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Personal and Enacted PCK for teaching Earth science: A case study of a seven grade-school teacher

Claudia Vergara Díaz, *Kasandra Navarrete, Carolina Cartes, Hernán Cofré and Paola Nuñez*

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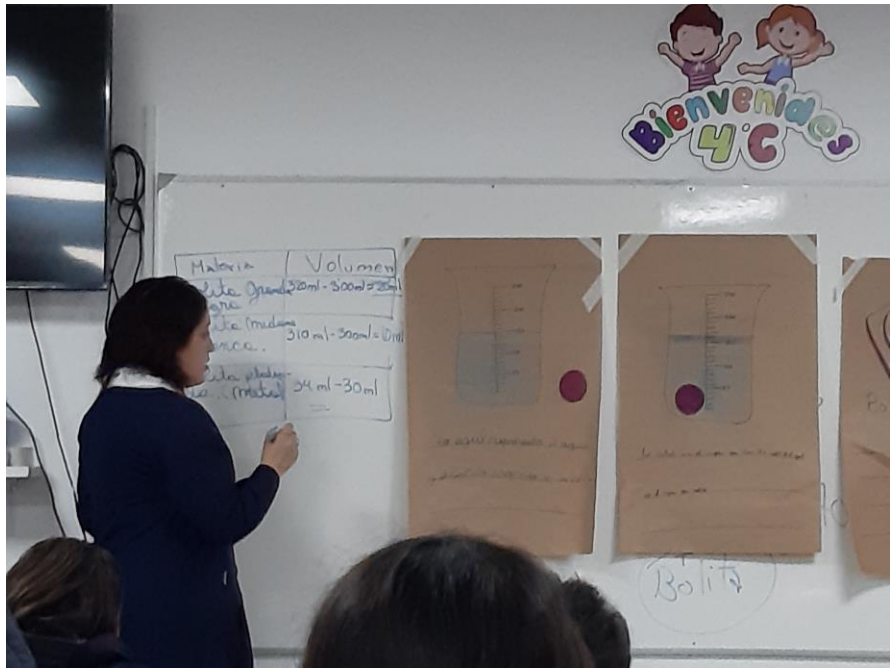
Introduction

Determining what teachers know and how they use this knowledge in their practice has been of great interest to researchers in recent decades (Van Driel et al., 2023).

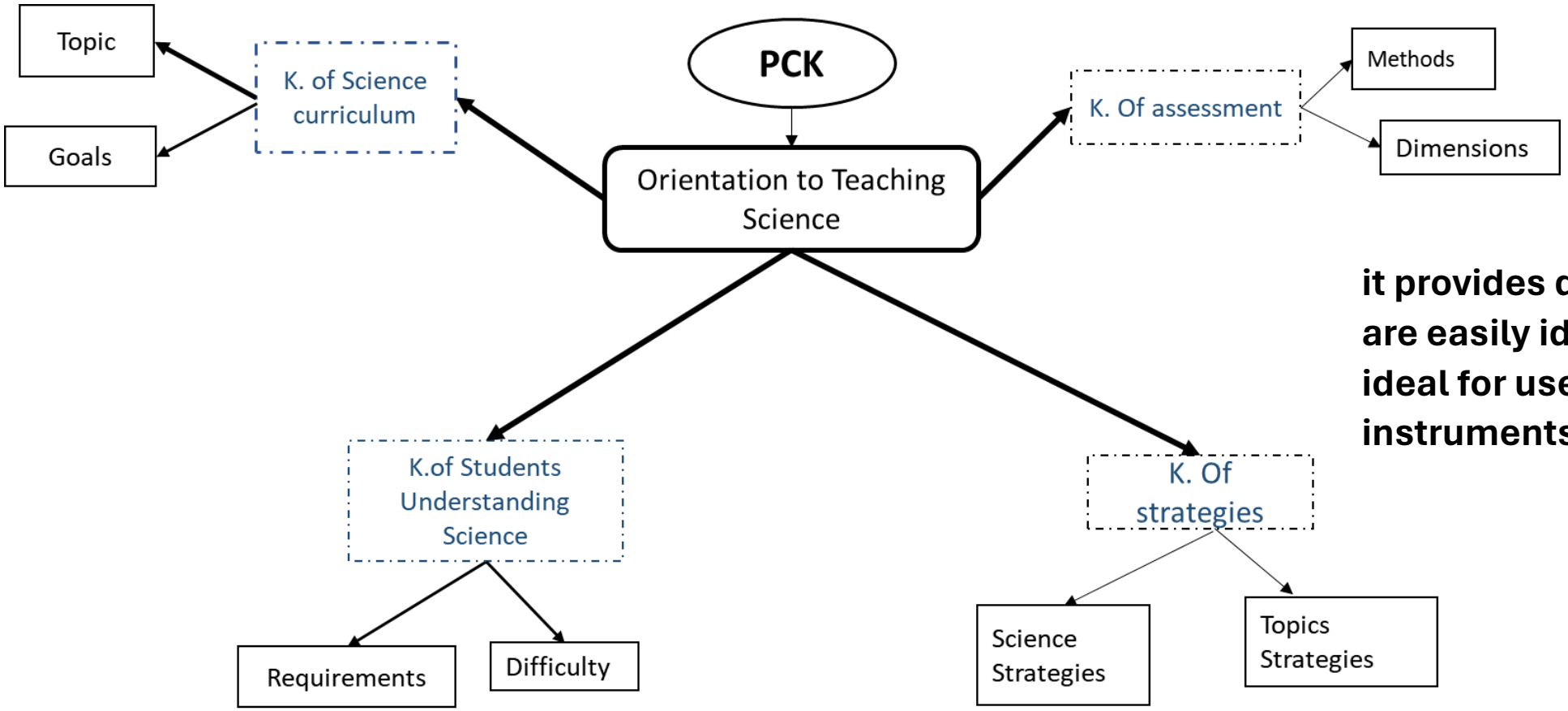


In the beginning, it was Shulman (1987)

- Content knowledge
- General Pedagogical Knowledge
- Curriculum knowledge
- Pedagogical Content Knowledge
- Knowledge of learners ans their characteristics
- Knowledge of educational contexts
- Knowledge of educational ends, purposes, and values

Magnusson, Krajcik and Borko (1999)

Creators of one of the most influential models of the last two decades and which concentrates almost 50% of the research published between the years 2008 and 2018 (Chan and Hume, 2019).



it provides discrete categories that are easily identifiable and therefore ideal for use in PCK assessment instruments.

Since the beginning of PCK research, the aim has been to **understand what the teacher does and what elements he/she considers when making decisions prior to teaching** (Loughran, Mulhall and Barry, 2008).

Declarative PCK / PCK-on-action / theoretical–formal PCK / propositional PCK

understanding it as the way of solving a series of tasks in the teaching preparation process. It is factual knowledge that can easily be expressed in sentences or indicative propositions

Baumert, Blum & Neubrand, 2004; Park & Oliver, 2008; Fenstermacher, 1994; Knight, 2002

Procedural PCK / PCK-in- action /craft knowledge / practical knowledge /

which refers to the actions that the teacher exhibits during teaching, for example, inside the classroom. Describes automated skills and action routines that are exercised in the performance of tasks.Thus, procedural PCK covers teachers' activities during a lesson.

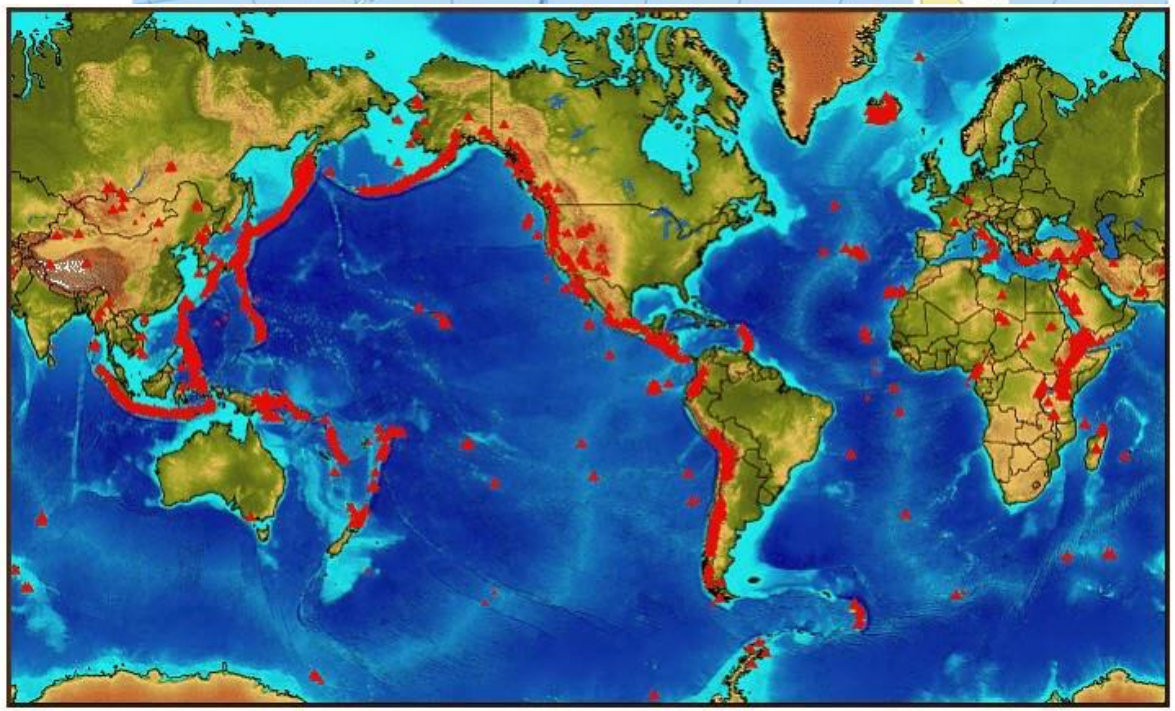
Baumert et al., 2004; Park & Oliver, 2008; van Driel et al., 1998; Fenstermacher, 1994

(Schmelzing et al, 2013).

In this study we work with the components of the Magnusson et al. (1999) model and recognize that this is expressed in a PCK on action and PCK in action (Park and Oliver, 2008).

Chilean Context

Located in a subduction environment for more than 4,000 km. where numerous earthquakes, volcanic eruptions, and geological faults occur (e.g., Tarbuck and Ludgens, 2005; Charrier et al., 2007), which can become a hazard by destroying or destabilizing a built ecosystem (Vargas, 2002; Lavell, 2004). In this sense earth science literacy (e.g., UNESCO, 2012; Cofré et al., 2010, Vergara et al., 2020) plays a significant role in all social aspects ranging from geological hazards and environmental degradation to the creation of sustainable economic systems or cities.



Research question

Our aim was to compare the **two types of PCK (on action and in action)**, to establish the level of concordance between them. We selected the topic **earth sciences** because this is a fundamental topic in Chilean curriculum and there is a scarcity of information on PCK on this topic in science education literature (Chan and Hume, 2019; Vergara et al., 2020).

The study was guided by the following questions:

- How is the PCK on action of a novel science teacher who teaches geoscience in 7th grade?
- How is the PCK in the action of a novel science teacher who teaches geoscience 7th grade?
- What is the relationship between PCK on action and in action in a novice teacher who teaches geoscience in middle school?

Methodology

The design is a case study, as it aims for a detailed and in-depth understanding of an elementary teacher with a background in earth science. According to Yin (2008) a case study is an empirical investigation that studies a contemporary phenomenon in depth and within its real-life context.

Matthew is an elemental school teacher with specializations in natural sciences. He has training in earth sciences and their teaching.

This is his second year of teaching experience, and work in a private subsidized school, in Santiago Chile. He teach from grade 4th to 8th

In 7th grade, earth science is included in the elementary Chilean national curriculum.

Table 1. The teacher taught 8 lessons (45 minutes long).

Lesson 1	Previous ideas on earth dynamics - plate tectonics. Pangea. Continental drift.
Lesson 2	Magnetism of the earth - Seafloor spreading. Guide.
Lesson 3	Layers of the earth and their distribution. Demonstration of convection.
Lesson 4	Tectonic plate
Lesson 5	Configuration of the Chilean relief.
Lesson 6	Analogical model configuration of the earth's surface - guide.
Lesson 7	Volcanoes Models Guide
Lesson 8	Rock classification activity

Design

Capture PCK

PCK **on action** in earth science: a CoRe (Content Representation) interview **before and after** teaching the unit was applied (Loughran, Berry, & Mulhall, 2004).

PCK **in action** in earth science: all lessons were video recording.

Analysis

The CoRe interviews were analyzed using a matrix with pre-existing categories (Knowledge of Science Curricula, Knowledge of Instructional Strategies, Knowledge of Students Understanding of Science and Knowledge of Assessment) and emerging categories (Flick, 2007).

The video recording was analyzed using Videograph software, with a coding protocol was established based on the five components of the Magnusson et al. (1999) model, where we chose seven observable variables with their respective categories.

Analysis unit = 5 seconds, it was carried out independently by two researchers.

Lesson 1: adjustments were made to the categories, giving rise to emerging categories, achieving agreements between the researchers.

Lesson 2: repeated the process,

Lesson 3: repeated the process.

achieving agreement and the differences in the coding's were agreed upon and recoded**, with a Kappa of 0.78**

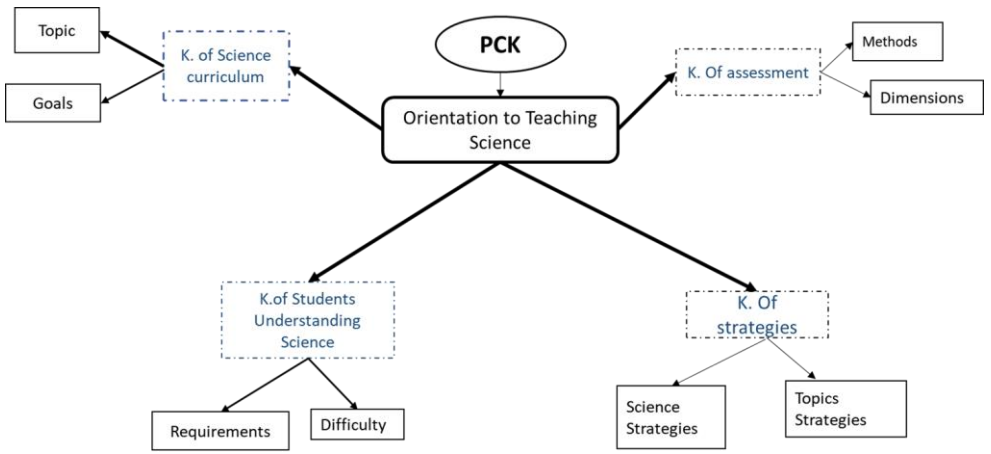
The coding of the lesson was transferred to SPSS for frequency analysis.

Finally, a methodologic al triangulation was carried out to increase the strength and quality of the study conclusions (Flick, 2007).

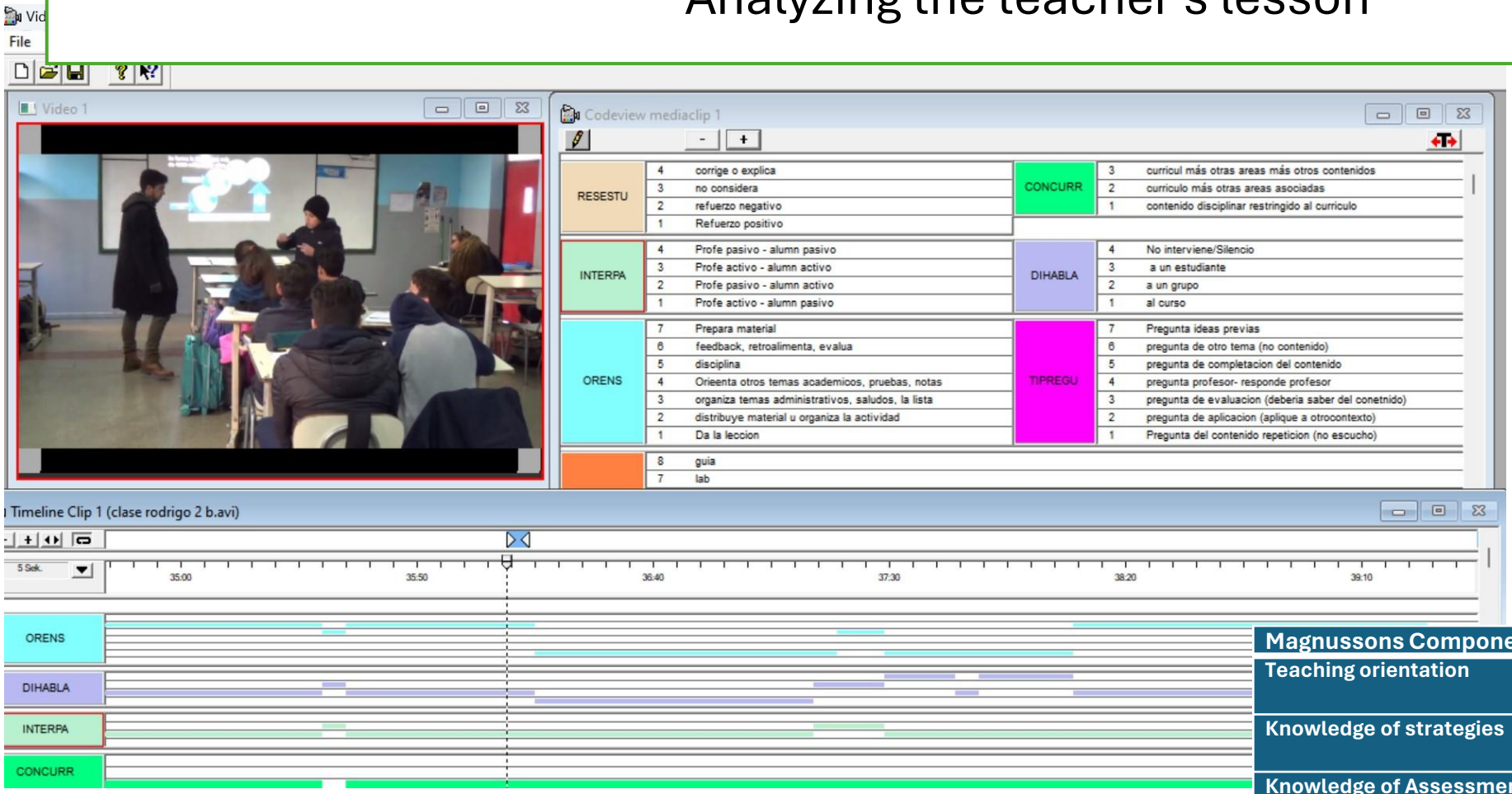
		How is teaching oriented?
Orientations to teaching science	1	Gives the lesson/Explains contents of the subject or unit
	2	Distribution of material or organization of the activity
	3	Guides administrative issues, greets
	4	Guides administrative issues, greets
	5	Discipline
	6	Feedback/asks questions
	7	Prepare the teaching-activity/introduce the content
	8	Introduction / Prepare teaching
		What type of strategies do you use?
Knowledge of teaching strategies. Type of Strategies	1	Models
	2	Expository/PPT
	3	Question-answer
	4	Videos- Audiovisual
	5	Puzzle with Guide
	6	H.O.S.
	7	Laboratory
	8	Use a Guide
	9	Demonstration
		Type of Question asked by the teacher?
Knowledge of assessment Teacher question type	1	Content-repetition question
	2	Application question (other context)
	3	Evaluation question (should know, current)
	4	Question teacher - answer teacher
	5	Content Completion Question
	6	Question from another topic
	7	Ask previous ideas
		How teacher respond to the student ?
Knowledge of assessment	1	Positive reinforcement
	2	negative reinforcement
	3	Not consider
	4	Explain or correct
		Content
knowledge of the curriculum	1	Disciplinary content restricted to the Learning Objective
	2	Learning Objective plus another area
	3	Learning Objective plus another area plus other content
		Knowledge of students

Coding Lesson

		Knowledge of students
Knowledge of student understanding Towards whom the speech is directed	1	The class
	2	A group
	3	A student
	4	I did not intervene / Silence
		TYPE OF INTERACTION
knowledge of student understanding Teacher - student interaction	1.	Active teacher - passive student
	2.	Passive student – active student
	3.	Active teacher – active student
	4.	Passive teacher - passive student

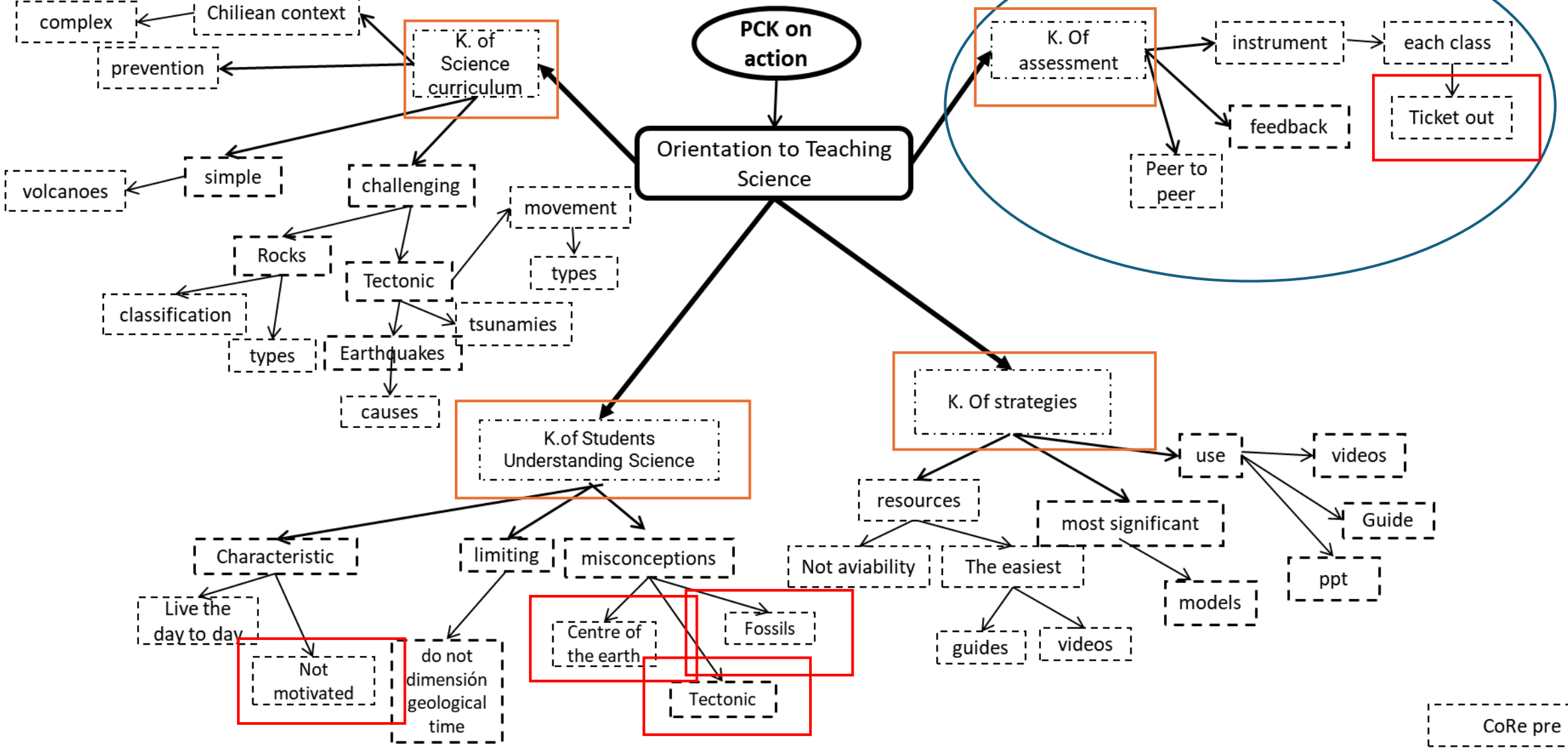


Analyzing the teacher's lesson



Magnussons Component	Guiding question	Categories
Teaching orientation	How is teaching oriented?	8 categories
Knowledge of strategies	What type of strategies do you use?	9 categories
Knowledge of Assessment	Type of Question asked by the teacher?	7 categories
Knowledge of Assessment	How teacher respond to the student	4 categories
Knowledge of Curriculum	Knowledge of Curriculum	3 categories
Knowledge of student understanding	Towards whom the speech is directed	4 categories
Knowledge of student understanding	Teacher - student interaction	4 categories

Findings


PCK on action
Orientation to Teaching Science
K. of Science curriculum
complex
Chilean context
prevention
volcanoes
simple
challenging
Rocks
classification
types
Tectonic
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Earthquakes
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Ticket out
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Peer to peer
K.of Students Understanding Science
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Live the day to day
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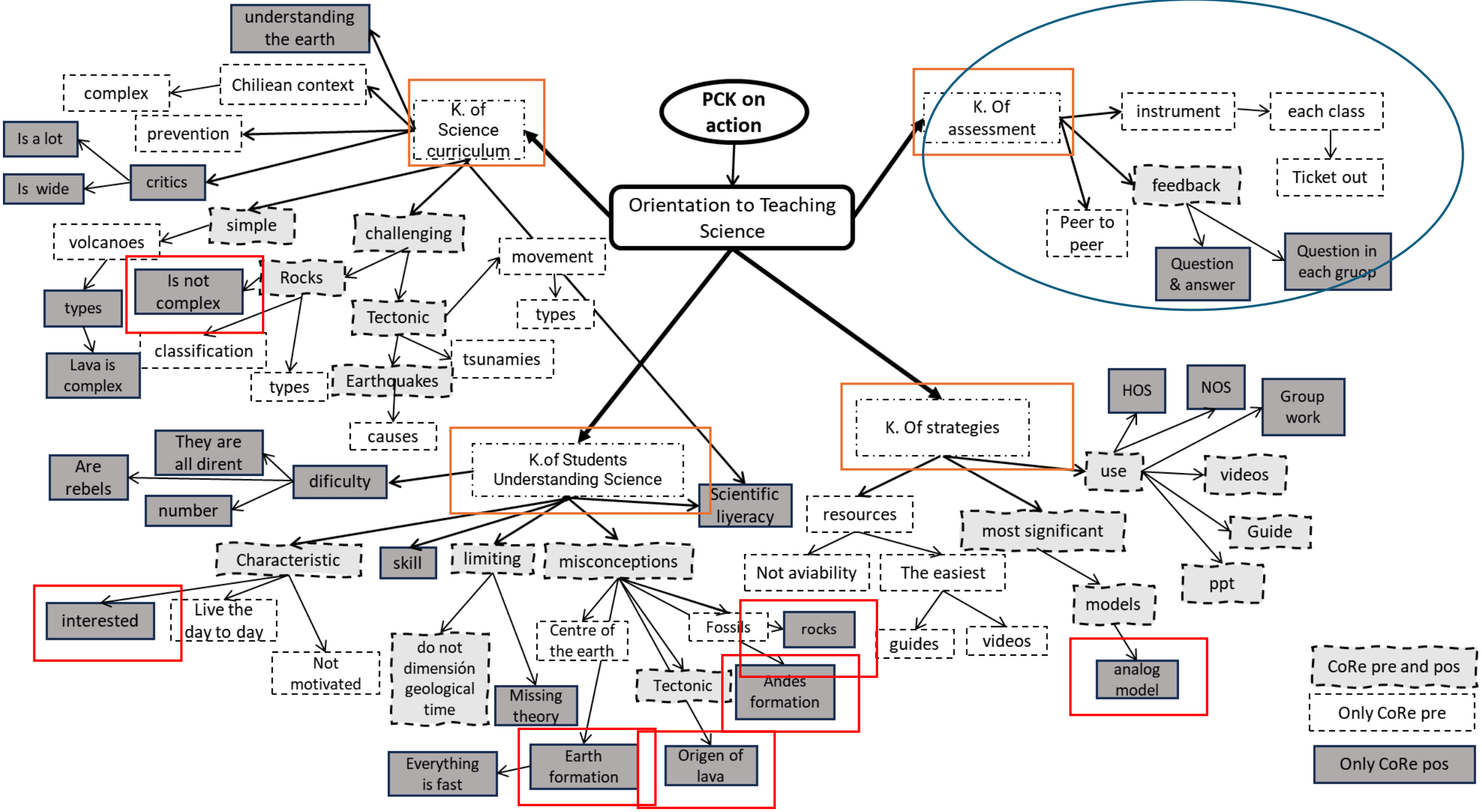
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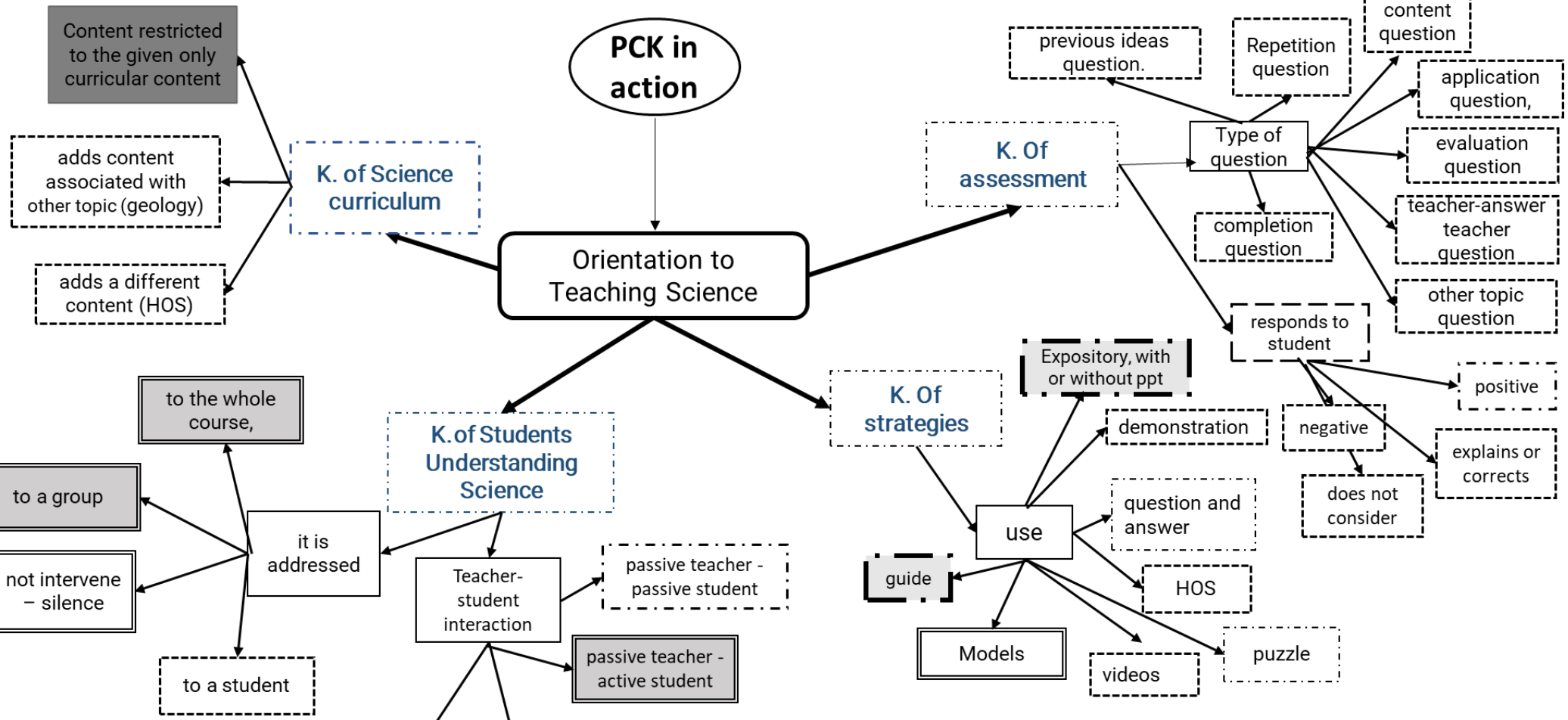
Only CoRe pos

Curriculum Knowledge	% Time 8 Lesson
Disciplinary content restricted to the Learning Objective	68,7
Learning Objective plus another area	1,1
Learning Objective plus another area plus other content	1,5



Towards whom the speech is directed	% Time 8 Lesson
The class	36
A group	40,9
A student	5,7
I did not intervene / Silence	16,3

Teacher - student intera	% Time 8 Lesson
Active teacher - passive student	23,3
Passive teacher – active student	37,8
Active teacher – active student	23
Passive teacher - passive student	11,7

Type of Strategies	% Time 8 Lesson
Models	**24,64**
Expository/PPT	**14,9**
Question-answer	8,48
Videos- Audiovisual	3,5
Puzzle with Guide	6,4
H.O.S.	5,2
Laboratory	13,82
Use a Guide	**13,8**
Demonstration	2,5

1% to 5 %
6% to 10%
10% to 15 %
25% to 30%
30% to 35 %
More at 60%

8 Lesson Analys

Discussion and Conclusions

This study describes the development of the PCK of a novice teacher on a content that has been little studied in the literature (Carlson and Daehler, 2019).
Our results emphasize that elementary school teachers who have been trained in the knowledge of earth sciences and its teaching can develop their PCK through their experience.

The most developed components were knowledge of strategies, knowledge of students understanding , and knowledge of science curriculum, which partially coincides with the theory on the PCK. Knowledge about assessment is the weakest component, as also described in the literature (Carlson and Daehler, 2019; Van Driel et al., 2023).

There is a certain degree of coherence between what the teacher declares and what he can implement. However, the teacher underestimates what he does in terms of evaluation, since he performs various instances throughout the lexion, although brief. He also seems to know more teaching strategies than he manages to implement.

The teacher is able to develop his or her PCK through reflection of his or her classes. He/she ends up with a more critical view of the content, recognizes new preconceptions and values more the teaching strategies used (Van Driel et al., 2023).

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