EUROPEAN SCIENCE EDUCATION RESEARCH ASSOCIATION

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Comparing Pedagogical Content Knowledge (PCK) in three exemplary Biology Teacher for Climate Change, Nature of Science, and Scientific Argumentation: A Study Case

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Introduction

To promote scientific literacy among students, it is not sufficient for teachers to be proficient in teaching content; they must be also able to develop skills and knowledge in teaching scientific argumentation (**SA**) and the nature of science (**NOS**).

This implies that science teachers need to enrich their **pedagogical content knowledge (PCK),** not only for specific disciplines, but also for NOS and scientific argumentation.

However, although there is research on **NOS PCK** (Schwartz & Lederman, 2002; García-Carmona, 2016; Mesci, 2020) and **SA PCK** (McNeill, & Knight, 2013; Sengul et al., 2020) separately, there are not studies that simultaneously explore the three types of PCK necessary to develop scientific literacy: NOS, SA, and Content.

Introduction

There are very few studies on PCK that have investigated two or more subjects (Chan & Hume, 2019). Some exceptions are: two specific historical contexts (Tuithof et al., 2023); mathematics and economics (Jeschke et al., 20221), two contents in chemistry (Aydin et al, 2014; Mavhunga, 2016; Akin & Uzuntiryaki-Kondakç, 2018), and two biology subjects (e.g., Park et al., 2011; Park and Chan, 2012; Barnett and Frederichsen, 2015).

However, there not exist many (or any?) studies that analyze PCK of content and PCK of NOS or PCK of content and PCK of SA together.

Introduction

Of particular interest is the study by Shu and Park (2017), which examined PCK of force and motion, and PCK of argumentation, because they recognize that "researchers have identified the components constituting the specialized PCK for SA" (e.g., the structure of argument or students' conceptions of argumentation) (McNeill & Knight, 2013).

However, they also said arguments and argumentation are not science content, therefore, talk about PCK of SA conflicts the topic-specificity definition of PCK (e.g., Shulman, 1987; Gess-Newsome, 2015). Therefore, they include PCK of SA inside the Orientation component of Magnusson model in the analyzes of content PCK.

Introduction

In this study, unlike Shu and Park, (2017), we assume that the PCK of SA, as well as PCK of NOS, are different PCKs from content (in this case CC), **therefore, we represent and study the 3 PCKs separately.**

Therefore, the main objective of this study was to compare the personal PCK of three exemplary biology teacher about Climate Change, NOS, and SA when they teach the same science content at secondary School?

Research Questions

What similarities and differences do the three pPCKs (climate change, NOS, and SA) have in each of the teachers?

What common patterns emerge when comparing the three pPCKs in the three teachers?

Methodology

This study employed a multiple case study design in which multiple cases are described and compared to provide insight into PCK relationships (Yin, 2018). Three exemplary biology teacher were selected, with between 11 and 28 years of experience and who had attended a professional development program on teaching climate change through scientific argumentation (SA) and nature of science (NOS) during the austral summer of 2022-2023. All teachers participated voluntarily and signed an informed consent form approved by the ethics committee of the university of the researcher responsible for the project. They taught in three different schools, in the subject of Science for Citizenship at grade 11.

Teacher	Teaching experience	Qualifications	Experience teaching NOS and using SA	Gender
T1	17 years	Biology teacher. Master in Sciences Education (2025)	12 and 3	M
T2	28 years	Biology teacher. Master in Sciences Education (2024)	3 and 4	M
T3	11 years	Biology teacher. Master in Sciences Education (2024)	10 and 4	F

Methodology

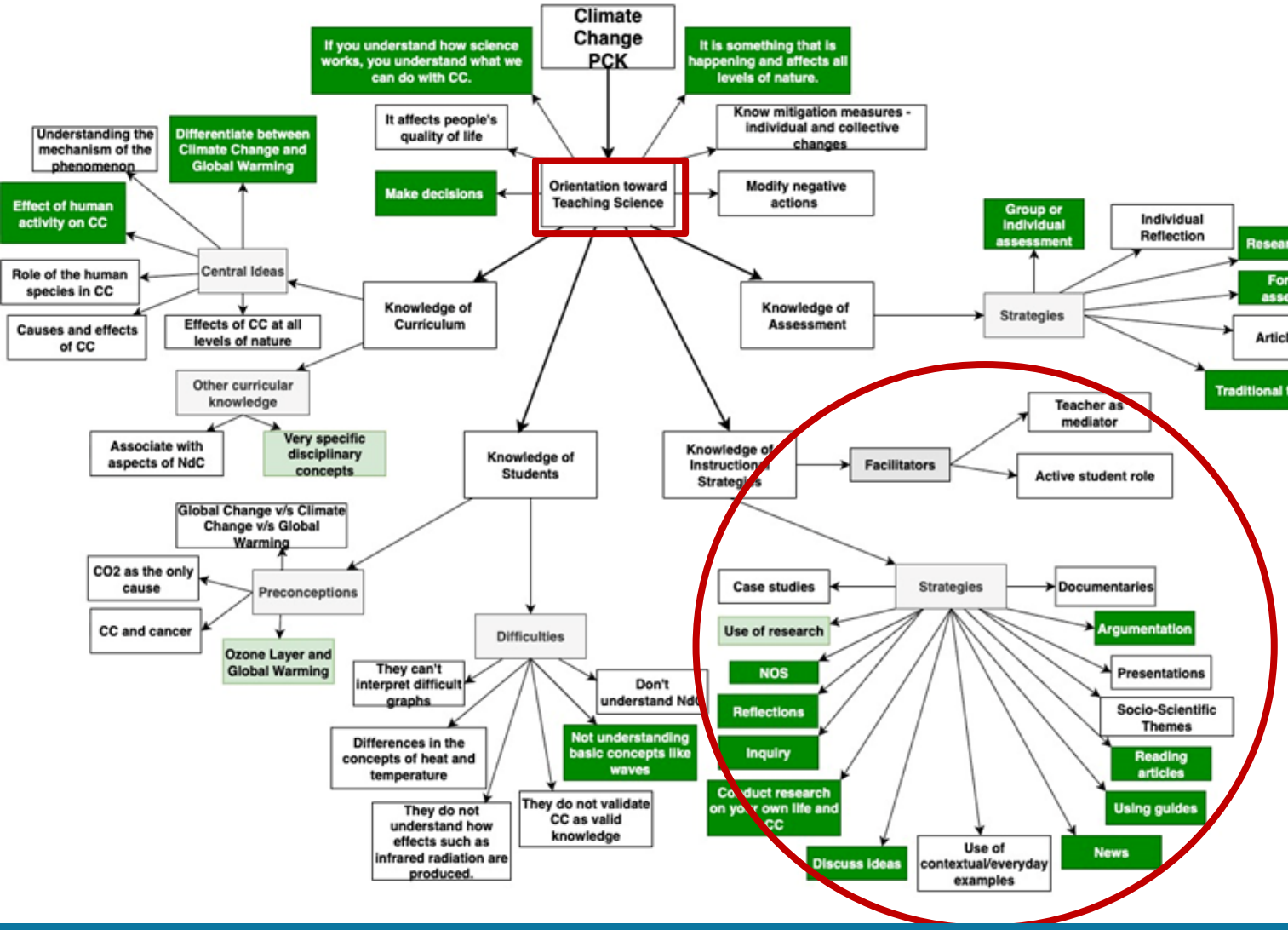
To capture their personal PCK in Climate Change, NOS and argumentation, 2 semi-structured Content Representation interviews (CoRe) were conducted (Loughran et al., 2004) by teacher, before (pre CoRe), and after (post CoRe) teaching a climate change module (between 5 and 6 lessons) in the subject of "Science for Citizenship" at grade 11.

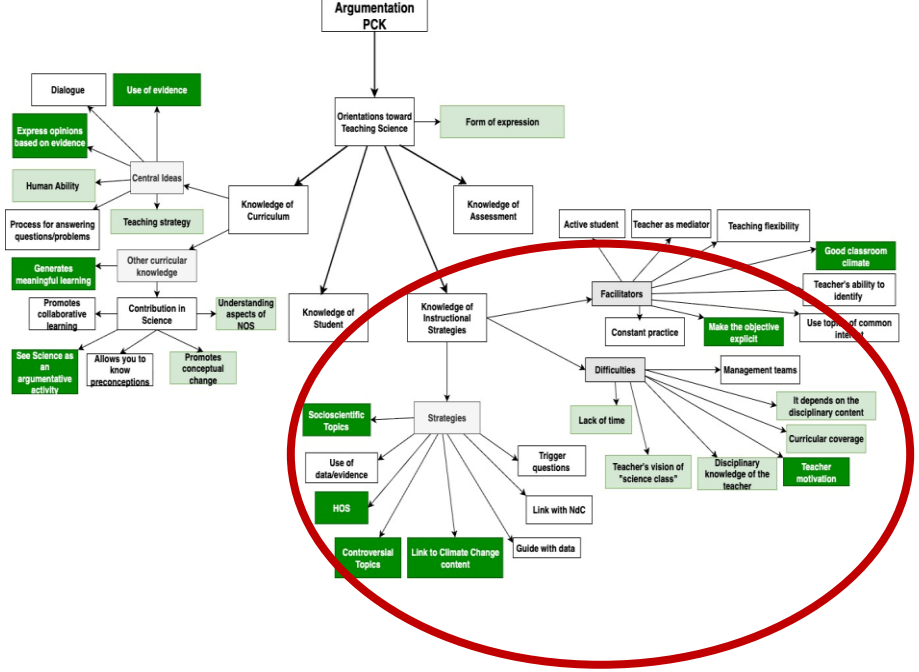
To analyze the teachers' PCK, a qualitative data analysis was conducted, in which conceptual coding was guided by theory on PCK (e.g., Forsler et al., 2024). In a final stage, the generated codes were sorted and classified by associating them to some broader theme such as the PCK components of **Magnusson et al.'s (1999) model** in a deductive process (Miles et al., 2019).

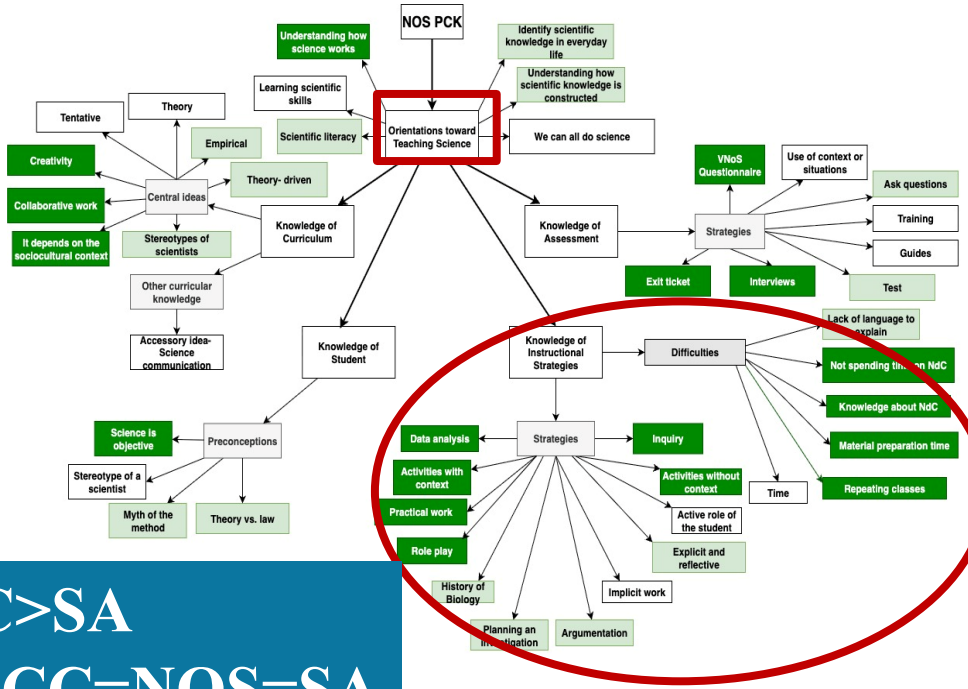
The three PCKs were compared according to possible interactions between components (total and final number of codes); symmetry of components; and presence of each theme in the other pPCKs.

Results (T1)

Refers only to CoRe PRE | Refers to CoRe PRE and POST | Refers only in CoRe POST





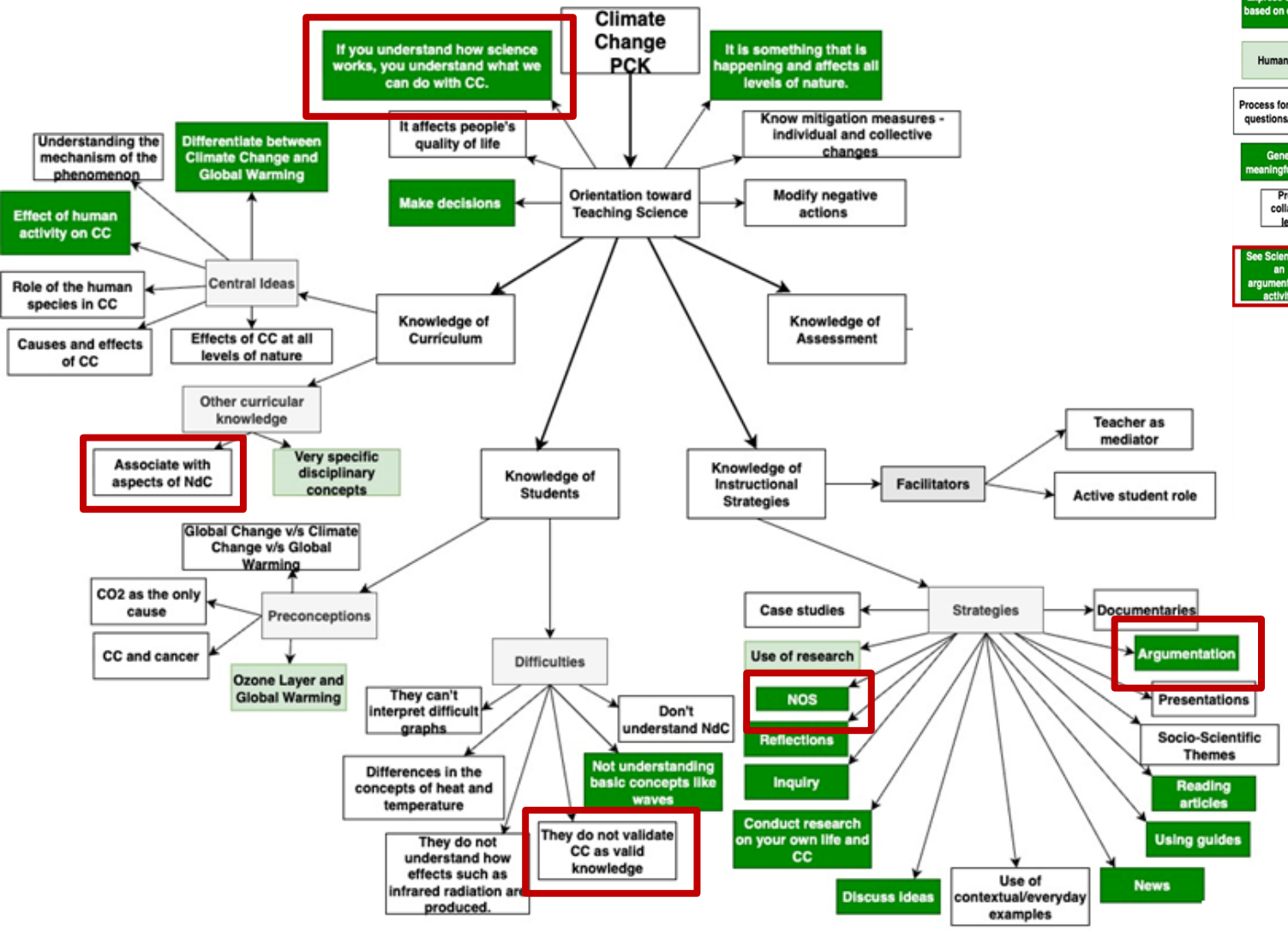


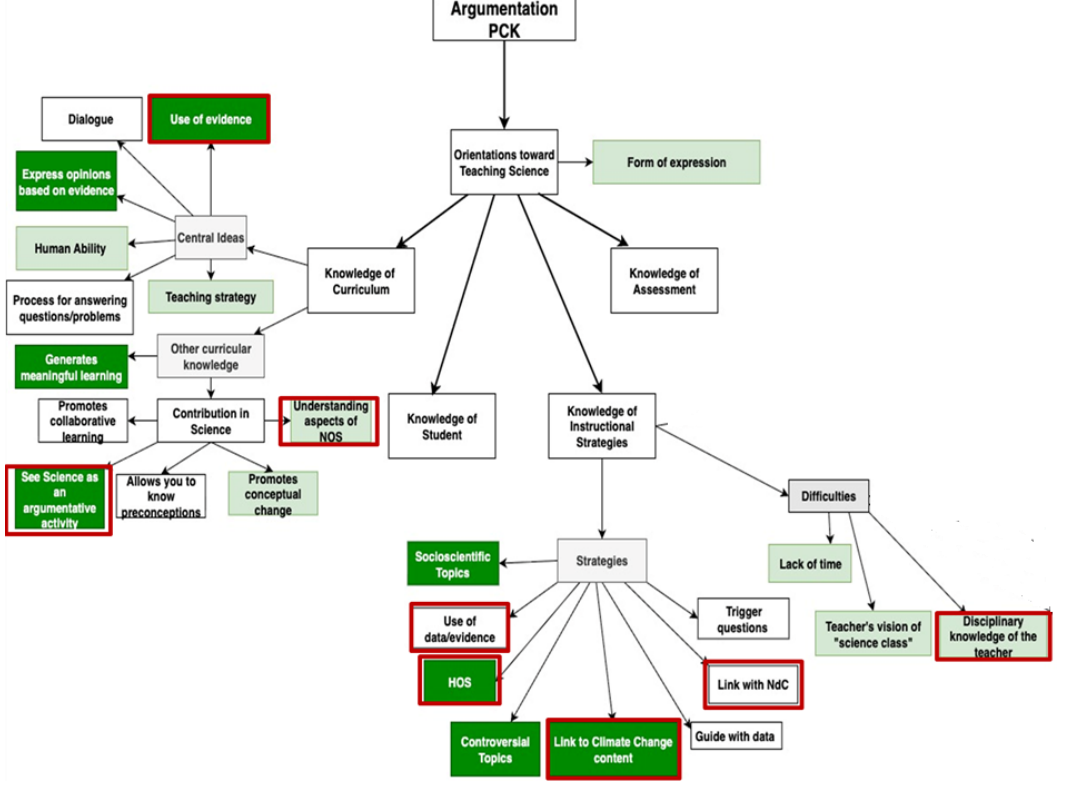
Total n° codes: CC=NOS >SA; Final n° codes: NOS>CC>SA

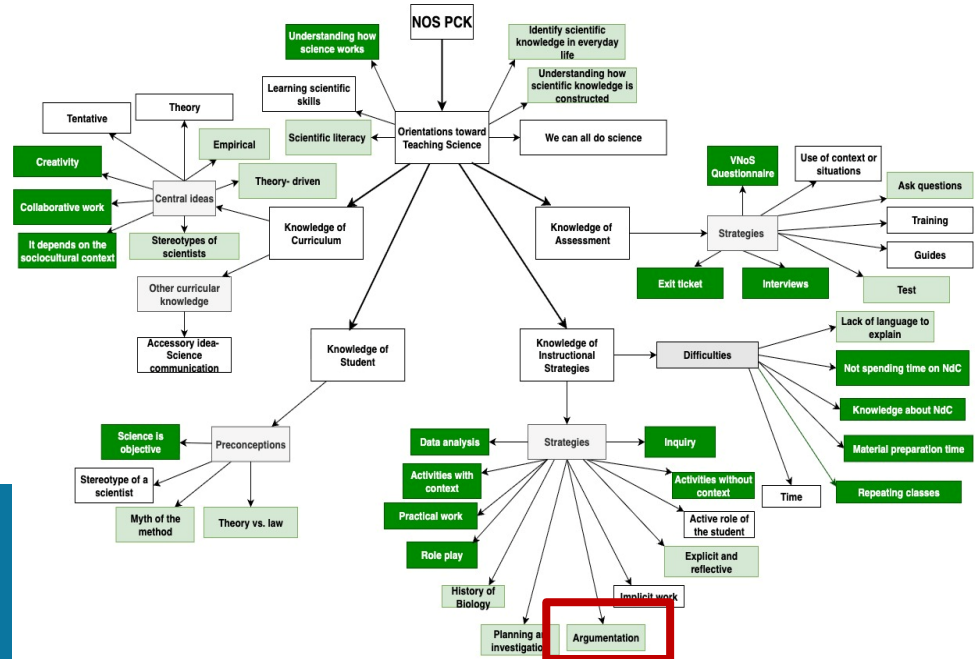
Orientations: CC>NOS>SA; Curriculum & Strategies: CC=NOS=SA

Results (T1)

Refers only to CoRe PRE | Refers to CoRe PRE and POST | Refers only in CoRe POST







The teacher include many codes in pPCKcc connected with pPCKsa and pPCKnos

Results (T2)

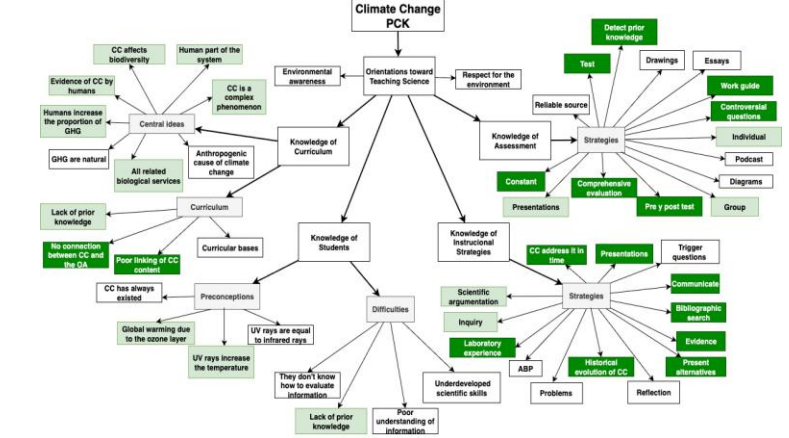
Total n° codes: CC = NOS > SA

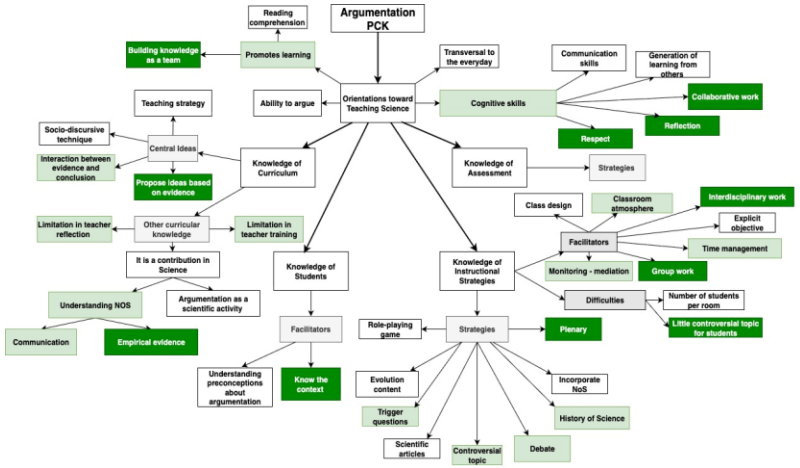
Final n° codes: NOS = CC= SA

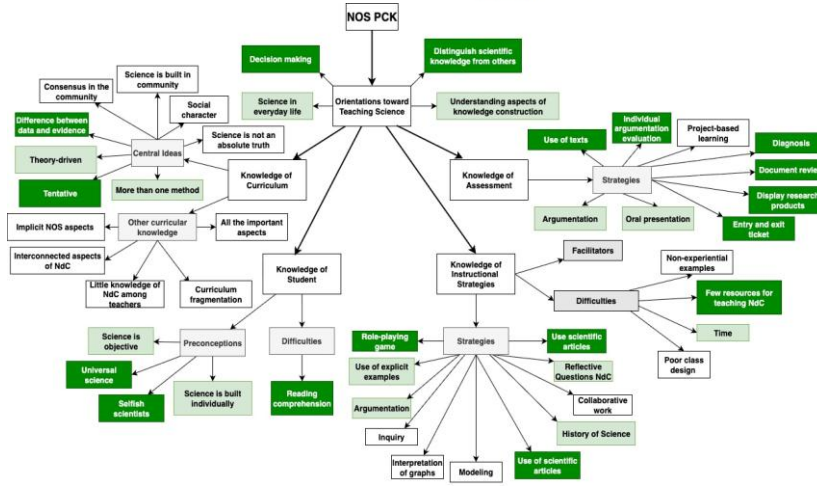
Orientations: SA > NOS > CC

Curriculum & Strategies: CC = NOS = SA

The teacher did not include many codes in pPCKcc connected with pPCKsa and pPCKnos, but did include more codes in pPCKsa related with pPCKnos.







Results (T3)

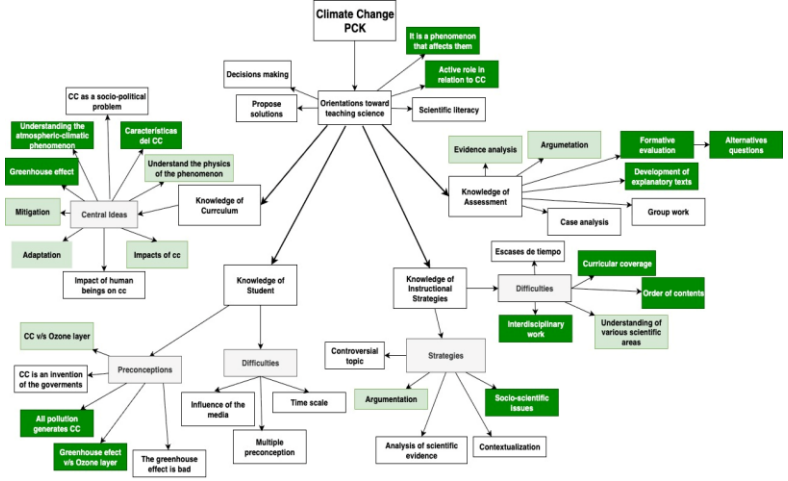
Total n° codes: CC > NOS > SA

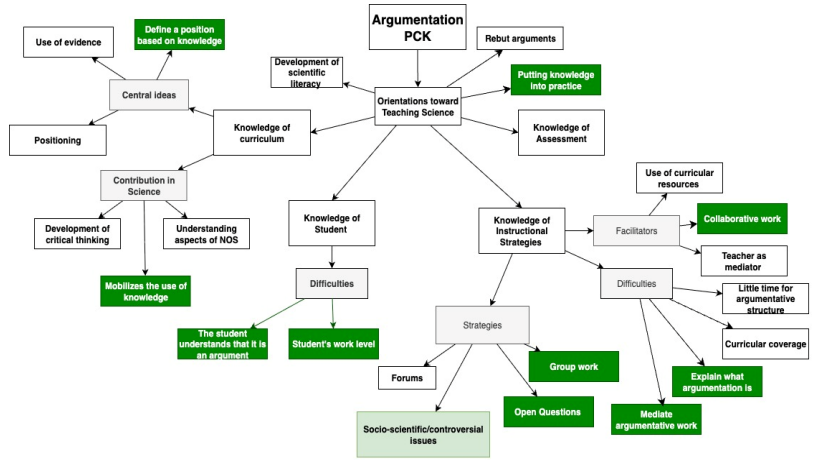
Final n° codes: NOS = CC > SA

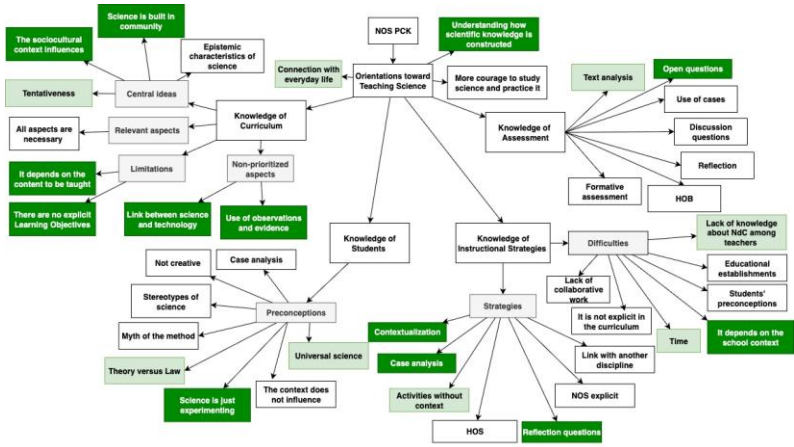
Orientations: SA = NOS = CC

Curriculum & Strategies: CC = NOS = SA

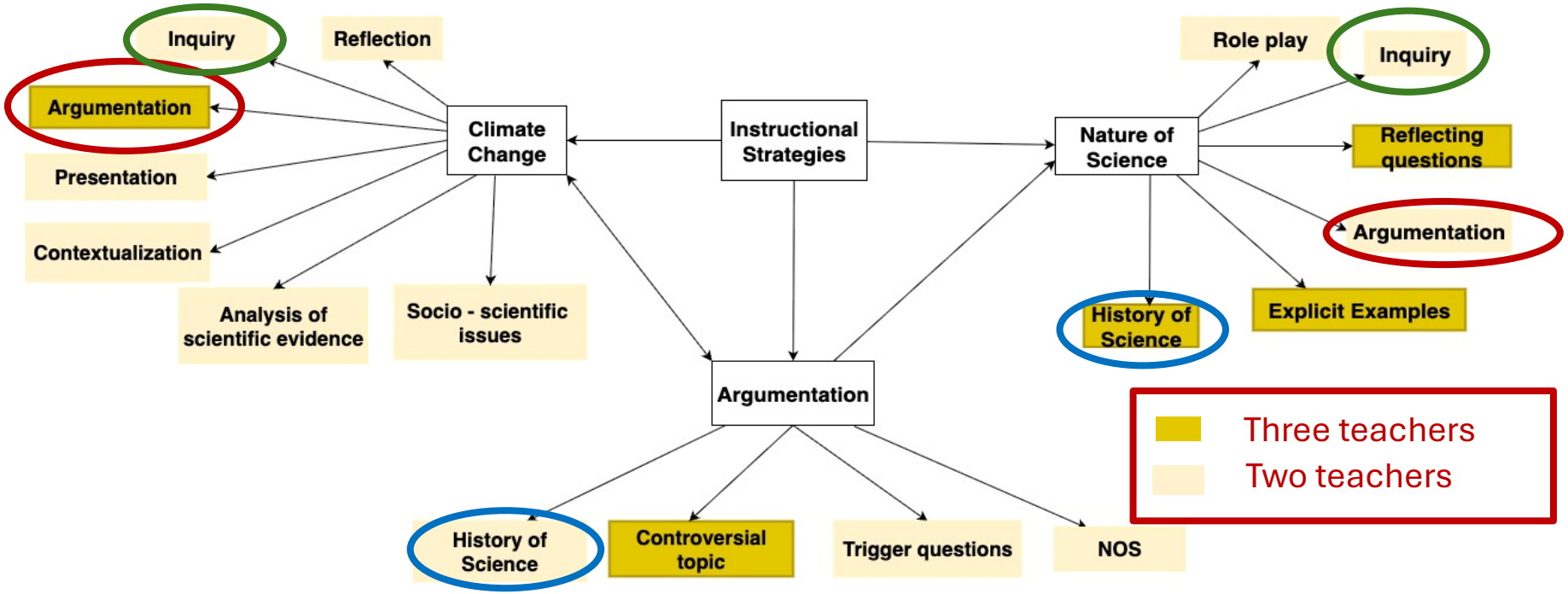
The teacher did not include many codes in pPCKcc connected with pPCKnos, but included some codes of pPCKas in pPCKcc







Results (Synthesis)



- Teachers show greater development in the strategy components of the three content areas.
- They converge on certain strategies for teaching the three content areas.
- The three teachers seem to have less developed pPCK in scientific argumentation.
- The teacher with fewer years of experience shows fewer possibilities for connections.

Discussion and conclusions

- The three teachers show greater development of the strategies component in all content areas (CC, NOS, and SA), as has been generally described in the literature (e.g., Park et al., 2011; Park and Chan, 2012; Van Driel et al., 2023; Vergara et al., 2024).
- There is less development of SA PCK in the three teachers who participated in the study, which is consistent with what has been described in studies focusing solely on SA PCK (e.g., McNeill & Knight, 2013).
- The pattern of interactions within and between the three PCKs of each teacher appears to be idiosyncratic, as suggested by comparisons of two PCKs of disciplinary content (e.g., Park and Chan, 2012).
- The strategy component seems to converge in the three teachers toward similar teaching approaches for CC, NOS, and SA (e.g., argumentation or HOS).
- It is interesting to note that at least two of the teachers have a degree of sophistication in their PCK of NOS like that of the content (CC).
- Different PCKs should continue to be explored simultaneously in teachers during the teaching of other content (other than CC) and in the context of initial training.

Limitations and Projections

- This study only presents a comparison of pPCK using the CoRe (Content Representation) interview, but future studies could include other data sources to capture personal PCK.

- Furthermore, here we only investigated personal or declared PCK, therefore future research could extend the comparison to enacted or collective PCK in this three issues.

- Finally, the filters and amplifiers that emerge in this study were not compared in depth, but future studies could focus on comparing some of those already described in the literature and preliminarily in this study (e.g., time and students' prior knowledge and skills).

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¡Gracias por su atención!

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