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Teaching Out-of-field: Personal Pedagogical Content Knowledge of Science and Engineering Practices and their implementation in the classroom

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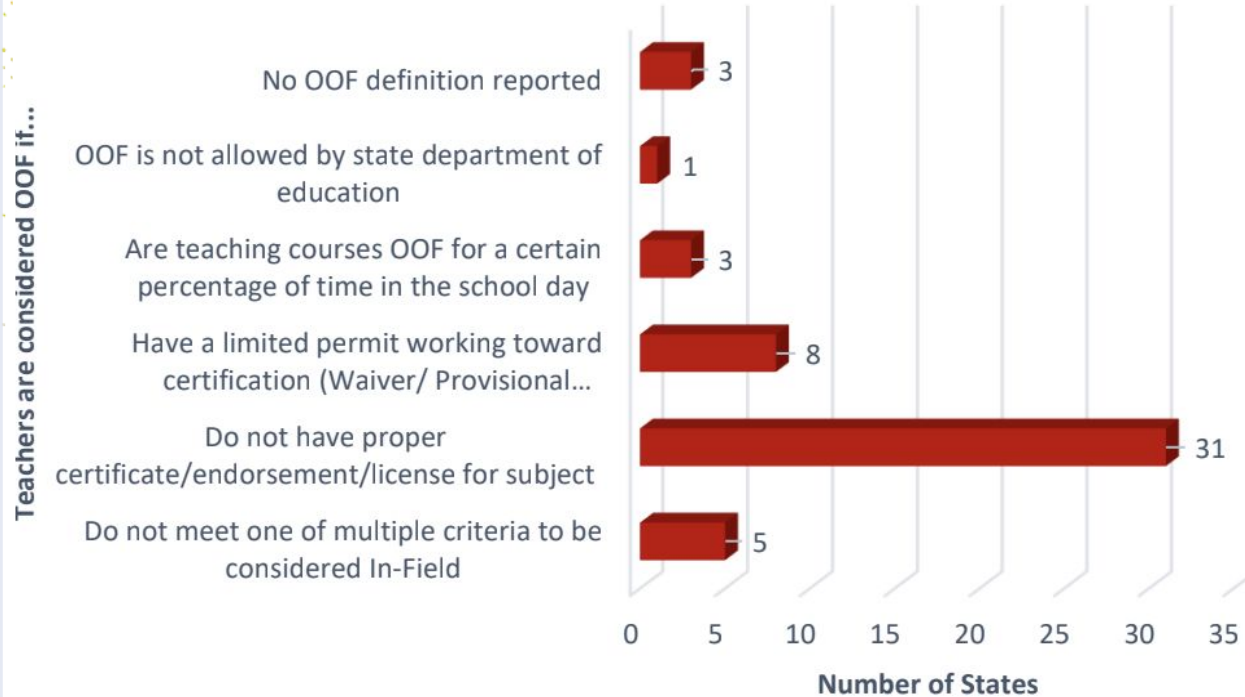


Current education law in the US

It lays the responsibility of addressing teacher effectiveness on the state.

It is up to the states how they monitor OOFT, and resolve the disproportionate occurrence of OOFT in low income and minority serving schools.

Definitions of OOF:



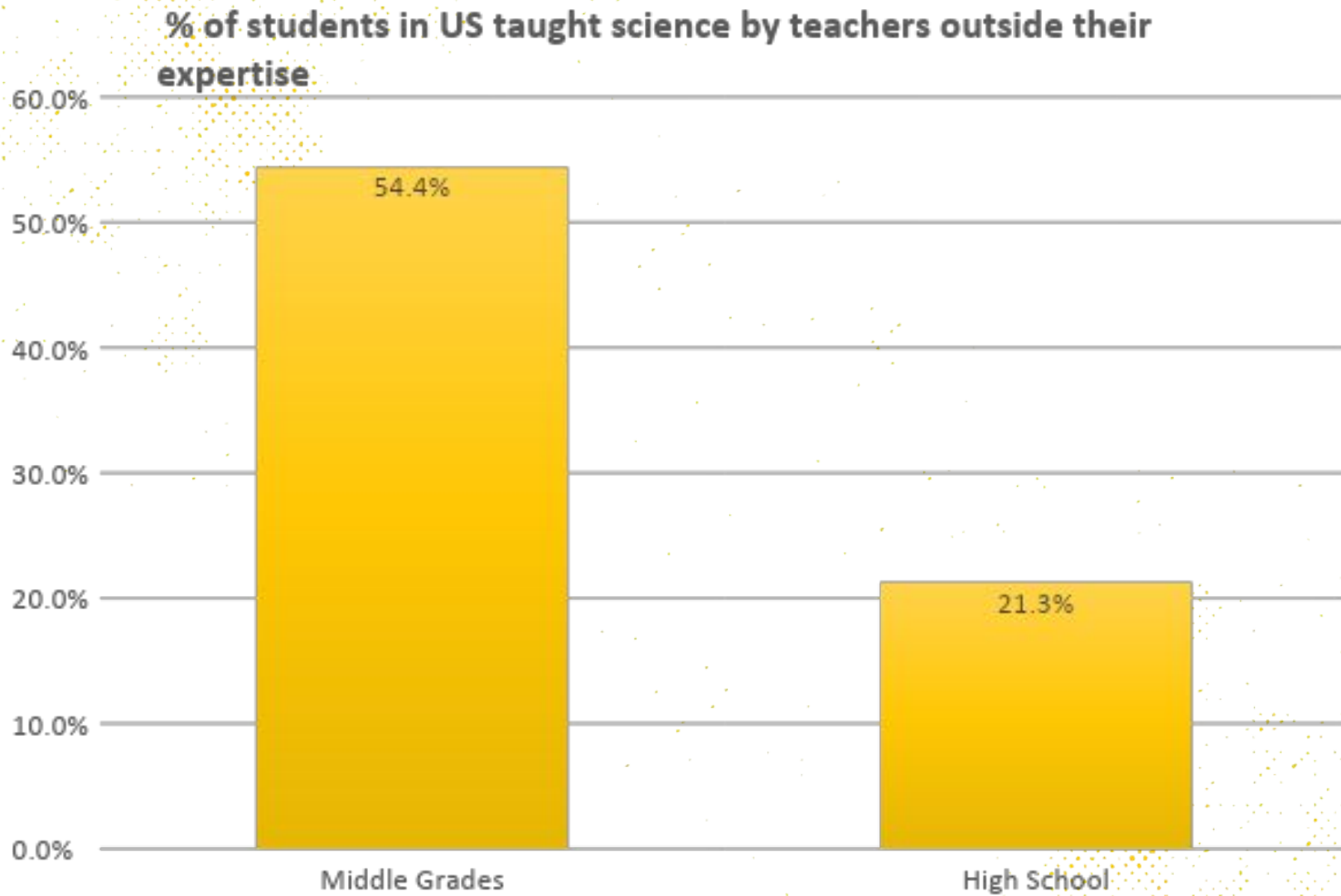
Without an agreed upon definition, it becomes difficult to understand the magnitude of OOF teaching

The criteria within the definition can vary from the teacher lacking adequate certification to detailed measures such as, credit hours in the content area or the amount of instructional time spent OOF in a day (U.S. Department of Education, 2018).

Hidden in Plain Sight



OOF teaching has been recognized and researched for more than two decades. Yet the issue continues to exist due to high rates of teacher turnover, attrition, and misassignments.



Prevalence of Science OOTF in the US

(Rahman et al., 2017)

Teaching Reform-based Standards



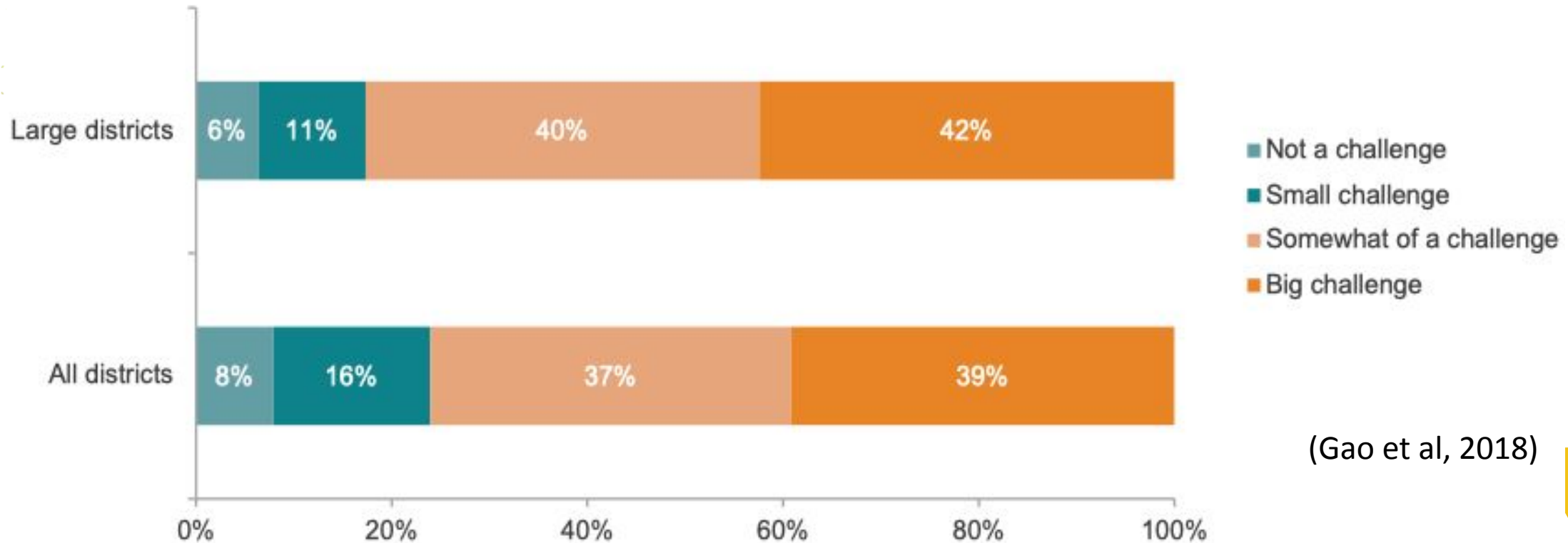
The NGSS require teachers to adopt reform-based practices, and prioritize implementation of SEPs

OOF science teachers may not have the expertise or sufficient training to implement aspects of the standards

(Napier et al, 2020
Singh et al, 2021)



Implementation of the NGSS has been found to be uneven in California



(Gao et al, 2018)

Insufficient training in NGSS a challenge for teachers

However, there is no data on implementation of NGSS by OOF teachers





Next Generation Science Standards

SEPs are a crucial part of the standards

Practices reflect the work of scientists and engineers

8 SEPs are the experiences teachers should provide students

Engaging students in SEPs leads to improved learning and understanding of science

(National Research Council, 2012)
(Lead States, 2013)

Research questions

Q1 How does secondary science teachers' personal Pedagogical Content Knowledge (pPCK) of Science and Engineering Practices (SEPs) of *creating and using models, analyzing and interpreting data, and engaging in argument from evidence* compare between in-field and OOF science teachers?

Q2 Does the high level of pPCK of the science and engineering practices ensure their implementation in classroom instruction?



SEPS

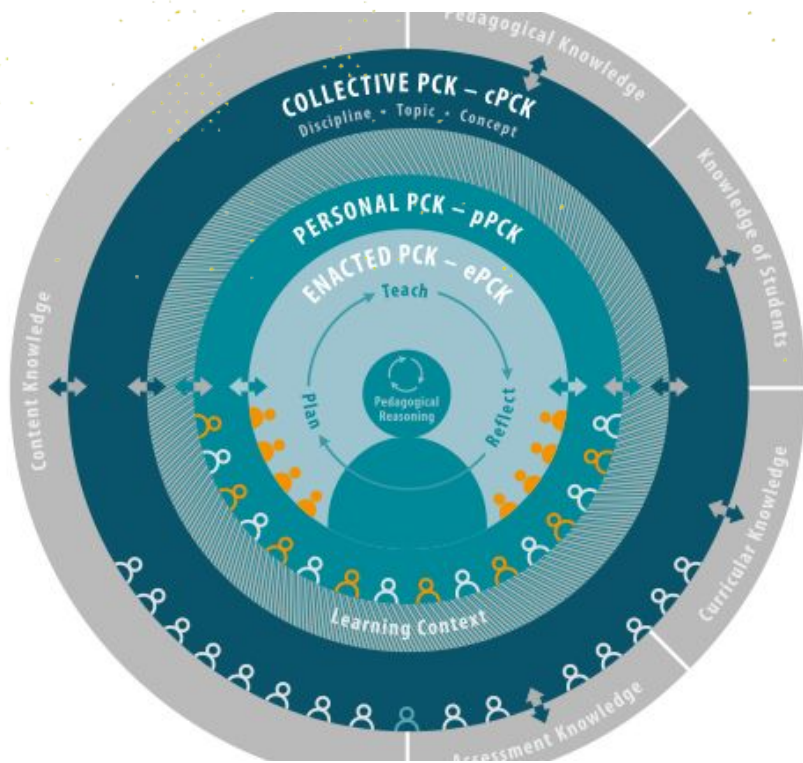
Engaging in argument from evidence

Creating and using models

Analyzing and interpreting data

(National Research Council, 2012)
(Lead States, 2013)

Framing of the Study



(Carlson & Daehler, 2019)

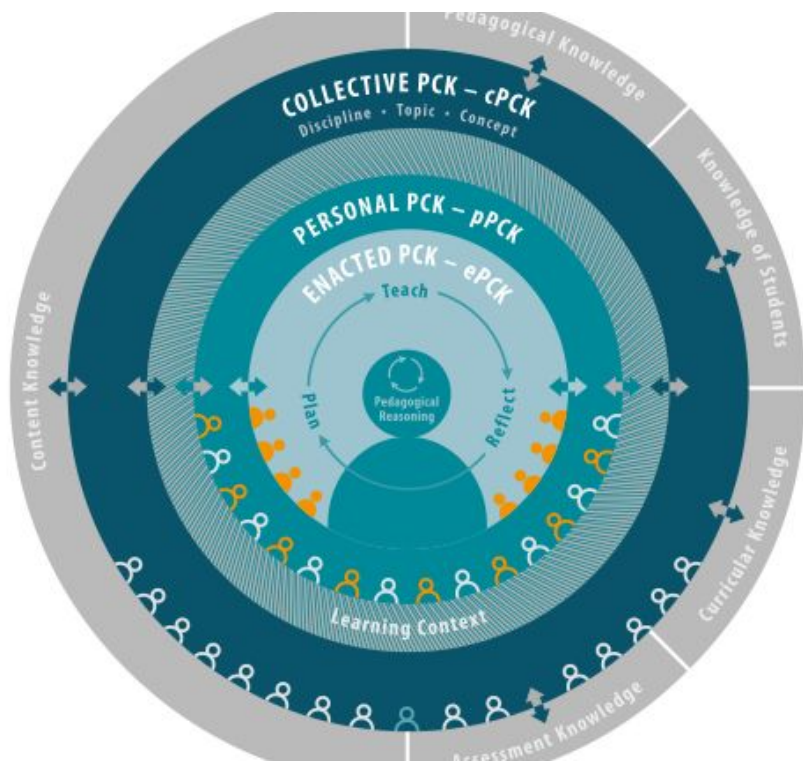
personal PCK

pPCK is the knowledge of, and reasoning behind teaching a particular topic, in a particular way, for a particular purpose

Teachers draw upon this reservoir of knowledge and skills while teaching

pPCK reflects their own dynamic teaching and learning experiences, as well as contributions of others

Framing of the Study



(Carlson & Daehler, 2019)

enacted PCK

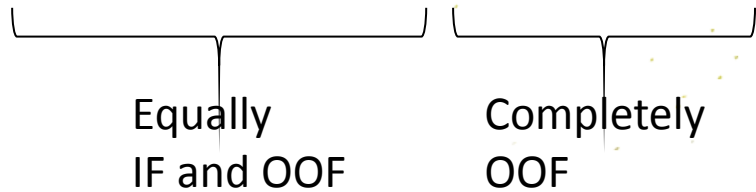
ePCK is the specific knowledge and skills utilized by an individual teacher for instruction

How a teacher enacts their PCK reflects the context of the school, the classroom, student and teacher interactions, the teacher's understanding of the science subject matter as well as their pedagogical knowledge and skills

Participants

● ● ● ● ● ● ● ● In-Field Teachers

● ● ● ● ● ● ● Out-of-field Teachers



| Teacher Pseudonym | IF/OOF |
|-------------------|--------|
| Daisy | 1 |
| Rosy | 1 |
| Noel | 1 |
| Juan | 1 |
| Nicole | 1 |
| Raj | 1 |
| Mia | 1 |
| Brandon | 1 |
| David | 2 |
| Joseph | 2 |
| Emma | 2 |
| Aurora | 2 |
| Teresa | 3 |
| Rita | 3 |
| Jasmine | 3 |



Data Collection

Weekly-Overview Interviews

- One week of instruction
- Three times a year
- Total of 30 days of instruction

Video Based Interviews

- Shown three 1-2 minute videos
- Each video focused on one SEPs



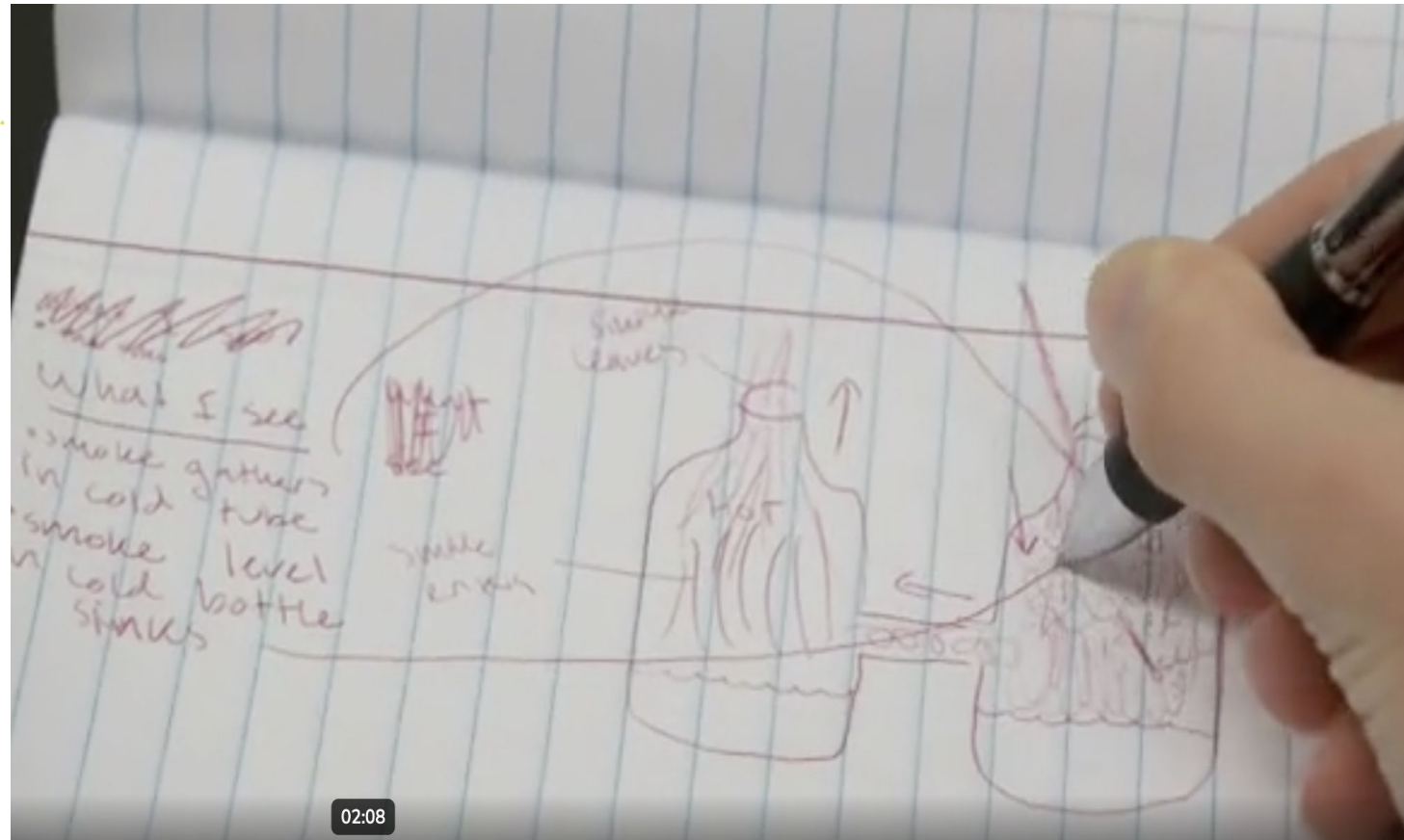
Data Collection

Video Based Interviews: pPCK

Shown three 1-2 minute video clips

Each video focused on students engaging in one SEP

Asked if they saw something important to the teaching of science, explain reasoning



Data Analysis: pPCK

Rubric to determine the level of student engagement with The SEPs (Chen & Tarda, 2021)

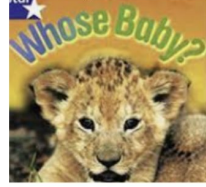
5 or 6= Well developed pPCK
3 to 4= Developing pPCK
1 or 2= Limited pPCK

| State the SEP | Describe the SEP | Interpret the SEP |
|--|--|---|
| State the appropriate SEP' name (NGSS) or their state's language (2) | IONIC-aligned description of SEP (2) | Interpret, evaluate, analyze, or predict the correct SEP shown in the video regarding science education (2) |
| State the SEP's by their own words (1) | Partially IONIC-aligned description of SEP (1) | Interpret, evaluate, analyze, or predict the correct SEP shown in the video regarding non science education (1) |
| Not state the SEP(0) | Wrongly describe the targeted SEP or do not describe the SEP (0) | Do not interpret evaluate, analyze, or predict the SEP or interpret evaluate, analyze, or predict the wrong SEP (0) |



Data Collection

Grade Level K Content Understand that the world around us is filled with many different plants and animals that can be classified in many different ways based on their features.

| DATE & FORMAT- Highlight which mode best fits your mode of instruction. | LESSON ORIGIN- Is it a new lesson? Where did you get this lesson from? (Highlight all that apply) | LESSON GOAL- What did you want students to learn at the end of the lesson? | ACTIVITIES / STRATEGIES- What did you do during the lesson- discussion, data collection? | MATERIALS FOR LESSON- What were materials you used that were specific to the lesson- textbook, website? | ASSESSMENT(S)- How did you know that students were learning the materials covered? |
|--|--|--|---|---|--|
| MONDAY DATE <u> </u> 4/12 <u> </u> Face to face Hybrid* Hyflex* Online | <ul style="list-style-type: none"> •From previous year •New lesson for this year •Published/online source •From school/district •From mentor/colleague •Self created •Other | No Science this day due to returning from spring break | | | |
| TUESDAY DATE <u> </u> 4/13 <u> </u> Face to face Hybrid* Hyflex* Online | <ul style="list-style-type: none"> •From previous year •New lesson for this year •Published/online source •From school/district •From mentor/colleague •Self created •Other | State what living and <u>non living</u> means and give an example. | -refreshed our memories with living or nonliving sort introduced the <u>topic</u> read: Whose Baby is it? -talked about babies we have seen | -interactive sort of living/nonliving from a colleague (smart board) -Whose baby is it? book  | paper sort of living and <u>non living</u> |
| WED DATE <u> </u> 4/14 <u> </u> Face to face Hybrid* Hyflex* Online | <ul style="list-style-type: none"> •From previous year •New lesson for this year •Published/online source •From school/district •From mentor/colleague •Self created •Other | Describe characteristics of living things | read a few more pages of animal babies <u>book</u> -animal sort (gave students a baby or a parent). Played music then students walked around and "matched" | -Whose <u>baby</u> is it? book -color copies of real pictures of parents and their offspring -music | observation |

Weekly Overview: ePCK

One week of instruction

Three times a year

Total of 30 days of instruction

Data Analysis: ePCK

Frequency
Table ePCK

| Cohort | Group | Interview | Teacher lectures | Teacher conducts a demonstration or simulation | Teacher facilitates a whole-class discussion | Teacher facilitates in-class work - reading a book, reviewing, handout, | Teacher guides scientific investigations or labs | Teacher shows a movie, video | Teacher facilitates small group discussions | Teacher facilitates catch-up day | completing in-class work – notes, reading, review, | planning a conductin g their own inves tigation/ | Students are conducting investigations prepared by the teacher |
|--------|--------|-----------|------------------|--|--|---|--|------------------------------|---|----------------------------------|--|--|--|
| 1 | TN107b | 3 | 4 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| 1 | TN107b | 3 | 4 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| 1 | TN107b | 3 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | TN107b | 3 | 5 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 1 | TN107b | 3 | 5 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 1 | TN107b | 3 | 5 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN107b | 3 | 5 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN107b | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 1 | TN107b | 3 | 6 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN107b | 3 | 6 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 1 | TN107b | 3 | 6 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN107b | 3 | 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN107b | 3 | 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN108a | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 1 | TN108a | 3 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 1 | TN108a | 3 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| 1 | TN108a | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN108a | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN108a | 3 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN108a | 3 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN108a | 3 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN108a | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 1 | TN108a | 3 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | TN108a | 3 | 3 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |

Findings RQ1: IF teachers had a better developed pPCK than OOF teachers

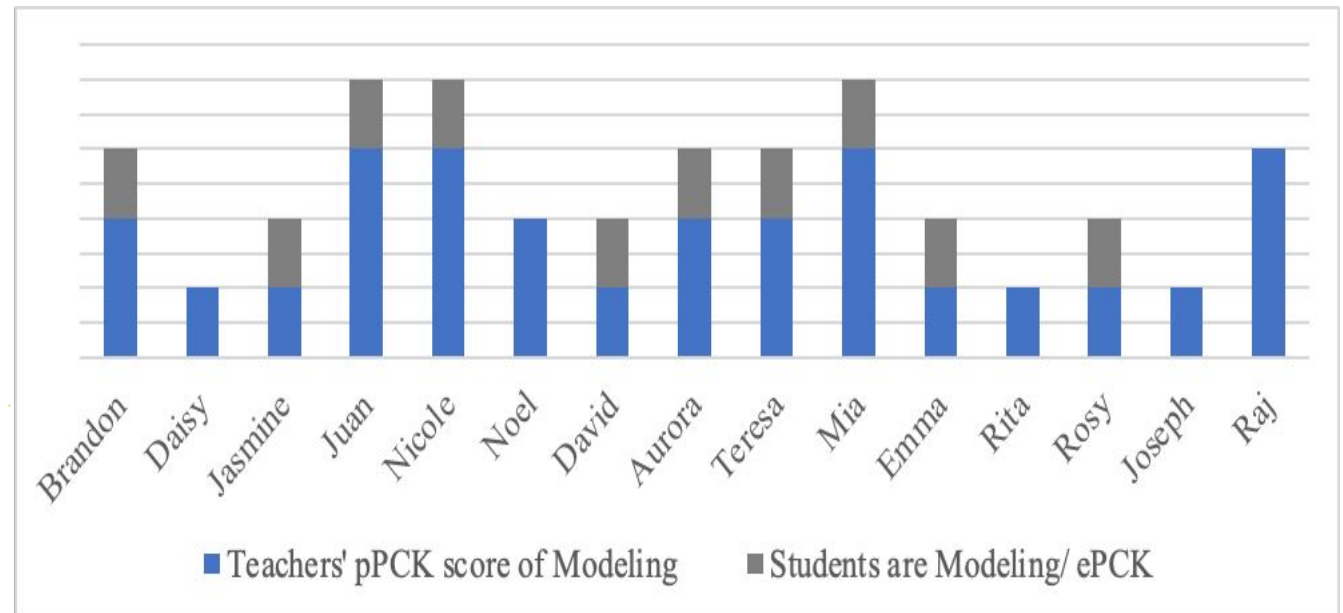
| Teacher Pseudonym | IF/OOF | pPCK score of Developing and using models | pPCK score of Analyzing and/or interpreting data | pPCK of Engaging in argument from evidence |
|-------------------|--------|---|--|--|
| Daisy | 1 | 1 | 1 | 2 |
| Rosy | 1 | 1 | 3 | 1 |
| Noel | 1 | 2 | 1 | 2 |
| Juan | 1 | 3 | 3 | 2 |
| Nicole | 1 | 3 | 3 | 2 |
| Raj | 1 | 3 | 3 | 2 |
| Mia | 1 | 3 | 3 | 3 |
| Brandon | 1 | 2 | 2 | 1 |
| David | 2 | 1 | 1 | 1 |
| Joseph | 2 | 1 | 1 | 2 |
| Emma | 2 | 1 | 2 | 2 |
| Aurora | 2 | 2 | 1 | 2 |
| Teresa | 3 | 2 | 1 | 1 |
| Rita | 3 | 1 | 2 | 1 |
| Jasmine | 3 | 1 | 2 | 2 |

pPCK: 3=Well developed pPCK, 2=Developing pPCK, 1= Limited pPCK

12 years teaching
physical science.
Undergrad degree in
History
Called herself a fake
science teacher

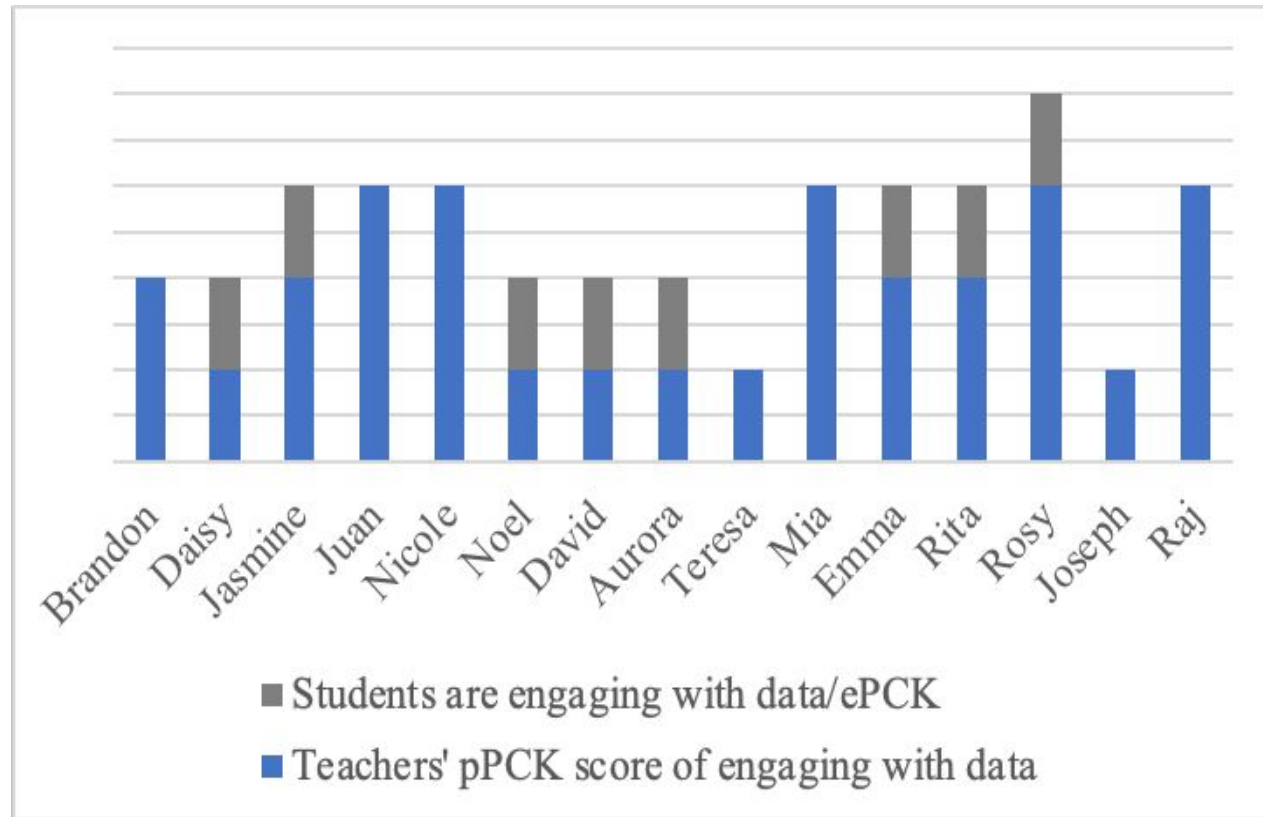
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|-------------------|--------|---|--|--|
| Daisy | 1 | 1 | 1 | 2 |
| Rosy | 1 | 1 | 3 | 1 |
| Noel | 1 | 2 | 1 | 2 |
| Juan | 1 | 3 | 3 | 2 |
| Nicole | 1 | 3 | 3 | 2 |
| Raj | 1 | 3 | 3 | 2 |
| Mia | 1 | 3 | 3 | 3 |
| Brandon | 1 | 2 | 2 | 1 |
| David | 2 | 1 | 1 | 1 |
| Joseph | 2 | 1 | 1 | 2 |
| Emma | 2 | 1 | 2 | 2 |
| Aurora | 2 | 2 | 1 | 2 |
| Teresa | 3 | 2 | 1 | 1 |
| Rita | 3 | 1 | 2 | 1 |
| Jasmine | 3 | 1 | 2 | 2 |

**Findings RQ2:
Teachers with
higher pPCK did
not necessarily
integrate SEPs in
their classroom
instruction**



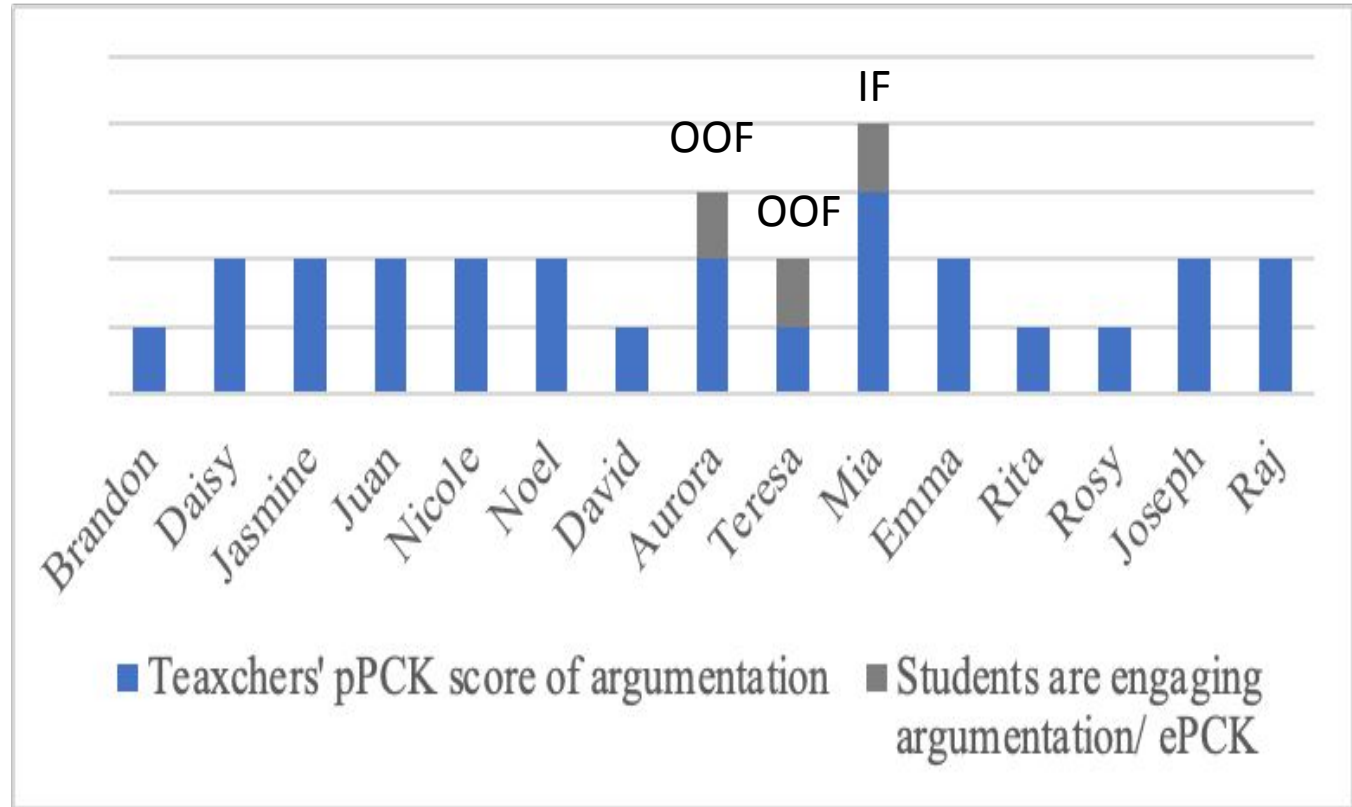
- pPCK and ePCK of *Creating and Using Models*

Findings RQ2: Teachers with higher pPCK did not necessarily integrate SEPs in their classroom instruction



- pPCK and ePCK of *Analyzing and interpreting data*

Findings RQ2: Teachers with higher pPCK did not necessarily integrate SEPs in their classroom instruction



- pPCK and ePCK of *Engaging in Argument From Evidence*
- This was the least implemented SEP

Discussion

Lower pPCK of SEPs by
OOF physical science
teachers

Knowledge of content
and SEPs in in-field
content areas

Developing knowledge

Knowledge of content
and SEPs in OOF
content area (physical
science)

The ability to develop
pPCK and enact it in the
classroom may be
science subject specific

OOF teachers may not
be able to translate
their knowledge of SEPs
into other science areas

OOF science teachers
may need extra support
to develop expertise in
reform-based science
teaching

Discussion: RQ2

High level of pPCK of the SEPs does not ensure their implementation in classroom instruction, for IF and OOF teachers

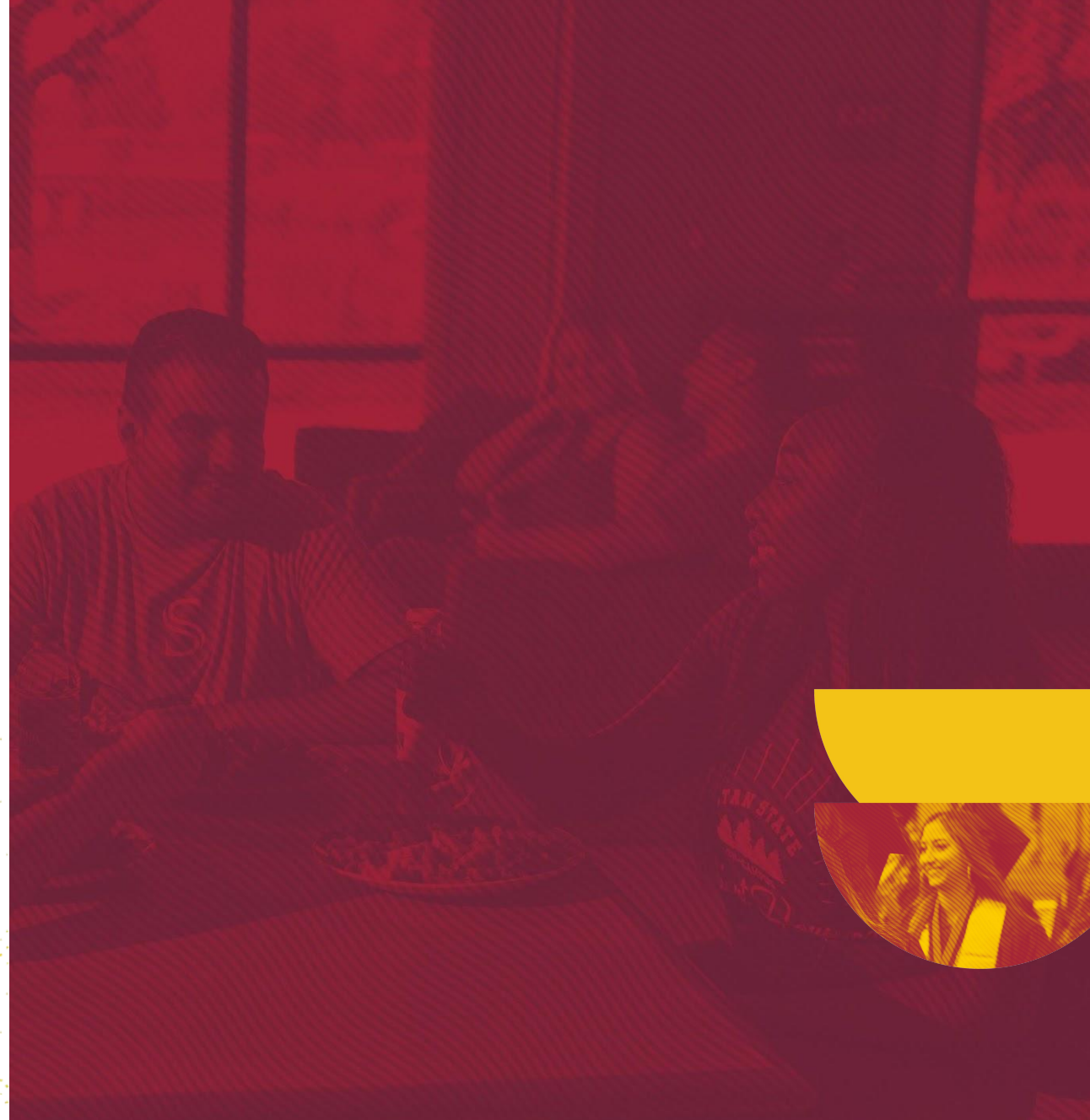
Context matters. Factors like teachers' beliefs in the role of SEPs in science learning, resources available like time and curriculum materials etc. may influence the implementation of the SEPs

(Singh et al., 2020),
(Napier et al., 2020)

PD targeted at the SEPs might need to (1) address multiple faces of SEPs enactment, and (2) differentiate the support based on the teachers' background (e.g., in-field or OOF)



Questions?





Thank You!

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