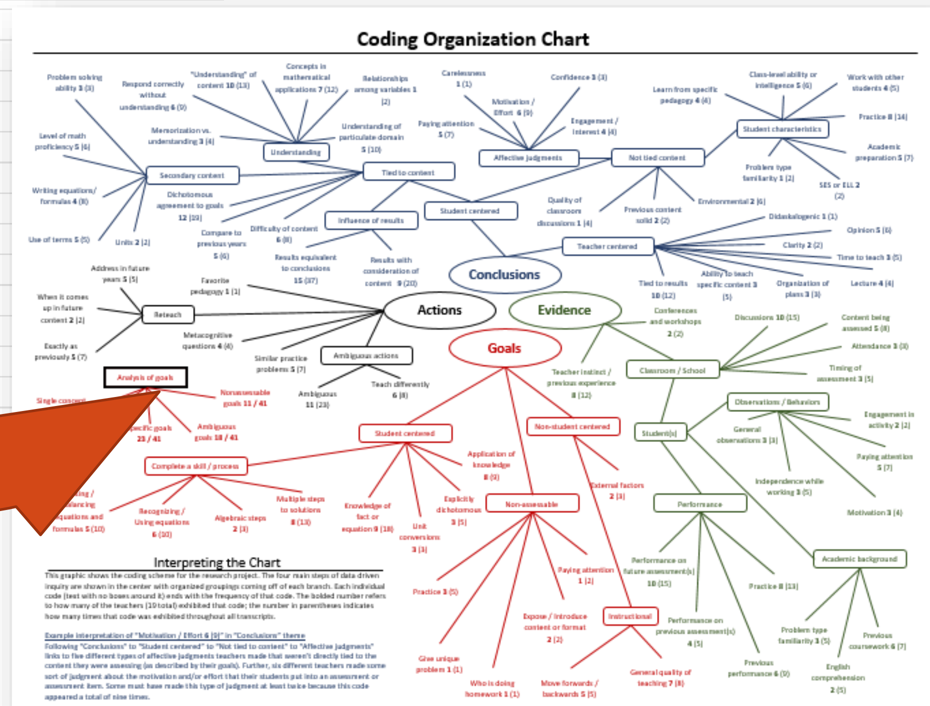
Electronic Supplementary Material (ESI) for Chemistry Education Research and Practice.

APPENDIX C:
QUALITATIVE METHODS ILLUSTRATION

Nodes

Name	Sources	References
General Codes	0	0
Accounting for evidence external to assessment	18	
Collaboration with other teachers	9	
Conclusions being made about students or learning	19	
Conclusions being made about teachers or teaching		
Content deficiencies in areas outside of chemistry		
Dichotomous goals and conclusions		
Feedback primarily or only for students	5	
Hodgepodge of actions or indecisiveness	14	
Identifying misconceptions and using them	18	
Reteaching in similar or different ways	15	
Student centered goals	19	
Teacher centered goals	14	
Wording as a problem	9	



This appendix will expand on the methods that are already detailed in the manuscript.

METHODS - CODING

Our qualitative methods are complex. Therefore, this appendix will walk through the steps taken in data analysis, starting with an overview of the process:

1. Open coding[1] into categories, big ideas
2. Horizonilization[2] and development of clusters of meaning[2] in order to develop specific codes
3. Coding
4. Closed coding codes into data-driven inquiry framework
5. Hierarchically organizing clusters of meaning under each DDI category

[1]Creswell, J.W. (2007). Qualitative Inquiry and Research design: Choosing Among Five Approaches (2nd Ed). SAGE, Thousand Oaks, CA.
[2]Moustakas, C. (1994). Phenomenological Research Methods. SAGE, Thousand Oaks, CA.

1. Open Coding (13 codes)

We were focused on big picture ideas by coding broad, overarching themes first. Here are the 13 big idea codes from our study:

Nodes

Name	Sources	References
General Codes	0	0
Accounting for evidence external to assessment	18	62
Collaboration with other teachers	9	21
Conclusions being made about students or learning	19	212
Conclusions being made about teachers or teaching	19	50
Content deficiencies in areas outside of chemistry	4	13
Dichotomous goals and conclusions	10	23
Feedback primarily or only for students	5	7
Hodgepodge of actions or indecisiveness	14	28
Identifying misconceptions and using them	18	59
Reteaching in similar or different ways	15	48
Student centered goals	19	101
Teacher centered goals	14	21
Wording as a problem	9	19

In order to see what happens next, I'll highlight "Conclusions being made about students or learning," which is displayed on the next page.

Creswell, J.W. (2007). Qualitative Inquiry and Research design: Choosing Among Five Approaches (2nd Ed). SAGE, Thousand Oaks, CA.

2. HORIZONILIZATION

Horizonilization is part of data reduction technique, but is not used like coding. Instead, it's simply a means of abstracting meaning from small pieces of text.

Conclusions being made about stu

Reference 6 - 1.43% Coverage

Conclusions about particulate nature

Um, based off of the results of this particular item, do you think you're students could give a verbal or written definition of the terms solid liquid gas and element compound and molecule?

Um, well, having, haven listened to um, their descriptions during the activity, I feel pretty confident that they could do that, um, and um, it kind of shows up in one of those next assessments if they can, so um, ya know I, I guess I'm expecting that they're going to be able to later. I know this question doesn't really prove that for me yet.

Students knowledge of terms

Students needed more practice

So, I know that there's a payoff um I know that I need to practice more with them. Um, ya know for them to be 100% comfortable. I think that most of them could draw me a simple solid liquid gas, it might tax them it might tax them to draw me a solid liquid gas and tell them I need an element compound or mixture ya know they don't all understand what a diatomic element is yet and things like that so I wouldn't say they're 100% comfortable.

Individual, very specific ideas were aggregated to develop *clusters of meaning*, which are clusters of specific ideas that have connection with each other (see next page).

2. CLUSTERS OF MEANING (35 CLUSTERS)

30. Teachers make a conclusions about their students in terms of their understanding, ability, learning, and interest in areas directly tied to the content of the assessment. The important caveat here is that these are conclusions that are directly related to chemistry content. For example, conclusions like students do/don't understand LeChatlier's principle, law of definite proportions, and stoichiometry problems are all directly related to content. Things like student engagement, motivation, developmental ability, communication strategies are things that are typically not found in the goals for chemistry assessments. That is, all ideas on this list are things that if you assume that teachers have a goal of assessment only chemistry content/skills, you would expect to see these things listed in goals. For ease of display, a list of all conclusions explicitly talked about from the teachers are below:

- understanding of concepts (**30.1**)
- understanding of relationships amongst key variables (**30.2**)
- level of proficiency with mathematical/algebraic portions of problems (**30.3**)
- understanding of conceptual concepts in mathematical application (**30.4**)
- conceptual understanding of sub-microscopic domain (**30.5**)
- proficiency in "secondary-requisite" content (i.e. nomenclature, equation-writing, SI unit conversions, sig-figs, etc.) (**30.6**)
- results of assessment is equivalent to conclusions (**30.7**)
- problem-solving ability (**30.8**)
- memorization versus understanding (**30.9**)

30.1 Adie
I represent those pictorially symbolically, and graphically and ya know my kids can all do that. That shows me that if they can represent the situation in more than one way, it shows me that they actually understand what's going on.

30.2 Adie
so I went through the labs to make sure that they had gotten the main idea but I mean, the vast majority, over ninety percent had had the relationships correct.

30.3 Adie
Was there any one of those three areas the math, the concept, or the application part of it that it seemed some students seemed to struggle more or find more problems with or were they fairly evenly distributed?
It's usually the math.

One sentence description

Detailed description

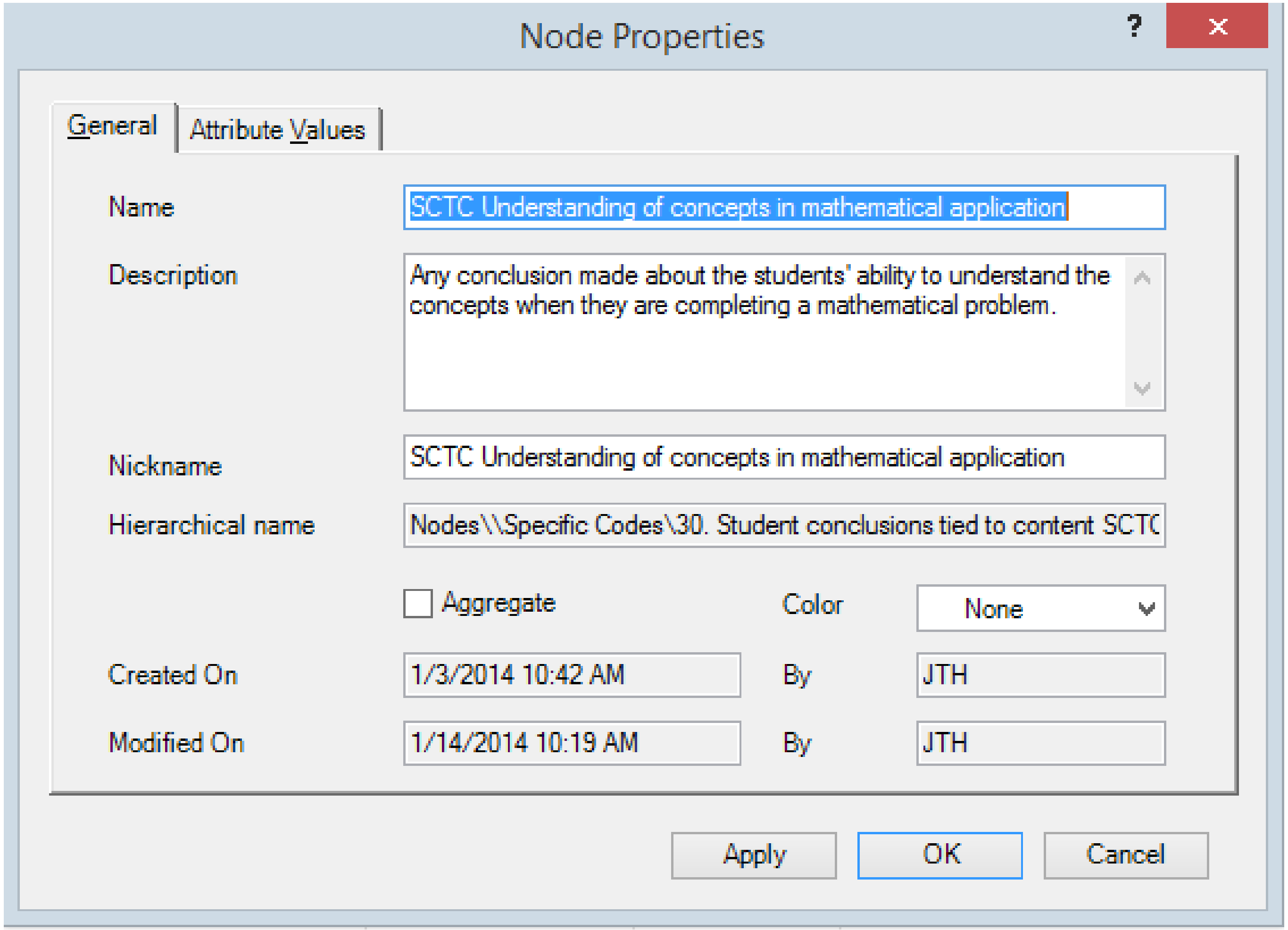
<u>Clusters of Meaning:</u> Larger than a code, description of an idea that then gets translated into multiple codes

Supporting quotes

- See "understanding of conceptual concepts in mathematical application" on next page

2. DEFINITION OF THE CODES (81 CODES)

With consideration to the specific idea and it's place within the cluster of meaning, we defined the code using the clusters of meaning. These are the descriptions that are listed in Appendix D.

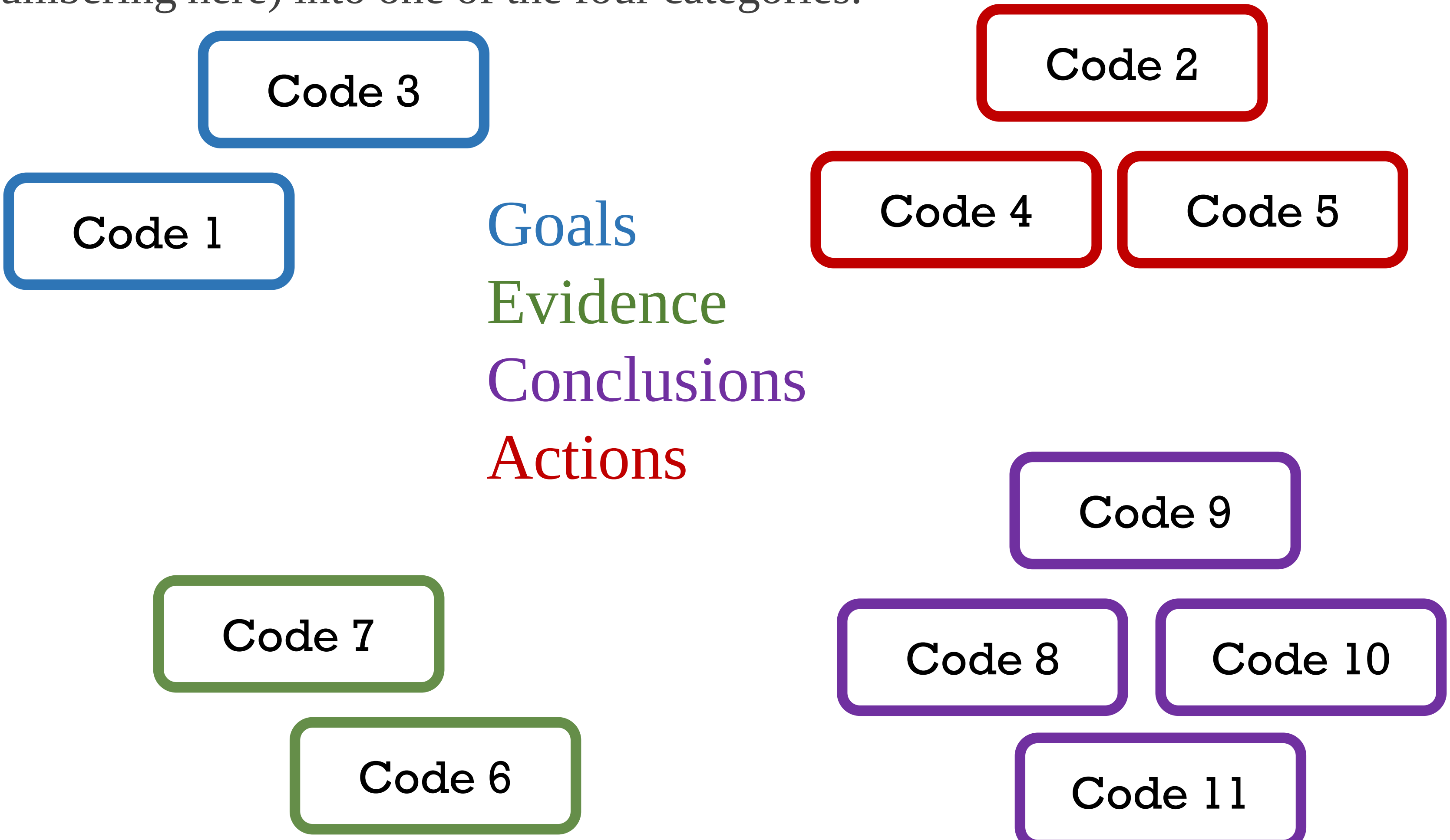


3. CODING

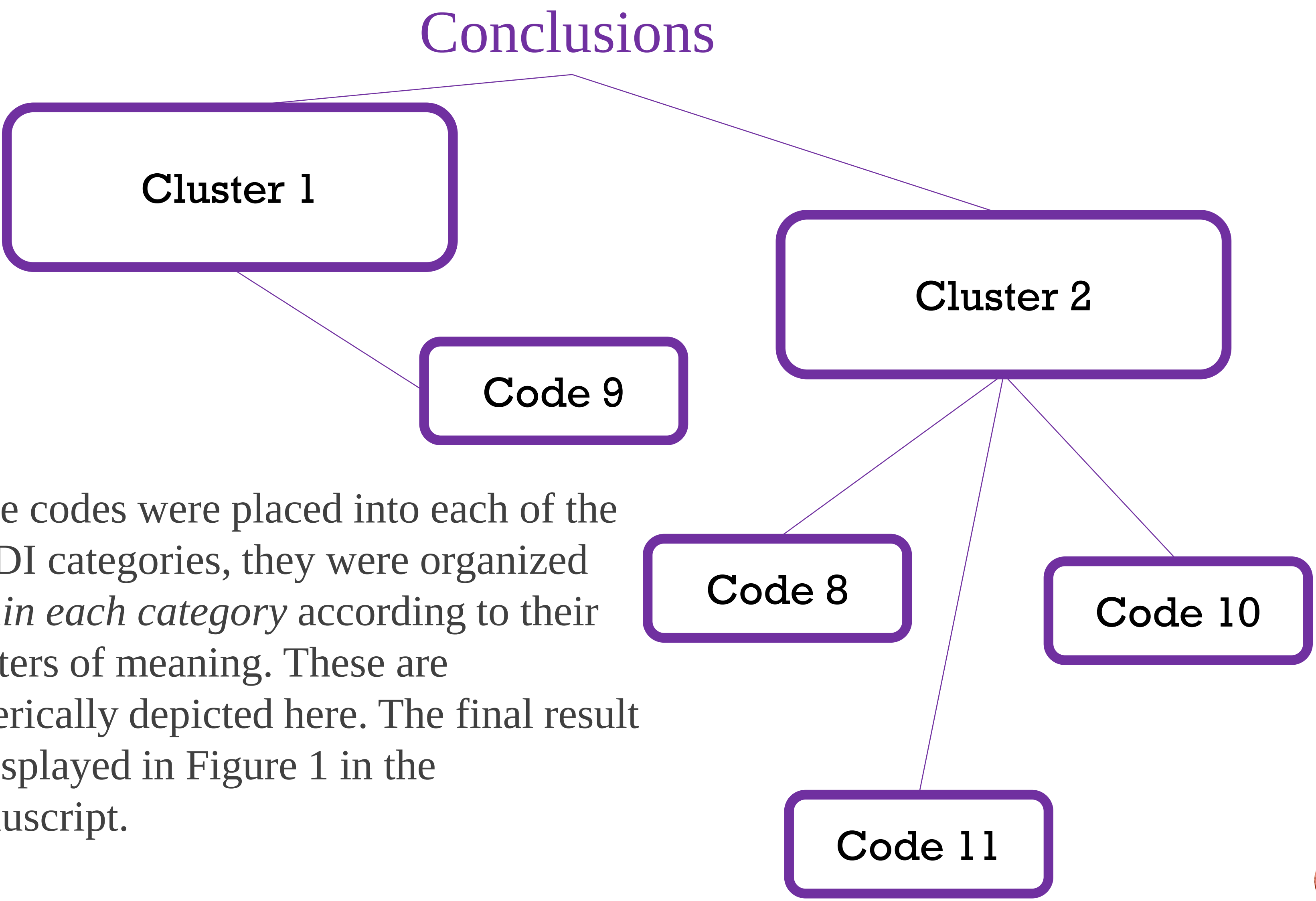
Transcripts were coded entirely with the 81 individual codes. (see "Reliability" section for information on inter-rater reliability and recoding)

4. CLOSED CODING INTO DDI FRAMEWORK

The final steps were to closed code specific codes into the DDI framework. As an example, we simply grouped codes (general codes depicted by numbering here) into one of the four categories.



5. ORGANIZATION INTO DDI FRAMEWORK



Once codes were placed into each of the 4 DDI categories, they were organized *within each category* according to their clusters of meaning. These are generically depicted here. The final result is displayed in Figure 1 in the manuscript.