Evolution of STEM Faculty Perceptions of Concept Map Assessments

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Background CEEMS Program

- Cincinnati Engineering Enhanced Mathematics and Science (CEEMS) Project
- Baseline research for a project to integrate Engineering Education into 7-12th grade mathematics and science classrooms.
- Courses include pre- and post-concept map assessments taken by the teachers participating in the PD

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Overarching Goal

- Understand how each faculty member interpreted the knowledge changes documented in:
  - the qualitative structuring of the pre-service and in-service teachers’ concept maps.
  - the quantitative results summary of their class.

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Research Questions

- How do Arts and Science and Engineering faculty understand student concept maps as reflections of students’ content knowledge?
- How do faculty interpret the changes in the students’ pre and post concept maps as a reflection of students’ learning?
- Do faculties’ reflections on the pre and post concept maps, lead to them to reflect on changes in their teaching?

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Why Concept Maps?

- Initial concept maps reveal initial concepts as well as the conceptual links between concepts present in the student's mind prior to instruction.
- By observing changes in pre- and post-concept maps, conceptual changes can be identified as a result of instruction

(Regis and Albertazzi, 1996; Jacobs-Lawson and Hershey, 2002; Srinivasan, M., McElvany, M., Shay,J., Shavelson, R., & West, D., 2008; West, Pomeroy, Park, Gerstenberger, & Sandoval, 2000)

Concept Maps Allow:

- Students to transform their learning from rote memorization to “meaningful learning” (Novak, 1990).

- Teachers to formatively assess student’s knowledge structure and identify preconceptions and misconceptions (Novak 1984; Novak1998).

- Teachers to organize important concepts before teaching and recognize hierarchical relationships between concepts. (Novak 1984).

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Concept Pre-assessment-Chemistry

Name ______________________________ Course ______________________

As a pre-assessment activity you should use the list of terms in the table on the left to create a concept map that represents how YOU think the different ideas fit together, in addition to the terms listed in the table you can add other concepts that fit with your understanding. The table on the right hand side offers some examples of connecting terms that will be located on the arrows that clarify how the different concepts are connected. Underneath the terms are some mapping rules and hints.

General Instructions

Terms to map

Matter
Infrastructure
Physical change
Chemical change
Exothermic
Endothermic
Intermolecular forces
Hydration
Composite
Mixture
Chemical reactions
Material strength

Sample connecting verbs or qualifiers

Is a (are)
Is similar to
Is an example of
Has (have)
Leads to
represents
Is different from
produces

Term List (left)
Sample Prepositional Phrases (right)

Rules/Hints:

1. Concepts are shown in ovals or boxes. The size of the oval or box does not represent anything about the concept.

energy $\boxed{\text{heat}}$

2. Concepts are connected by arrowed lines. The direction of the arrow DOES represent a directionality to the connections between the concepts.

A single arrow suggests the relationship is not reversible. $\longrightarrow$

A double arrow suggests the relationship is reversible. $\longleftrightarrow$

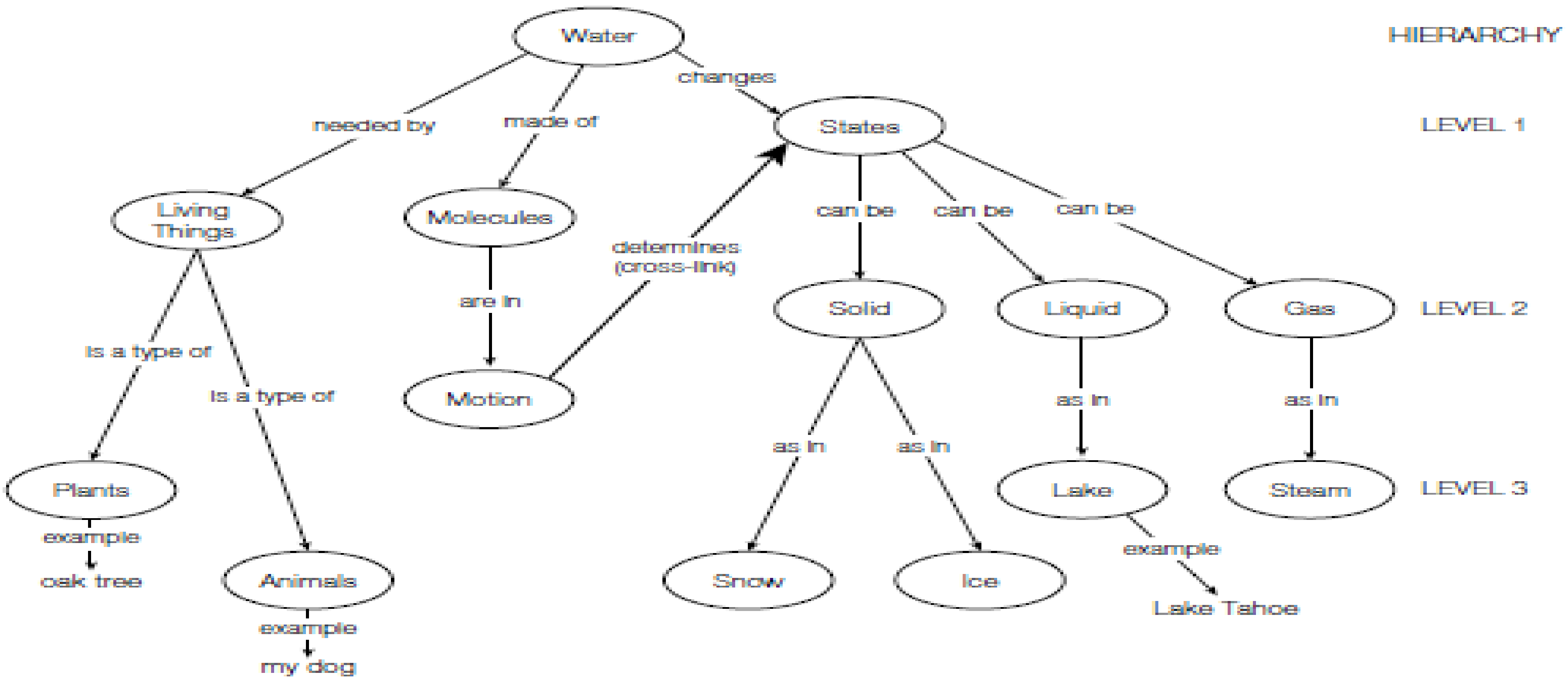
However the LENGTH of the line does NOT represent anything about the relationship.

3. Multiple arrowed lines may come from or go to the same concept ovals.
4. All arrowed lines should use a preposition, verb, or qualifying phrase to explain the relationship between the two concept circles.
5. A concept map is a model or representation of how YOU think ideas relate and work together, as such there is no correct or incorrect concept map.

On the next page is a sample of a concept map. Yours will be hand drawn but this gives you an idea of using the boxes and connecting terms.

Rules about using prepositions, indicating directionality with arrow, and boxing concept terms.

Figure 1. Example Concept Map



Example map of *water* demonstrating the basic components of hierarchical concept maps. Note the cross-link (bold arrow) between the concepts *motion* and *states*. Reproduced with permission from Cambridge University Press.[14]

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(West, D. C., Park, J. K., Pomeroy, J. R., & Sandoval, J. 2000)

Concept Map Scoring

Category	Point Value
Concept Link – Must include an accurate connection with an appropriate prepositional phrase and directionality	2
Hierarchical Step – Must include an accurate narrowing or broadening of the concept with an appropriate prepositional phrase and directionality. Shows top-down organization.	5
Cross Link – Must include an accurate joining of concepts across domains with an appropriate prepositional phrase and directionality. Shows higher order relationship.	10
Example - Must include an accurate example of a concept with an appropriate prepositional phrase and directionality	1
Invalid Link	0

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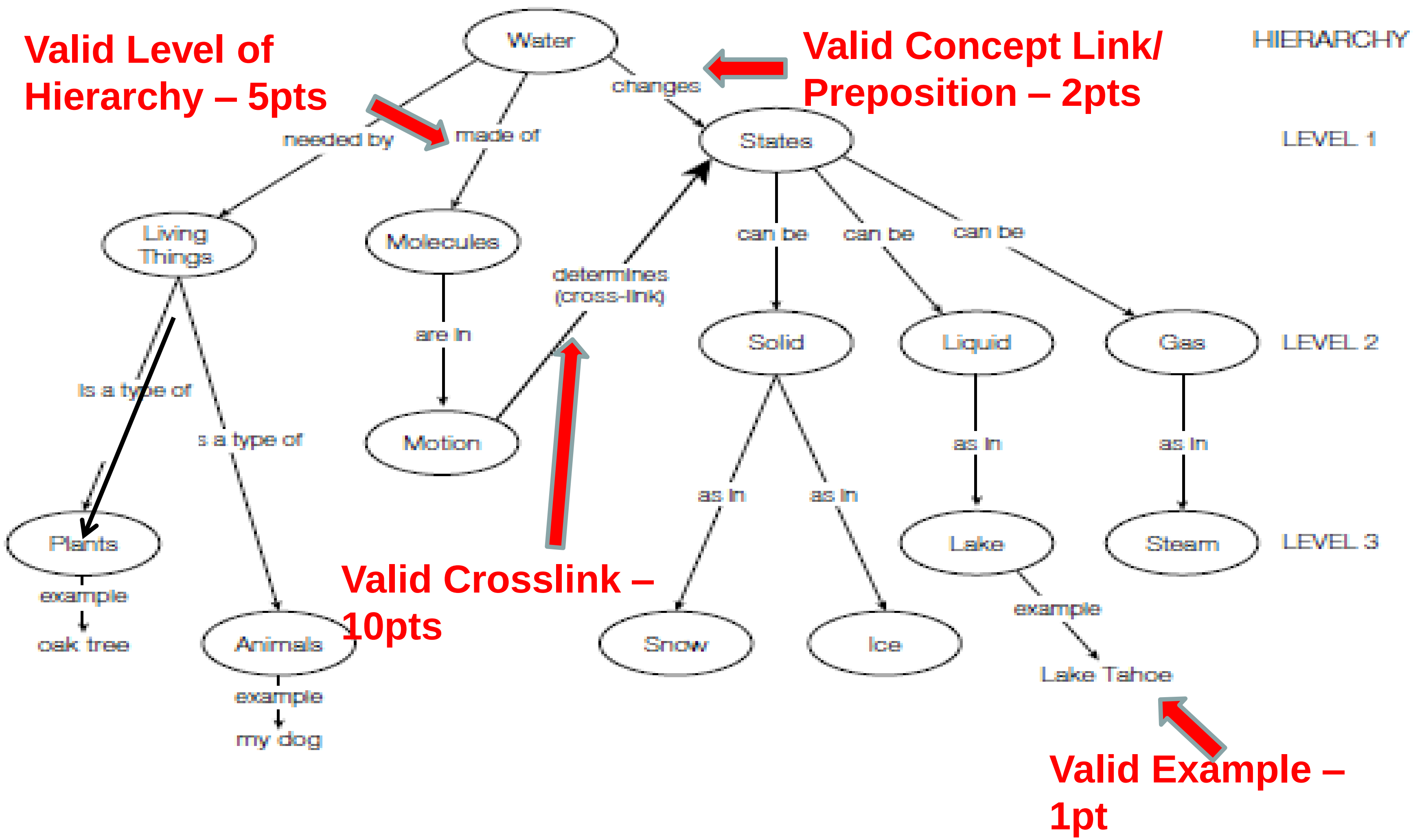
Figure 1. Example Concept Map



West et al. (2000)

Score Template

Participant 12017	Concept Link (2 points)	Hierarchy (5 points)	Cross Link (10 points)	Example (1 point)	Total
Biology PRE	5	5	0	0	35
Biology POST	9	9	0	0	63
Biology GAINS	**4**	**4**	**0**	**0**	**28**

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Limitations of Quantitative Measurement

Phillip: Looks like it **would have gotten lots of points**. Uh, let's see here. Oh, I like that one. This person's had a physics class before, I think. They didn't put a verb there. **If they'd have put a verb there** they'd have gotten more points. Yeah, this person had a physics class before (Philip, lines 900-904).

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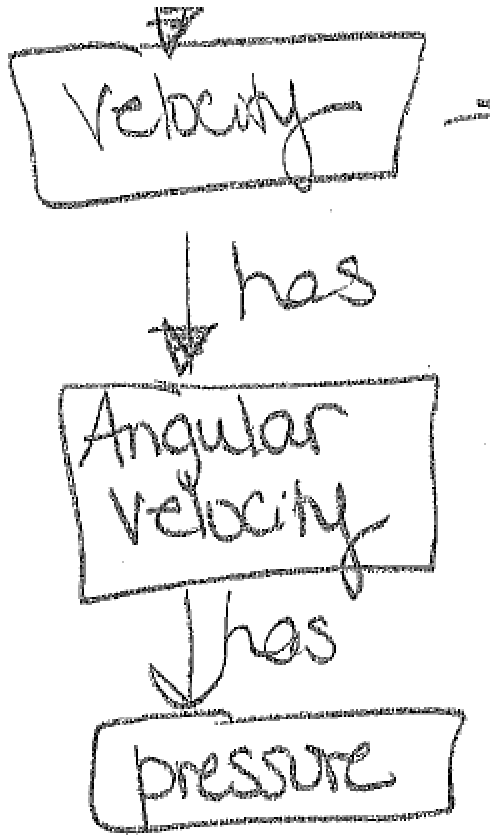
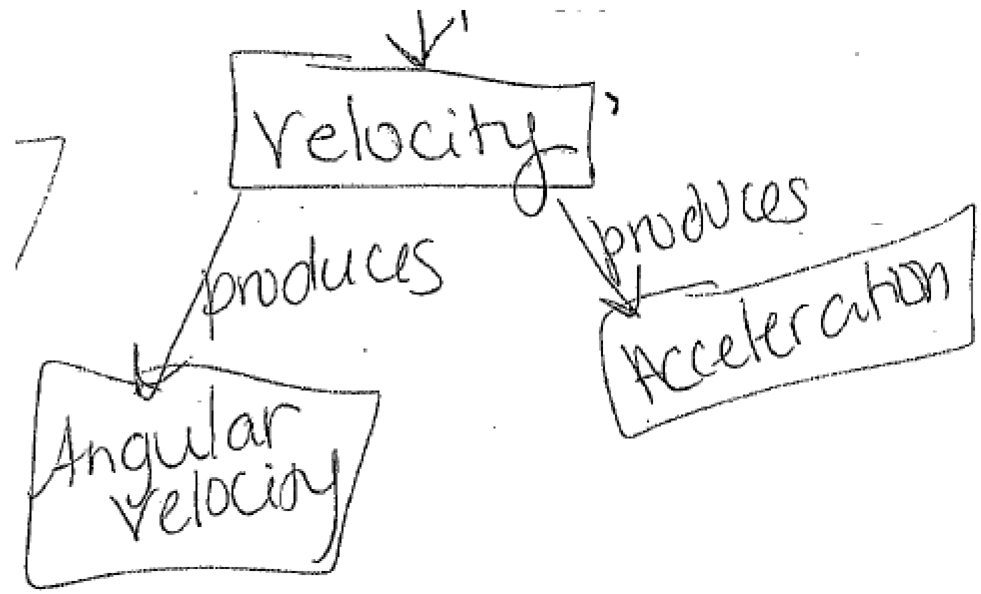
Qualitative Interpretation

Pre-Concept Map



Post-Concept Map



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Participants

Name	CEEMS Subject Taught	Pre-knowledge of Concept Maps
Christine	Chemistry	Attended PD workshops but never used in own classroom
Phillip	Physics	No exposure
Mark	Math	Attended PD workshops but never used in own classroom
Mary	Math	No exposure
George	Geology	Has used Concept Maps in courses previously

How do Arts and Science and Engineering faculty understand student concept maps as reflections of students' content knowledge?

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Previous Knowledge

Phillip: **<u>This person's had a physics class before</u>**, I think. They didn't put a verb there. If they'd have put a verb there they'd have gotten more points. Yeah, this person had a physics class before (Philip, lines 901-904).

Mark: People **<u>didn't know</u>** what capacitors and resistors were **<u>coming in</u>** and if you looked through to the entire stack of pre-maps they're kind of thrown in every which place. (Mark, lines 1289-1291).

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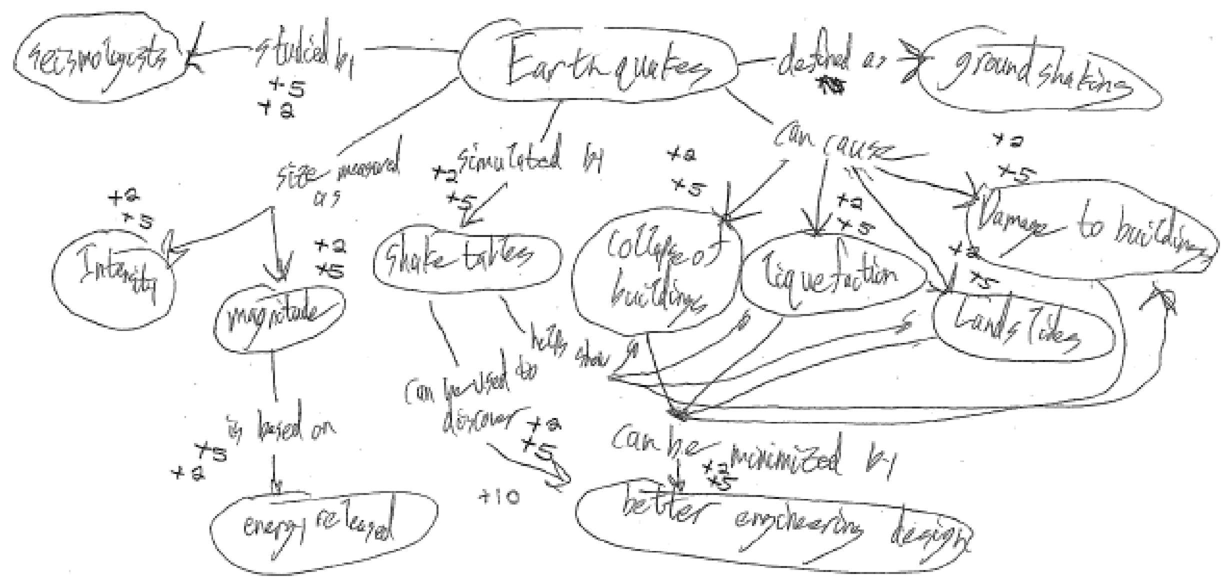
Knowledge Organization

George: Yeah again **<u>I would say the hierarchy is missing</u>**; everything else seems to be alright, and these cross relationships are okay. But at the same level **<u>seismologists, earthquakes and ground shakings are put uh at the same level</u>**. I would put for example earthquakes are the ground shakings and then studied by seismologists and they use two scales, intensity and magnitude (George, lines 682-687).



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Insight to Student Thinking

Felt that concept maps gave a full representation of knowledge because they show what students are thinking about ***how*** concepts relate together instead of simply knowing that those concepts have some connection.

Interviewer:	So this person, **you can tell they were really trying to link things together**.
Christine:	Just didn't know what was getting the linkages in the right places. That's very interesting. Oh, **I don't know whether it shows that they know that they should have been connected, but they just didn't quite know what to put between**. Oh, that's very interesting, isn't it?
	(Christine, lines 980-987).

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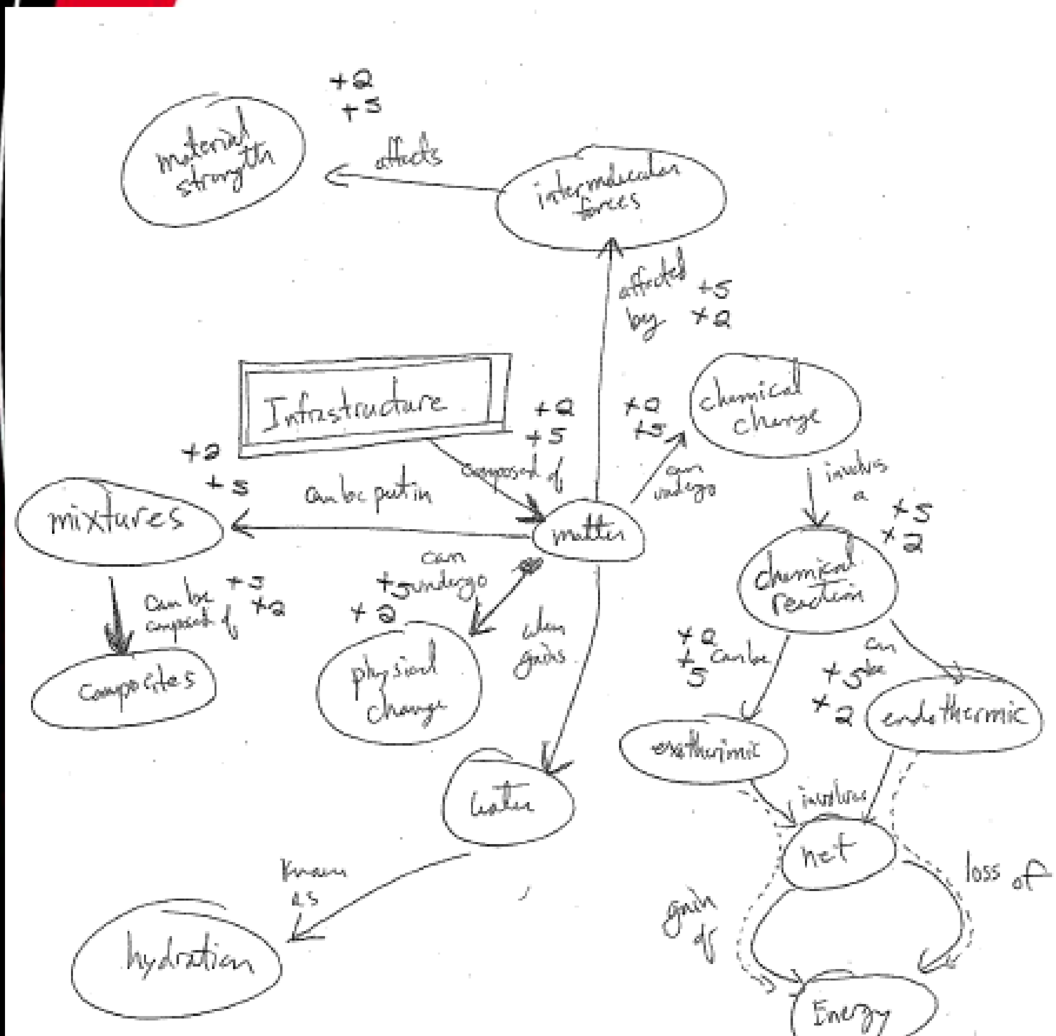
How do faculty interpret the changes in the students' pre and post concept maps as a reflection of students' learning?

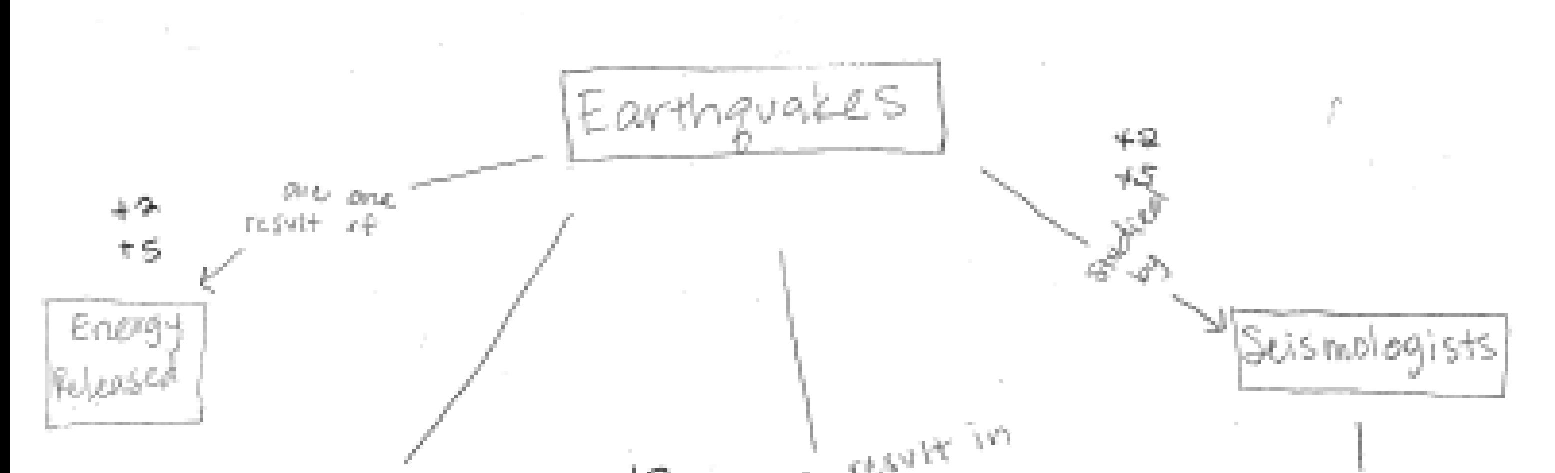
More Sophisticated Understanding



Christine:

This definitely, the post-map, definitely looks more sophisticated […] Yeah, I think they have certainly, um, understood that things are connected differently from what they thought before they started. (Christine, 690-695).

George: Notice that in terms of hierarchy they put energy release and seismologists at the same level; here earthquakes as the highest priority and then everything else is coming down, which is what we want. (George, lines 639-641)



Do faculties' reflections on the pre- and post-concept maps, lead to them to reflect on changes in their teaching?

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Pre-concept maps to target pre-misconceptions

Christine : Um, well there's definitely **<u>some reasonable connections</u>** pre-, but there **<u>is also some incorrect connections</u>** in the pre-test. […] Uh, well I think it's more confusion than incorrect in the sense that it's an interesting way to have connected mixtures, physical change, composites and hydration. And it's also interesting how they don't really appear to, um, **<u>they don't really appear to have any concept that matter is the central connecting theme</u>** (Christine, lines 664-674).

Mark : We didn't do really an assessment to ourselves to know what they could do.

Interviewer: Okay. Would that be **<u>something beneficial for you to do in the future</u>**?

Mark: **<u>I kind of want it now</u>** (Mark, lines 1250-1256).

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Use of Pre-Concept Maps to Guide Curriculum in the Course

Interviewer:	*W*hat kind of links would you like to see [by the end of the course]?
Christine:	Um, well I definitely think that, um, these chemical reactions, chemical and intermolecular forces would be more connected […] connection [between] intermolecular forces, infrastructure and material strength concept. […] Um, physical change to intermolecular forces; hydration to intermolecular forces, things like that. (Christine, lines 598-610).

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Planning for Next Year

Mark: Yeah, but no, but that to me is a big deal because even – and **<u>that helps me maybe think about next year</u>** if I were to split and maybe I won't use the words algebra, calculus. **<u>I might use more of the bigger</u>** – the actual math. Algebra's just describing a field, but like graphs or these exponential equations; more specific to the math topic but yet it is a – because they are fields and **<u>then they may be able to tie that more in between</u>**. (Mark, lines 871-876).

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Attitude Toward Concept Maps

Mark: I'm taking this pretty serious this concept maps because I think **[…] this is our best assessment**. I really think it is. I mean, we have a few – we learned a few other things that might help track that learning pedagogy or whatever but this is the one I want as the real [assessment]. I believe in concept **– I think it's how the brain works**

(Mark, lines 760-776).

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Conclusion

- STEM faculty were able to see:
  - how student concept maps reflected student’s current knowledge
  - how changes in concept maps pre to post represented newfound understanding
  - how concept maps would benefit them in their own classrooms outside of the CEEMS program

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Limitations

- Students were not “taught” how to do concept maps.
- Faculty commented in their interviews that many students were mentally exhausted during the last day and rushed through the post-concept map.

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Acknowledgements

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