound pedagogical practices, technical skills, content knowledge, and how these concepts relate to one another (Tondeur *et al*., 2012).

Studies such as Koehler and Mishra (2005), Angeli and Valanides (2005), and Niess (2005), among others, present potential contributions to educating teachers about the use of technologies. These investigations discuss the knowledge related to technology and have their origin in Shulman's studies (1986, 1987) as well as other research that focused on the "Knowledge Bases" (KBs) and the development of the "Pedagogical Content Knowledge/PCK," as studies presented by Grossman (1990), Barnett e Hodson (2001), "The PCK Summit" (Helms; Stokes, 2013), among others. About the PCK, Shulman (1987, p.8) explained it this way: "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction." The Knowledge Bases, in turn, were defined by Shulman and Sykes (1986) as "the body of understanding and skills, and device and values, character and performance that together constitute the ability to teach" (as cited in Fernandez, 2014, p. 82). With that in mind, researchers have pointed out that

the appropriate development of the Knowledge Bases enables the appropriate development of PCK, which is crucial to teaching.

In this scene, since the 2000s, some studies have listed different types of Knowledge Bases related to technology (e.g., Angeli; Valanides, 2005; Koehler; Mishra, 2005; Niess, 2005), and the term "Technological Pedagogical Content Knowledge – TPCK or TPACK" was presented. Basically, it refers to the technology related to PCK, whereas researchers believe that, as well as PCK, the appropriate development of some types of Knowledge Bases related to the technology could develop an adequate TPCK/ TPACK, which is also crucial to teaching with technologies.

Niess (2005) was one of the first researchers to study teachers' technological knowledge from a systematized and theoretical view. Based on Shulman (1987) and Grossman (1990), she suggested that during their education process, teachers should develop: i) a conception of the purposes for incorporating technology in teaching subject matter topics, ii) Knowledge of students' understandings, thinking and learning about subject matter topics with appropriate technologies, iii) Knowledge of curriculum and curricular materials that integrate technology in learning and teaching subject matter topics, iv) Knowledge of instructional strategies and representations for teaching and learning subject matter topics with technologies. In the same year, Angeli and Valanides (2005), based on Shulman (1986) and other studies, proposed five teachers' Knowledge Bases: i) Content Knowledge, ii) Pedagogical Knowledge, iii) Learner Knowledge, iv) ICT Knowledge (that refers to the educator's knowing how to operate a computer, how to use a multitude of tools/software, and about their affordances); and v) Knowledge of Context. Mishra and Koehler (2006) were other researchers in this area who presented new KBs. They considered the existence of three teachers' knowledge initial domains: i) Technological Knowledge, which refers to the teacher's understanding of technologies capable of helping him to achieve technical objectives; ii) Pedagogical Knowledge, which refers to the educator's understanding of the teaching-learning processes and practices (such as educational proposals, values, teaching objectives, among others); and iii) Content Knowledge, which refers to the educator's understanding of the topic to be taught. From the combinations among these three initial domains, they came up with new types of Knowledge Bases: iv) Pedagogical Content Knowledge, defined as Shulman (1987),

as we described above; v) Technological Content Knowledge, which refers to the educator's understanding of how a particular technology is interrelated with a specific teaching content; and vi) Technological Pedagogical Knowledge, which refers to the teacher's understanding of how technologies can be used for pedagogical purposes. Technological Pedagogical Content Knowledge (TPCK/ TPACK) arises from the interrelationship among all of them. As mentioned above, according to researchers, TPCK/ TPACK is crucial for adequate teaching with technologies. It is important to say that Mishra and Koehler (2006) also called "TPCK" as "TPACK."

As previously mentioned, the adequate development of the Knowledge Bases is crucial for the appropriate development of TPCK/ TPACK. Therefore, researchers and teacher educators must identify possible gaps in these types of teachers' knowledge, helping them adequately insert technological resources for teaching and learning. Similar to PCK, different research instruments have been used to address TPCK/TPACK (and the Knowledge Bases), as its framework cannot be assessed by a single instrument (Alayyar *et al*., 2012). The TPCK/ TPACK "need to be investigated from a number of complementary angles that contribute to a holistic assessment of how teachers teach with ICT" (Doering *et al*., 2009, p. 331). In this scene, the questionnaires are widely used in quantitative approaches as research data collection instruments (Chai *et al*., 2016), including those related to teachers' Knowledge Bases (such as PCK and TPCK/TPACK). Regarding the qualitative approaches, beyond the questionnaires, Archambault (2016) postulates that the most used data collection instruments are performance assessments (such as lesson plans, case-based scenarios, and an evaluation of design tasks, among others), interview measures, and observation tools.

Bearing those ideas in mind, in this paper, we aim to present a new instrument that should be used (simultaneously with other tools) for collecting data in research about teaching with technologies related to technological Knowledge Bases, including TPCK/ TPACK: the "*Content Representation with Technology*" or "*T-CoRe*." Unlike existing instruments, the *T-CoRe* will allow the identification of different types of KBs, which is crucial for the adequate development of TPCK/TPACK. Beyond that, it will be promising to identify possible gaps in teacher education related to these aspects and assist research in this field. From this, we will describe the test of this instrument, performed with Biology undergraduate students (USts) – prospective basic education

teachers of Science and Biology. The next section will explain how *T-CoRe* was created and developed.

2 Methodology

2.1 Theoretical fundaments for *T-CoRe* development

Due to the importance of the development of different kinds of Knowledge Bases (especially TPCK/TPACK) to the adequate insertion of technologies in teaching and learning, many researchers have been studying them. From this, we reviewed the papers written by Niess (2005; 2016), Angeli and Valanides (2005), and Mishra and Koehler (2006), some of the most important researchers in the area and the first to research it, categorizing the KBs that they postulated (Table 1). In the first column, we name the KBs based on our interpretation of the authors:

Table 1: Categories that summarize the teachers' Knowledge Bases postulated by Niess (2005;2016), Angeli and Valanides (2005), and Mishra and Koehler (2006).

KBs (our interpretation)	Niess (2005;2016)	Angeli and Valanides (2005)	Mishra and Koehler (2006)
Technological Pedagogical Knowledge	An overarching conception about the purposes for incorporating technology in teaching subject matter topics	----	Technological Pedagogical Knowledge
Knowledge of Students	Knowledge of students' understandings, thinking, and learning in subject matter topics with appropriate technologies	Knowledge of Students	----
Knowledge of Curriculum	Knowledge of curriculum and curriculum materials that integrate technology in learning and teaching subject matter topics	----	----
Content Knowledge	----	Subject area Knowledge	Content Knowledge
Pedagogical Knowledge	----	Pedagogical Knowledge	Pedagogical Knowledge
Technological Knowledge	----	ICT Knowledge	Technological Knowledge
Knowledge of Context	----	Knowledge of the environmental context	----
Technological Content Knowledge	----	----	Technological Content Knowledge
Pedagogical Content Knowledge	----	----	Pedagogical Content Knowledge
Technological Pedagogical Content Knowledge	Knowledge of instructional strategies and representations for teaching and learning subject matter topics with technologies	----	Technological Pedagogical Content Knowledge

Elaborated by the authors.

From these studies, as well as research about the teacher's Knowledge Bases and the use of technologies for teaching and learning, we believe that some KBs listed in Table 1 must be expanded due to the existence of knowledge related directly to technology. Starting from that, we propose: i) Knowledge of Curriculum: must include the teacher's knowledge of contents that students have to learn (we named it **Content Curriculum Knowledge/ CCuk**), as well as the teacher's knowledge of technological skills that students must develop from learning the content – e.g., collaboration, interaction, among others (we named it **Technology Curriculum Knowledge/ TCuK**); ii) Knowledge of Students: must include the difficulties that students may have about the content that is taught by teacher (we named it **Student' Difficulties with Content Knowledge – SDCK**) as well as their difficulties to use the chosen technology (we named it **Student' Difficulties with Technology Knowledge – SDTK**); iii) Technological Knowledge: must include general knowledge about technologies, focusing on technical skills such as knowing how to use a computer or a cell phone (we named it **General Technological Knowledge – GTK**) as well as specific knowledge about technologies (we named it **Specific Technological Knowledge – STK**), for example, know what kinds of videos teachers can find to teach Evolution or what kind of software they can use to teach Human Anatomy, etc. From this, we believe that teachers, besides knowing about technologies and how to use them, need to know what types of technological resources are available or can be developed for the specific content that they are going to teach (among the many possibilities that exist today); iv) Knowledge of Context: we consider that teachers, beyond knowledge about the **General Context – CxK**– (which includes socioeconomic factors, the general infrastructure of the school, pedagogical beliefs of school, among others), must know, specifically, about the technological context of the school, because their choices to use technologies in teaching depends on this context. We called this base **Technological Context Knowledge – TCxK**. Finally, we also believe that "Assessment" must be added to the Knowledge Bases shown in Table 1, as some studies have pointed out (e.g., The PCK Summit, as related by Helms and Stokes, 2013). Although this knowledge base can be included in Pedagogical Knowledge (PK), it is important to highlight it during teacher education: researchers have pointed out that teachers must know how to develop good assessments to succeed in the teaching-learning process. Thus, it is important to know what the teacher's conception of evaluative methods is related to the subject taught (we named it **Content Assessment Knowledge/CAK**)

and the technology they used (we named it **Technology Assessment Knowledge/ TAK**).

Figure 1 summarizes the Knowledge Bases that, in our analytic review, are important to develop TPCK/TPACK. It summarizes the Knowledge Bases proposed by Niess (2005; 2016), Angeli and Valanides (2005), and Mishra and Koehler (2006), as well as the new Bases that we proposed to expand them based on our literature review. We also consider the influence of teachers' beliefs about the insertion of technology in teaching: as some studies point out (e.g., Petko, 2012), teachers' beliefs are the key to the effective use of technologies in classrooms and their KBs development. From this, when teachers develop all these types of knowledge, they are likely to have a robust TPCK/TPACK or a "High-level TPCK/TPACK":

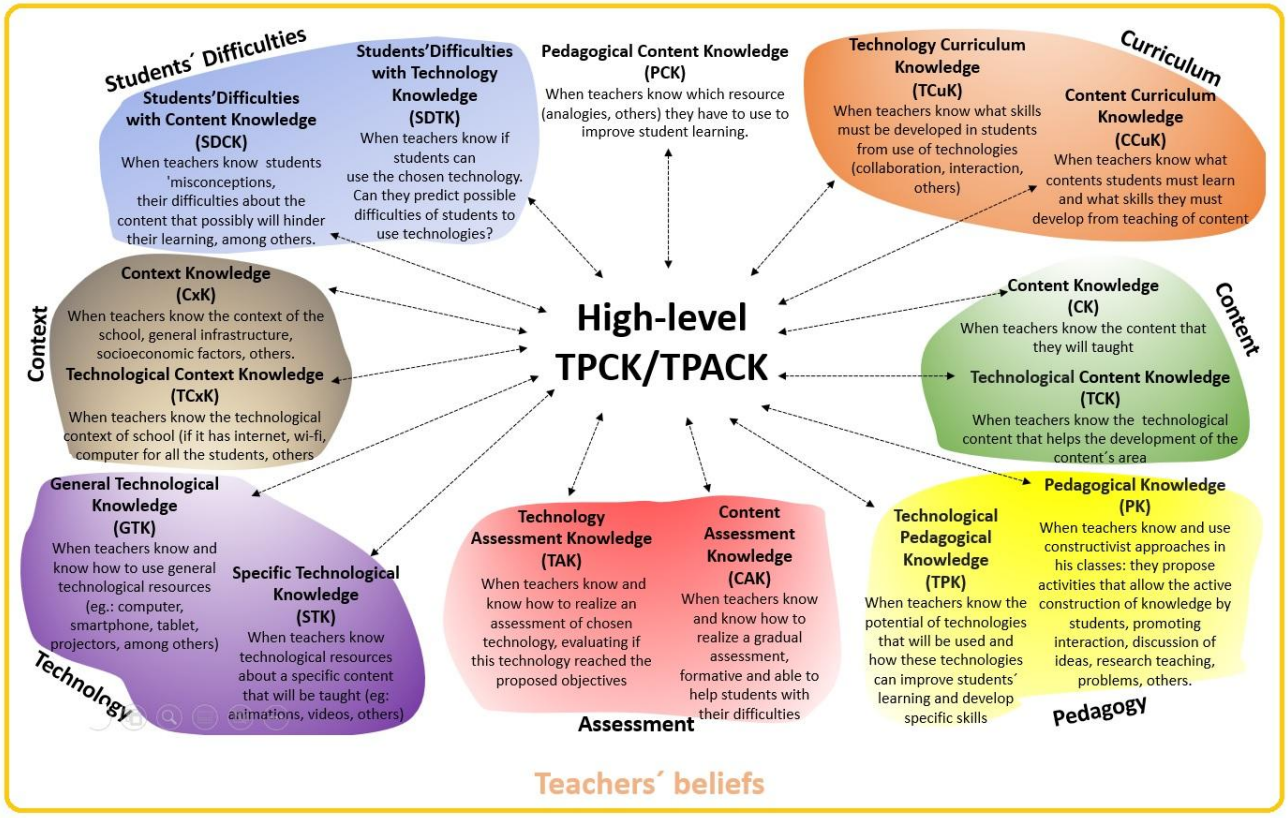

Figure 1: Knowledge Bases related to the construction of the high-level TPCK/TPACK, in our analytic review. Elaborated by the authors.

2.2 The construct of *T-CoRe*

Based on the Knowledge Bases presented in Figure 1 and on "*Content Representation*/*CoRe*" (which is a qualitative data collection instrument commonly used in studies about the *"Pedagogical Content Knowledge/PCK*" that was proposed by Loughran *et al*., 2004), we propose the "*T-CoRe.*" We believe this instrument can

be used in TPCK/TPACK research to help identify teachers' Knowledge Bases, evidencing their possible gaps and allowing more effective interventions in teacher education courses. In addition, we believe that *T-CoRe* can be a valuable instrument to be used during teachers' education because it can nurture reflections about the choices of specific technologies for teaching specific content. Below, we present the *T-CoRe*:

1. Content that will be taught: _____

2. Which ideas about this content do you want to teach?

Idea 1: _____
Idea 2: _____
Idea 3: _____
Idea... _____

	T-CoRe			
	Idea 1	**Idea 2**	**Idea 3**	**Idea ...**
1. What do you expect students to learn with this idea?	1.1	1.2	1.3	...
2. Which technology will you use to help students learn this idea?	2.1	2.2	2.3	...
3. Why did you choose this technology?	3.1	3.2	3.3	...
4. How can this technology help students understand this idea?	4.1	4.2	4.3	...
5. What kinds of skills does this technology help students develop?	5.1	5.2	5.3	...
6. What are the possible difficulties that this technology could pose to students learning this idea?	6.1	6.2	6.3	...
7. How do you intend to use this technology to teach this idea?	7.1	7.2	7.3	...
8. How do you evaluate if this technology was adequate to promote the teaching objectives related to this idea?	8.1	8.2	8.3	...

Figure 2: The *T-CoRe*, based on Loughran *et al.* (2004). Elaborated by the authors.

Table 2 below shows the types of Knowledge Bases we can identify in each question of *T-CoRe*. As it is possible to see, sometimes the bases may appear mixed in the responses of *T-CoRe* because, as we know, the knowledge is interconnected. Some studies have discussed this difficulty (e.g., Graça, 1997), which reflects how the Technological Pedagogical Content Knowledge (as well as "PCK") is complex and difficult to access (Loughran *et al*., 2004). From this, we highlight that we attempted to

separate the KBs into categories to facilitate the studies in this area, as well as the proposals for teachers' education:

Table 2: Knowledge Bases that we can identify in each *T-CoRe* question.

	Questions / Knowledge Bases	1	2	3	4	5	6	7	8
Content	**Content Knowledge (CK)**	X	X	X	X				
	Technological Content Knowledge (TCK)	X	X	X	X				
Curriculum	**Content Curriculum Knowledge (CCuK)**	X	X	X	X	X			
	Technological Curriculum Knowledge (TCuK)		X	X		X			
Pedagogy	**Pedagogical Knowledge (PK)**		X	X	X	X	X	X	X
	Technological Pedagogical Knowledge (TPK)		X	X	X	X	X	X	
Students' Difficulties	**Students' Difficulties with Content Knowledge (SDCK)**				X		X	X	
	Students' Difficulties with Technology Knowledge (SDTK)				X		X	X	
Technology	**General Technological Knowledge (GTK)**		X	X	X	X	X	X	X
	Specific Technological Knowledge (STK)		X	X	X	X	X	X	X
Assessment	**Content Assessment Knowledge (CAK)**						X	X	X
	Technology Assessment Knowledge (TAK)						X	X	X
Context	**Context Knowledge (CxK)**		X	X			X		
	Technological Context knowledge (TCxK)		X	X			X		
Pedagogical Content	**Pedagogical Content Knowledge (PCK)**			X	X		X	X	
	Technological Pedagogical Content Knowledge (TPCK/TPACK)		X	X	X		X	X	

Elaborated by the authors.

2.3 The test of *T-CoRe*

We applied a *T-CoRe* test with 18 undergraduate students (USts), with ages varying between 19 to 25 years old, who were divided into five groups in the Biological Sciences course from São Paulo University (Brazil) during the optional subject called "*Contexto e Práticas no Ensino de Zoologia*" [Context and Practices in Zoology

Teaching]. The subject was chosen due to its technological focus. In Table 3, we present the profile of the USts that participated in the *T-CoRe* test:

Table 3: Profile of the USts that participated in the *T-CoRe* test.

Groups	Gender	Age	Graduation period		Groups	Gender	Age	Graduation period
G1	W	21	6º		G4	W	20	8º
G1	W	24	6º		G4	M	21	7º
G2	W	25	8º		G4	W	21	8º
G2	W	25	6º		G4	M	22	8º
G2	W	24	12º		G4	M	23	8º
G2	W	NA	NA		-	-	-	-
G3	W	23	8º		G5	M	23	9º
G3	M	23	8º		G5	M	22	10º
G3	M	23	8º		G5	M	23	10º

Note: NA: No answer. Elaborated by the authors.

During fifteen classes of four hours, the USts studied different contents about Zoology teaching, and they were stimulated to create didactic sequences about this theme using Information and Communication Technologies – ICTs.

The application of *T-CoRe* happened during the 11th lesson, when the undergraduate students had already chosen the subjects of the didactic sequence and the technology that they would use in it. The specific content that each one of the five groups chose to teach was: *Comparative anatomy of the respiratory and circulatory systems in Chordates* (Group 1); *Diversity and phylogeny of Metazoa* (Group 2); *Vertebrates´ evolution* (Group 3); *Identification keys and phylogeny of vertebrates* (Group 4); *Concept of keystone species and flagship species* (Group 5). During *T-CoRe* application, the filling time of each group presented some differences: G1: 51 minutes; G2: 33 minutes; G3: 18 minutes; G4: 34 minutes and G5: 69 minutes.

The *T-CoRe* was answered in groups. From this, we could identify the reflections of the undergraduate students about technologies in educational practices. So, this helped us identify the real potentialities of our instrument for teacher education and for further research on this theme.

2.4 Analysis

We analyzed our data (the filling of the *T-CoRe* of each group as well as their dialogues during the filling of this instrument) according to Bardin (2013). The results and the discussion of this test is presented in the following section. The model of our analysis method is presented only for the first question of *T-CoRe*. For the other

questions, we present only the final categories we found (which represent the Knowledge Bases that are possibly identified in each question of the *T-CoRe* – Table 2). In some questions of the *T-CoRe*, as we expected, the dialogues of the USts and their fillings of the *T-CoRe* may be representative of more than one Knowledge Base.

Finally, we reinforce that in this article, we intend to demonstrate how Knowledge Bases can be identified by filling out the *T-CoRe*. It is not our purpose to assess the TPCK/TPACK of the USts, although many times we did that (as well as demonstrated some evidence of gaps in their Knowledge Bases) just to show the potential of the T-*CoRe* in identifying these aspects. For analysis of the technological Knowledge Bases of the surveyed USts, we recommend the paper published by Barbosa (2021).

3 Results and analysis of the test

We presume that the first question of *T-CoRe* (*What do you expect that students learn with this idea?)* allows us to identify these types of Knowledge Bases (as we showed in Table 2): i) Content knowledge (CK); ii) Technological Content Knowledge (TCK); iii) Content Curriculum Knowledge (CCuK). So, for G3, we could detect evidence of CK related to the subject matter that they chose to teach (Vertebrates' Evolution), as we present in the example below:

Dialogues of G3 during recording (question 1):
USt 3.1: That students understand the Evolution ...
USt 3.2: Not as a linear process... that human is not at the top of Evolution... that there is no explicit consensus about how evolutionary history is ...

Answers of G3 to *T-CoRe* (*T-CoRe* filling – question 1):
1.2 (Idea 2): Students understand that evolution is not a linear process, and humans are not at the top of this process.

Table 4: Data analysis according to Bardin (2013).

Category	Subcategory	Registration units	Context units
Content Knowledge (CK)	Evolution	Not as a linear	**USt 3.2:** *Not as a linear process…*
			***T-CoRe* filling**: [...] *that evolution is not a linear process* [...]
		Human	**USt 3.2: ...** *that humans are not at the top of Evolution,*
			***T-CoRe* filling**: [...] *Humans are not at the top of this process.*
		Consensus	**USt 3.2:** *... that there is no explicit consensus about how evolutionary history is...*

Elaborated by the authors.

The CCuK, in turn, was detected in the dialogues and the *T-CoRe* filling of G1, as we present below, which also validated our instrument:

Dialogues of G1 during recording (question 1):
USt 1.1: That they know the Anatomy ... hum … no, stop! Let me think something more decent ... that they know how to recognize it and how it works ... I do not know!
USt 1.2: To recognize the structures...hum?
USt 1.1: And how it is working ...
USt 1.2: What do you mean by "working"?
USt 1.1: How it works! The Physiology...
USt 1.2: May we put as an objective that they will search about the subject? Because they will search…
USt 1.1: I don´t think so...

Answers of G1 to *T-CoRe* (*T-CoRe* filling – question 1):
1.1 (Idea 1): That they recognize the structures and the functions of systems,
1.2 (Idea 2): They perceive the differences that can be found in distinct groups, and that they can connect these differences to the environment.

Table 5: Data analysis according to Bardin (2013).

Category	Subcategory	Registration units	Context units
Content Curriculum Knowledge (CCuK)	Conceptual Content	Anatomy	**USt 1.1**: *That they know the Anatomy...*
		No, stop!	**USt 1.1**: *...no, stop! Let me think of something more decent...*
		Structures	**USt 1.2**: *To recognize the structures...hum?*
			***T-CoRe* filling:** *That they recognize the structures* [...]
		Working	**USt 1.1:** *And how it is working ...*
			USt 1.2: *What do you mean by "working"?*
		Functions	**T- CoRe filling**: [...]*and the functions of systems*.
		Physiology	**USt 1.1:** *How it works! The Physiology...*
		Differences	**T- CoRe filling**: *That they perceive the differences that can be found in distinct groups* [...]
		Connect	**T- CoRe filling**: [...]*and that they can connect these differences to the environment...*
	Procedural Content	Recognize	**USt 1:** *that they know how to recognize it and how it works ... I do not know!*
		Search	**USt 2**: *May we put as an objective that they will search about the subject? Because they will search…*
		Don't think	**USt 1**: *I don´t think so...*

Elaborated by the authors.

We could not detect the TCK in the answers of the USTs for *T-CoRe* during this test. However, this absence may evidence a gap in the Knowledge Bases of USts that participated in this research, which was confirmed by Barbosa (2021). Despite that, we believe that we can find evidence of the TCK in future applications of *T-CoRe* (for answers to questions 1, 2, 3, and 4 – Table 2) because it is related to CK:

> Technological Content Knowledge (TCK) is an extension of content knowledge (CK). Both CK and TCK are examples of desired student knowledge as well as teacher knowledge. TCK in science represents

> knowledge of the technologies and representations that are relevant to functioning within a scientific domain: the technological knowledge that a scientist would have and that educators want young student-scientists to acquire. Examples of this kind of knowledge might include how to use technology to collect and analyze data, or how to use technology to model and understand difficult relationships in scientific data. (GRAHAM *et al*., 2009, p. 74)

For the second question of *T-CoRe* (*Which technology will you use to help students learn this idea?),* we intended to identify these types of Knowledge Bases (Table 2): i) Content Knowledge (CK); ii) Technological Content Knowledge (TCK); iii) Content Curriculum Knowledge (CCuK); iv) Technology Curriculum Knowledge (TCuK); v) Pedagogical Knowledge (PK); vi) Technological Pedagogical Knowledge (TPK); vii) General Technological Knowledge (GTK); viii) Specific Technological Knowledge (STK); ix) Context Knowledge (CxK); x) Technological Context Knowledge (TCxK); xi) Technological Pedagogical Content Knowledge (TPCK/TPACK). So, we detected some of them.

The evidence of PK was shown through the dialogue of G5 during the audio recording (excerpts below) when the USts demonstrated their knowledge about some kinds of didactic strategies (e.g., "expository lesson"). However, we believe that PK can be recognized in other moments, mixed with other Knowledge Bases. For example, about the ways of using technological resources suggested by the undergraduates, we can infer their conception of the teaching-learning process if they present proposals centered on the teacher or the student.

Dialogues of G5 during recording (question 2):
USt 5.2: That would be an expository *lesson* ...
USt 5.1: *Normal expository lesson*?
USt 5.2: Yeah...

About TPK, we detected it through the dialogue of G1:

Dialogues of G1 during recording (question 2):
USt 1.1: Circulatory? I found a website about respiratory, but it is a minimum! *Too superficial...not like those that were ridiculous, horrible, frightening!* (Laughs)

Dialogues of undergraduate students from G1 and G5 during audio recording show evidence of TPCK/TPACK:

Dialogues of G1 during recording (question 2):
USt 1.1: ...the teacher can say for the students...
USt 1.2: *...that they must make two videos? One with the compared and the other ... with the circulatory system* ...

Dialogues of G5 during recording (question 2):
USt 5.1: ...the keystone species and flagship species…

USt 5.3: May we present a video? Showing examples...
USt 5.2: Because this is a part of the conservation project. I think you can put the second and the third questions together because *we will ask students to search on the Internet about conservation projects, we will also show videos about the subject…I do not know…flyers about the theme, things like that* …

From *T-CoRe,* we identified that most groups proposed using technologies centered on the teacher, not the student, as Harris and Hofer (2009) recommended. This result is similar to other studies, such as Graham *et al*. (2009): these researchers defend that teacher-centered approaches with technologies may result from limited technology in the classroom or from the modeling and preparation they received in their teacher education courses. We believe that technologies must help develop some skills in students, such as building their knowledge, capacity for interaction and collaboration, and critical thinking skills (among others). Therefore, from the *T-CoRe* answers of the investigated groups, we believe some teacher education gaps are related to these Knowledge Bases (especially the PK, TPK, and TPCK/TPACK). So, we agree that teacher education courses must pay more attention to these aspects because, as we commented, technological resources nowadays represent an important part of the daily life of students in schools and other settings beyond this (Unesco, 2014). We have pointed out one exception to this result: as we presented, G1 intended to *ask students to make a video showing the subject* they studied during the classes. From our perspective, that means the technology used was centered on students and, in this case, teachers' TPCK/TPACK is closer to what we consider high-level TPCK/TPACK (Figure 1).

To the third question of *T-CoRe* (*Why did you choose this technology?*), we intend to identify these kinds of Knowledge Bases (as shown in Table 2): i) Content knowledge (CK); ii) Technological Content Knowledge (TCK); iii) Content Curriculum Knowledge (CCuK); iv) Technology Curriculum Knowledge (TCuK); v) Pedagogical Knowledge (PK); v) Technological Pedagogical Knowledge (TPK); vi) General Technological Knowledge (GTK); vii) Specific Technological Knowledge (STK); viii) Context Knowledge (CxK); xi) Technological Context Knowledge (TCxK); x) Pedagogical Content Knowledge (PCK); xi) Technological Pedagogical Content Knowledge (TPCK/TPACK).

We could detect PCK during the audio recording of G2, as evidenced by the passage below:

Dialogues of G2 during recording (question 3):
USt 2.1**:** *I chose to do a phylogeny to teach the montage of the phylogeny*. Why did I choose to do a phylogeny to teach montage of phylogeny? There's nothing to talk about! How will I explain the montage of phylogeny without doing a phylogeny?
USt 2.4: Yes... this makes sense!
USt 2.1: Because seeing a ready phylogeny is not enough for students to mount a phylogeny…
USt 2.4: It is because t*he montage of phylogeny is so much easier to learn when a student's learning is an active process… when the student is doing an active action, it is easier for them to internalize the concepts also because a montage of phylogeny is a part of the ... it shows a scientific method*, that's right?

Another knowledge base that was identified in the dialogues of the undergraduate students (G2) in this question was TPK:

Dialogues of G2 during recording (question 3):
USt 2.4: I do not know whether it's an argument, but the *facility of using videos*, right? It's *easier to use a video*!
USt 2.1: Yes! I put here: that it´s easier to *use a video to show the process*…

About TPCK/TPACK, we detected it through G2's dialogue and G4's answer to the *T-CoRe*:

Dialogues of G2 during recording (question 3):
USt 2.4: Why did we choose video? Because...
USt 2.1: It is *an easier way to show diversity because you cannot bring the animals into the classroom*. We could take them to the zoo, but even then, it does not show… many times, just shows vertebrates….

G4 during *T-CoRe* filling (question 3):
3.2 (Idea 2): To *introduce the concepts of systematics, we will give a dialogic lecture showing that PowerPoint is a useful technology for presenting images and helping the construction of cladograms* and the related conceptual content.

From the dialogues, we can assume that PCK of USt 2.1 shows some gaps because he could not explain why the montage of phylogeny was chosen to teach this content to students. USt 2.4, on the other hand, presented some arguments for choosing this type of activity: for him, besides the montage of phylogeny facilitating students' understanding of the theme to be taught, it will also allow these students to actively experiment with the scientific method, one of the procedural contents that are presented in Brazil Science teaching and Brazil Biology teaching today (e.g., Brasil, 2018). So, we noted that *T-CoRe* helps us identify that USt 2.1 shows gaps in his PCK, while USt 2.4 has a more robust knowledge base.

Regarding TPK, from the use of the *T-CoRe*, we note that the pedagogical choice of G2-USts is related to the *facility of using videos*. However, we also believe that this dialogue evidence them PK: the choice of a technological resource is primarily related to the teacher's practice, not students' learning (for G2-USts, videos can be easily used by teachers in general). In addition, some excerpts from this dialogue (such as "*show* the process") provide evidence of their conception of teaching, possibly

marked by traditional approaches to teaching that often treat students as passive subjects and receivers of information.

About TPCK/TPACK, the excerpts of G2 and G4 evidenced that the undergraduate students presented some gaps in this knowledge base. So, we cannot consider that they have a high-level TPCK/TPACK, as explained in Figure 1. Although both groups had chosen different technological resources (G2: video; G4: presentation with PowerPoint), they suggested similar forms of use of these technologies (to show images and to present information). In our view, this demonstrates (in an implicit way) that the pedagogical beliefs of these USts may be rooted in traditional conceptions of teaching. As we have discussed, when organizers of teacher education courses identify these gaps, they can help USts (as well as in-service teachers) develop their TPCK/TPACK, enabling them to propose activities with technologies that could promote active participation of students in schools, as highlighted by some studies (e.g., Blackwell, 2013).

From the fourth question of *T-CoRe* (*How can this technology help students understand this idea?*), we intended to identify these kinds of Knowledge Bases (as shown in Table 2): i) Content Knowledge (CK); ii) Technological Content Knowledge (TCK); iii) Content Curriculum Knowledge (CCuK); iv) Pedagogical Knowledge (PK); v) Technological Pedagogical Knowledge (TPK); vi) Students' Difficulties with Content Knowledge (SDCK); vii) Students' Difficulties with Technology Knowledge (SDTK); viii) General Technological Knowledge (GTK); ix) Specific Technological Knowledge (STK); x) Pedagogical Content Knowledge (PCK); xi) Technological Pedagogical Content Knowledge (TPCK/TPACK).

We could detect PCK in the dialogue of G2 about *this T-CoRe* question:

Dialogues of G2 during recording (question 4):
USt 2.1: Montage of phylogeny... I think that *the montage of phylogeny helps students to learn Evolution*…
USt 2.3: Yes! It helps them to know that there is more than one possibility to do a montage of phylogeny...
USt 2.4: The scientific process...
USt 2.3: Yeah! The scientific process...
USt 2.4: The scientific method...another thing: *phylogeny is a graphical representation of relationships, so I think this also helps students to understand the relationships… to understand Evolution*...
USt 2.3: It shows that there is more than one possibility of answer…

Other Knowledge Bases that were identified are TPK, PK, CCuK, and TPCK/TPACK, as shown below:

Dialogues of G1 during recording (question 4):
Technological Pedagogical Knowledge –TPK (about the choice of websites)
USt 1.1: Ham... is it [a way] *less boring*?
USt 1.2*: It has not have so much text*…
USt 1.1: Yeah! And *it is an alternative to expositive lessons*…I don´t know…
USt 1.2: It is an alternative to expositive lessons…

Dialogues of G5 during recording (question 4):
Pedagogical Knowledge – PK
USt 5.1: Why did we choose PowerPoint?
USt 5.2: It's not PowerPoint! It's a *dialogic lecture*!
USt 5.1: OK, so why did we choose a dialogic lecture?
USt 5.2: Because they knew the concept previously, so we chose...

Dialogues of G5 during recording (question 4):
Content Curriculum Knowledge – CCuK (procedural content)
USt 5.1: 4.3 is how technology can help? It will help because *it will put the student in the researcher's place… so, he will reflect better*...

Dialogues of G4 during recording (question 4):
Technological pedagogical Content Knowledge –TPCK/TPACK (about PowerPoint)
USt 1.4: How can this *technology help students understand this idea?*
USt 1.2: [It shows*] the steps for the construction of a cladogram*…

In the same way, as observed in other questions, in question 4 of *T-CoRe*, we detected some gaps in the Knowledge Bases of these USts: they showed traces of traditional teaching, focusing the process of learning on the teacher (they chose technologies to show the contents to the students, for example), as discussed in some research (e.g., Graham *et al*., 2009). Therefore, we believe their TPCK/TPACK cannot be considered "high-level," reinforcing the point of attention to teacher training courses. Besides that, the *T-CoRe* also shows that G5 knows some procedural contents that students must learn at school, as highlighted by the new Brazilian curriculum proposal (e.g., Brasil, 2018).

On the fifth question of *T-CoRe* (*What kinds of skills does this technology help students develop?*), we intended to identify (as shown in Table 2): i) Content Curriculum Knowledge (CCuK); ii) Technological Content Curriculum Knowledge (TCuK); iii) Pedagogical Knowledge (PK); iv) Technological Pedagogical Knowledge (TPK); v) General Technological Knowledge (GTK); vi) Specific Technological Knowledge (STK).

From this, we could detect CCuK during the audio recording of G3: according to Brasil (2018), for Scientific Education, the student must understand the Nature of Science. It means that he must know that Science is not neutral, and that knowledge can change:

Dialogues of G3 during recording (question 5):
USt 3.3: *Knowing that knowledge is a changeable thing*, it is not a...

About TCuK and TPK, we considered they were mixed in the dialogues of the groups because, for us, knowing what skills the students must develop when technology is used in teaching demonstrates the USts understanding of the curriculum in technologies as well as their understanding of the pedagogical potentialities of the chosen technologies for the development of some skills (TPK). So, we considered the excerpt "*to learn by themselves*" as evidence of a required skill that belongs to TCuK because the USts wish that students could research on the Internet independently of the teacher. The excerpt "*perhaps the website is to make them learn by themselves,"* in turn, could be included in TPK because the USts believe that websites, in general, can be used to provide the development of the mentioned skill ("*learn by themselves*"). The excerpts below show these results:

Dialogues of G1 about websites during recording (question 5):
USt 1.2:5... what kind of skills... (Thinking of)
USt 1.1: ... in the students ... *perhaps the website could allow them to learn by themselves. How do we say that? Self-taught? What's that word*?

From this, as we pointed out, *T-CoRe* shows that USt 3.3 demonstrates his understanding of one of the Science teaching objectives (CCuK), which allows students in schools to understand Science as a human product, questionable and susceptible to errors (Brasil, 2018). Besides that, the instrument also shows that USts know some potentialities of websites, focusing the use of these technologies on the students, which, in our vision, is positive. About the PK, GTK, and STK, we believe they are implicit in these dialogues because we can infer some conceptions of the USTs about teaching and learning, as well as evidence of the undergraduate student's knowledge of technologies (e.g., websites - GTK; websites about the content of the class - STK).

On the sixth question of *T-CoRe* (*What are possible difficulties the use of this technology could endorse in students learning this idea?*), we intended to identify (as shown in Table 2): i) Pedagogical Knowledge (PK); ii) Technological Pedagogical Knowledge (TPK); iii) Students' Difficulties with Content Knowledge (SDCK); iv) Students' Difficulties with Technology Knowledge (SDTK); v) General Technological Knowledge (GTK); vi) Specific Technological Knowledge (STK); vii) Content Assessment Knowledge (CAK); viii) Technology Assessment Knowledge (TAK); ix) Context Knowledge (CxK); x) Technological Context Knowledge (TCxK); xi)

Pedagogical Content Knowledge (PCK); xii) Technological Pedagogical Content Knowledge (TPCK/TPACK).

So, the dialogue of G4 during recording (about the use of PowerPoint presentations) was about how the teacher should prepare the presentations and not about the pedagogical potentialities of PowerPoint use for students' learning. Specifically, regarding the TPK, the dialogue of G2 during the recording showed that USt 2.1 presented some gaps in his knowledge base because she could not say what the main difficulties that students could have when the teacher had to work with a video were (for example, tiredness or demotivation if the video was too long).

Dialogues of G2 about Videos during recording (question 6):
Technological Pedagogical Knowledge – TPK:
USt 2.1: About video?
USt 2.4: Difficulty?
USt 2.1: *There is not any difficulty with video*... but, about the montage of phylogeny is the montage itself...

On the other hand, from *T-CoRe*, we could detect TCxK, SDTK, and SDCK; in some moments, the USts had an adequate vision of the technological context of some Brazilian schools (e.g., the absence of internet access, especially in some public schools) as well as about some difficulties that students possible show when they learn about some contents (e.g., difficulties with the montage of phylogeny, when they learn "Evolution"). The perception about possible difficulties when they use technologies also appeared in the dialogues (e.g., difficulties with "boring" sites that make tiredness in the students):

Dialogues of G1 during recording (question 6):
Technological Context Knowledge – TCxK:
USt 1.2: Computers*... internet access*...

Dialogues of G1 during recording (question 6):
Students' Difficulties with Technology Knowledge – SDTK:
USt 1.1: Good remembrance is what she wrote here: *that if it* [websites*] is boring, they will give up* ...

Dialogues of G2 during recording (question 6):
Students' Difficulties with Content Knowledge – SDCK:
USt 2.4: Difficulty?
USt 2.1: There is not any difficulty with the video... but, *about the montage of phylogeny is the montage itself* ...
USt 2.2: Yeah! *They know kinship relations...*
USt 2.4: *Through the data...*
USt 2.3: *The principles of montage... the principle of cladistics*... I do not know!

On the seventh question of *T-CoRe* (*How do you intend to use this technology to teach this idea?*), we intended to identify these kinds of Knowledge Bases (as shown

in Table 2): i) Pedagogical Knowledge (PK); ii) Technological Pedagogical Knowledge (TPK); iii) Students' Difficulties with Content Knowledge (SDCK); iv) Students' Difficulties with Technology Knowledge (SDTK); v) General Technological Knowledge (GTK); vi) Specific Technological Knowledge (STK); vii) Content Assessment Knowledge (CAK); viii) Technology Assessment Knowledge (TAK); ix) Pedagogical Content Knowledge (PCK); x) Technological Pedagogical Content Knowledge (TPCK/TPACK).

From *T-CoRe,* we could detect PK (e.g., didactic strategy: circles of conversation; students' preconceptions about the content), SDTK, PCK, STK, and TPCK/TPACK, whose evidence is presented below:

Dialogues of G5 during recording (question 7):
Pedagogical Knowledge – PK:
Ah…*the circles of conversation* will be applied to promote a debate *about species concepts that they know*. Oh, I thought: the discussion is going to be used *to debate* the *previous concepts* of species of students and, at the same time, to create... not to create, to consolidate... [concepts]
USt 5.3: *Concepts that they know previously...*
USt 5.1: Yes…

G3 during T- CoRe filling (question 7):
Students' Difficulties with Technology Knowledge – SDTK:
USt 3.3: The students' age can also be one of the difficulties because some students *do not know how to use media*...

Dialogues of G5 during recording (question 7):
Pedagogical Content Knowledge – PCK:
USt 5.1: Oh, I thought*: the discussion is going to be used to debate the students´ previous concepts of species and, at the same time, to create... not to create, to consolidate*...[concepts]

Dialogues of G5 during recording (question 7):
Specific Technological Knowledge – STK:
USt 5.1: Is *Bee Movie* an appeal to save the bees? I did not see *Bee Movie*, but a student asked me: "Is it true that the bees are dying out?" I said: "Yes! There's an extinction ..."

Dialogues of G1 during recording (question 7):
Technological Pedagogical Content Knowledge – TPCK/TPACK:
USt 1.1: *The video will show the differences that students should perceive between distinct group*s...
[…] the video is a summary of all the content.

Finally, on the eighth question of *T-CoRe* (*How do you evaluate if this technology was adequate to promote the teaching objectives related to this idea?*), we expected to find these Knowledge Bases (Table 2): i) Pedagogical Knowledge (PK); ii) General Technological Knowledge (GTK); iii) Specific Technological Knowledge (STK); iv) Content Assessment Knowledge (CAK); v) Technology Assessment Knowledge (TAK).

From *T-CoRe*, we detected all of them. However, for us, STK was implicit because it can be evidenced through the groups' discussions during the recording (as

well as through the USts answers to *T-CoRe*) when they demonstrate that they know some technological resources that can be used to teach about the content. GTK, in turn, can also be identified in this same way, but one of the USts of G4 evidenced gaps in this knowledge base when she demonstrated not knowing what she considered "technology." Beyond that, from *T-CoRe,* we observed that some groups had difficulties proposing assessments about the technologies they suggested using: G1, for example, proposed a final work (questions about the subject studied) as a form of assessment. We note that this evaluation proposal is related to the content they suggested teaching, not to the technology they suggested using (websites and videos). The excerpts below show our results in this question:

Dialogues of G4 during recording (question 8):
General Technological Knowledge – GTK
USt 4.1: What technology do you... *the montage of the cladogram is not a technology, is it?*

Dialogues of G3 during recording (question 8):
Pedagogical Knowledge – PK:
USt 3.2: ... because, as far as I know, *you cannot get two classrooms that are in the same year and apply the method to one and not to the other*, so what you can do is compare with previous classes ...[...]

Dialogues of G4 during recording (question 8):
Content Assessment Knowledge – CAK:
USt 4.2: Will it be [evaluated] *during the [cladogram] construction*?
[...]
USt 4.4: No, afterwards, too! *Maybe if they have any difficulty when listing characteristics that we gave them, it's one thing, but if they make a mistake about something that the teacher taught in class, that's because it did not work*...

Dialogues of G1 during recording (question 8):
Technology Assessment Knowledge – TAK:
USt 1.2: [We will evaluate] what they will put in the activities! Ah! I know! [We will evaluate] how they will use the indicated websites ... if they did a good job?
USt 1.1: If they used [the website]? No! If they...
USt 1.2: We will see... it depends... according to the answers in the... I do not know...
USt 1.1: In the quiz...

From this, as in the original studies on Pedagogical Content Knowledge (PCK), where the use of the qualitative instrument "*CoRe*" is recurrent (e.g., Loughran *et al*. 2004) and brings elements that would hardly be obtained only through quantitative data collection methods (present in large numbers in the fields of study on TPCK/TPACK – e.g., Luik, 2018), we believed it was necessary to develop an instrument that would allow the researcher (and teacher's educators) to access the teachers' technological knowledge deeply. We believe that *T-CoRe* is a promising instrument for this purpose because it allowed the identification of different types of Knowledge Bases of the undergraduate students that were investigated in this study. Also, the *T-CoRe* highlighted the gaps that need to be better addressed during

teachers' education, as well as the absence of some types of Knowledge Bases in the USts' responses (e.g., Technological Content Knowledge/TCK and Technology Assessment Knowledge/TAK), which need more attention from the teachers' educators and researchers.

Based on this study, we emphasize that teaching is not a simple transmission of information: educators must develop a set of Knowledge Bases that exceed the domains of disciplinary content, allowing them to create effective learning strategies. Thus, teachers' development of TPCK/TPACK can be a good plan. However, in a country with so many inequalities, like Brazil, this action goes beyond simple knowledge of the use of technological tools and choosing the most appropriate way of teaching each topic, which also involves deep knowledge of each student's context. Once again, teachers' technological-pedagogical choices must consider students' abilities and access to learning with the support of technologies.

4 Conclusions

The *T-CoRe* was presented and tested in this study, and the results highlighted the potential of this new instrument, which can be used in qualitative research on TPCK/TPACK and teacher education courses. In addition, the theoretical framework used to develop *T-CoRe* (summarized in Figure 1) can represent a new model to help analytical investigations about technology-related Knowledge Bases, since the model not only incorporated and revised traditional knowledge but also brought some new aspects that require researchers' attention.

We detected that each question of *T-CoRe* has great potential to help identify specific teachers' Knowledge Bases. However, the knowledge is composed of many strongly related parts, so it is important to look for indications of Knowledge Bases in all the responses, assuming a more integrated approach. Thus, researchers can better explore the potential of the instrument.

In the test, some of the Knowledge Bases were not directly identified in the discussions of the undergraduate students' groups nor in the fillings of *T-CoRe*. We believe that this absence may be related to specific characteristics of the participants, who were in the initial teacher education process, lacking practical classroom experiences. So, we do not exclude the possibility that these Knowledge Bases can be identified in further applications of *T-CoRe*.

Finally, we highlight the importance of teacher education courses helping develop TPCK/TPACK and its related Knowledge Bases, allowing preservice teachers (and in-service teachers) to reflect on the potential of technologies in the teaching-learning process. From this, we believe we can qualify students capable of living in contemporary society and adequately using today's technologies.

References

ALAYYAR, G.; FISSER, P.; VOOGT, J. Developing technological pedagogical content knowledge in pre-service science teachers: Support from blended learning. **Australasian Journal of Educational Technology**, v. 28, n.8, p. 1298-1316, 2012.

ANGELI, C.; VALANIDES, N. Preservice elementary teachers as information and communication technology designers: an instructional systems design model based on an expanded view of pedagogical content knowledge. **Journal of Computer Assisted Learning**, v. 21, n. 4, p. 292–302, 2005.

ARCHAMBAULT, L. Exploring the use of qualitative methods to examine TPACK. In M. C. HERRING, P. MISHRA, & M.J. KOEHLER, (Eds.). **Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators**. New York, NY: Routledge, p.65-86, 2016.

BARBOSA, P. P. Os conhecimentos tecnológicos na prática educativa: reflexões ressurgentes na formação de docentes de Ciências e Biologia. **Investigações em Ensino de Ciências**, v. 26, n.3, p. 259-280, 2021.

BARDIN, L. **L'analyse de contenu.** Paris: Presses Universitaires de France – PUF, 2013.

BARNETT, J.; HODSON, D. Pedagogical content knowledge: toward a fuller understanding of what good science teachers know. **Science Teacher Education**, v. 84, n.4, p.426-453, 2001.

BLACKWELL, C. K. Teacher practices with mobile technology: Integrating iPads into the early childhood classroom. **Journal of Education Research**, v.7, n.4, p.1–25, 2013.

BRASIL. Ministério da Educação. Base Nacional Comum Curricular. Secretaria da Educação Básica. Brasília, DF: MEC/CONSED, 2018.

BRIANZA, E., SCHMID, M., TONDEUR, J., PETKO, D. The digital silver lining of the pandemic: The impact on preservice teachers' technological knowledge and beliefs. **Ededucation and Information Technologies**, v. 29, p.1591-1616, 2024.

CHAI, C. S.; LING KOH, J. H.; TSAI, C. A Review of the Quantitative Measures of Technological Pedagogical Content Knowledge (TPACK). In M. C. HERRING, P. MISHRA; M.J. KOEHLER, (Eds.). **Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators**. New York, NY: Routledge, p.87-106, 2016.

COSTA, F.; RODRIGUES, A.; PERALTA, M. H.; CRUZ, E.; REIS, O.; RAMOS, J. L.; SEBASTIÃO, L.; MAIO, V.; DIAS, P.; GOMES, M. J.; OSÓRIO, A. J.; RAMOS, A.; VALENTE, L. **Competências TIC**: Estudo de Implementação. Vol. I. Lisboa: GEPE-Ministério da Educação, 2008.

DOERING, A.; SCHARBER, C.; MILLER, C.; VELETSIANOS, G. GeoThentic: Designing and assessing with technology, pedagogy, and content knowledge**. Contemporary Issues in Technology and Teacher Education**, v.9, n.3, p.316-336, 2009.

FERNANDEZ, C. Knowledge base for teaching and pedagogical content knowledge (PCK): Some useful models and implications for teacher training. **Problems of Education in the 21st Century**, v.60, p.79–100, 2014.

GRAHAM, C.R.; BURGOYNE, N.; CANTRELL, P.; SMITH, L.; CLAIR, L.ST.; HARRIS, R. TPACK Development in Science Teaching: Measuring the TPACK Confidence of Inservice Science Teachers. **TechTrends,** v.53, n.5, p.70-79, 2009.

GROSSMAN, P.L. **The making of a teacher:** teacher knowledge and teacher education. New York: Teachers College Press, 1990.

HARRIS, J.; HOFER, M. Instructional Planning Activity Types as Vehicles for Curriculum-Based TPACK Development**. Research Highlights in Technology and Teacher Education,** p.99-108, 2009.

HELMS, J.; STOKES, L. **A meeting of minds around pedagogical content knowledge**: designing an international PCK Summit for professional, community, and field development. Inverness Research, 2013.

INTERNATIONAL ASSOCIATION FOR THE EVALUATION OF EDUCATION ACHIEVEMENT – IEA. **The International Computer and Information Literacy Study (ICILS)***:* main findings and implications for education policies in Europe, 2014.

KOEHLER, M. J.; MISHRA, P. What happens when teachers design educational technology? The development of technological pedagogical content knowledge. **Journal of Educational Computing Research**, v.32, n.2, p.131–152, 2005.

LOUGHRAN, J.J.; MULHALL, P.; BERRY, A. In Search of Pedagogical Content Knowledge in Science: Developing Ways of Articulating and Documenting Professional Practice. **Journal of Research in Science Teaching**, v.41, n.4, p.370-391, 2004.

LUIK, P; TAIMALU, M; SUVISTE, R. Perceptions of technological, pedagogical and content knowledge (TPACK) among pre-service teachers in Estonia. **Education and Information Technologies**, v.23, p.741–755, 2018.

MISHRA, P.; KOEHLER, M.J. Technological pedagogical content knowledge: A framework for teacher knowledge. **Teachers College Record,** v.108, n.6, p.1017–1054, 2006.

NIESS, M. L. Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. **Teaching and Teacher Education**, 21, p. 509–523, 2005.

NIESS, M. L. Transforming Teachers' Knowledge for Teaching With Technologies: an Online Learning Trajectory Instructional Approach. In M. C. HERRING; P. MISHRA; M.J. KOEHLER, (Eds.). **Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators**. New York, NY: Routledge, p.131-142, 2016.

PETKO, D. Teachers' Pedagogical Beliefs and Their Use of Digital Media in Classrooms: Sharpening the Focus of the "Will, Skill, Tool" Model and Integrating Teachers' Constructivist Orientations. **Computers & Education**, v.58, n.4, p.1351-1359, 2012.

RIBEIRO, P.R.L.; PIEDADE, J.M.N. Teacher Training for Distance Learning: an Analysis Considering the Knowledge Domains of the TPACK Model. **EaD em Foco**, 13, 1, e1935, 2023.

SHULMAN, L. S. Those who understand:knowledge growth in teaching. **Educational Researcher**, v.15, n.4, p.4-14, 1986.

_____. Knowledge and teaching: foundations of a new reform. **Harvard Educational Review,** v.57, n.1, p.1-22, 1987.

SHULMAN, L. S.; SYKES, G. **A national board for teaching?** In search of a bold standard. A report for the task force on teaching as a profession. Carnegie Corporation, New York, 1986.

TONDEUR, J.; VAN BRAAK, J.; SANG, G.; VOOGT, J.; FISSER, P.; OTTENBREIT-LEFTWICH, A. Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. **Computers & Education**, v.59, n.1, p.134–144, 2012.

UNESCO. **Unesco ICT competency framework for teachers**. United Nations Educational, Scientific and Cultural Organization, 2011, 95p.

UNESCO. **Tecnologias para a transformação da educação**: experiências bem sucedidas e expectativas. Madri: El País, Fundação Santillana, UNESCO, Google, Insper, Samsung, Microsoft, Fundação Telefônica Vivo, 2014.

URSI, S. Possibilidades e desafios da formação inicial de professores na Educação a Distância: relato sobre uma disciplina de Práticas para o Ensino de Biologia. IN: III ENCONTRO REGIONAL DE ENSINO DE BIOLOGIA - REGIONAL 1, 2017, Campo Grande, p. 52-57, 2017.

URSI, S., LIMA, T.F. Algae Approach on a Distance Education Course to In-service Brazilian Teachers. **IOSTE Letters**, v. 1, p. 284-289, 2021.