“Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited.”
VII. CONCLUSIONS

To date, concept maps have been primarily utilized as an intervention mechanism for improved learning, even though they have potential as an assessment tool. Although researchers have examined using these maps for assessment, to date there have been few reported cases in which inferences have been made about students’ level of conceptual understanding. A major limitation has been the reliance on “traditional” scoring methods based on count data. Although these methods attempt to quantify the map’s content, they fail to capture the quality of that content. Further, these scoring methods can be time consuming, lack standards, and may introduce inappropriate bias. To combat these problems we first took a holistic approach to scoring the maps and then formalized this approach by constructing a structured rubric.

The results of our study suggest that concept maps can be an effective way to measure a student’s conceptual understanding in a particular area. The experts that scored the students’ concept maps were able to distinguish the various class levels through their self-developed holistic score that corresponded to the map’s quality and later through the rubric. This indicates that the holistic rubric is sufficiently sensitive to detect growth in students’ knowledge integration from the sophomore to senior year. The formal scoring rubric not only allows one to distinguish the class levels, but also further quantifies these differences across three attributes.

Our results are encouraging because they suggest that concept map knowledge can be measured in a meaningful, reproducible and efficient manner. Validation efforts revealed high correlation between the two pairs of professors who scored the concept maps using the rubric. Paired analysis of 30 maps also showed that no significance differences resulted in scoring in the area of comprehensiveness and correctness, although a significant difference was found relative to organization. An adjustment to the rubric, may have resolved this one area of difference. These results demonstrate the rubric’s potential for accurately quantifying the knowledge portrayed by the student through their map.

The University of Pittsburgh IE department has seen the value of using student concept maps and has formalized plans to annually conduct concept map investigations. Based on our recent findings a second engineering department also plans to incorporate

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Table 4. Concept Map scoring rubric (Understanding of Engineering Field).

<table>
<thead>
<tr>
<th>Category</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comprehensiveness</strong></td>
<td>The map lacks subject definition; the knowledge is very simple and/or limited. Limited breadth of concepts (i.e., minimal coverage of coursework, little or no mention of employment, and/or lifelong learning). The map barely covers some of the qualities of the subject area.</td>
<td>The map has adequate subject definition but knowledge is limited in some areas (i.e., much of the coursework is mentioned but one or two of the main aspects are missing). Map suggests a somewhat narrow understanding of the subject matter.</td>
<td>The map completely defines the subject area. The content lacks no more than one extension area (i.e., most of the relevant extension areas including lifelong learning, employment, people, etc. are mentioned).</td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td>The map is arranged with concepts only linearly connected. There are few (or no) connections within/between the branches. Concepts are not well integrated.</td>
<td>The map has adequate organization with some within/between branch connections. Some, but not complete, integration of branches is apparent. A few feedback loops may exist.</td>
<td>The map is well organized with concept integration and the use of feedback loops. Sophisticated branch structure and connectivity.</td>
</tr>
<tr>
<td><strong>Correctness</strong></td>
<td>The map is naïve and contains misconceptions about the subject area; inappropriate words or terms are used. The map documents an inaccurate understanding of certain subject matter.</td>
<td>The map has few subject matter inaccuracies; most links are correct. There may be a few spelling and grammatical errors.</td>
<td>The map integrates concepts properly and reflects an accurate understanding of subject matter meaning little or no misconceptions, spelling/grammatical errors.</td>
</tr>
</tbody>
</table>
# Rubric Example #2: A Rubric for Sociology Online Discussion (S. Evans, 2010)

<table>
<thead>
<tr>
<th></th>
<th>4 Points</th>
<th>2 Points</th>
<th>0 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content</strong></td>
<td>You show that you can apply or extend the idea you are discussing.</td>
<td>Some of your messages analyze, interpret, or apply the material well, but some do not. This might either be because the analysis was not done well, or because it was not attempted (that is, was simply opinion or hearsay).</td>
<td>Your messages generally show little evidence of analysis, consisting instead of opinion, feelings and impressions.</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td>You accurately represent the concepts discussed.</td>
<td>You generally represent the concepts accurately, but you do not do so in all cases.</td>
<td>You have significant issues with regard to accurately representing the concepts.</td>
</tr>
<tr>
<td><strong>Use of material</strong></td>
<td>You use and cite sources, including the text and articles and/or bring in an outside source, all of which clearly add significantly to the discussion.</td>
<td>You clearly refer back to a definition, example or concept from the reading or lecture.</td>
<td>You do not bring in or refer to any material from the text, outside sources, or lectures.</td>
</tr>
<tr>
<td><strong>Sociological Analysis</strong></td>
<td>You focus on the sociological implications of the issue at hand (e.g., social meaning, the outcomes for society or groups, the social function served).</td>
<td>You touch on some sociological issues, but focus also on individual ones.</td>
<td>You focus primarily on individual issues.</td>
</tr>
<tr>
<td><strong>Responses</strong></td>
<td>You extend or politely question the post of another person in a way that advances the discussion.</td>
<td>You add new examples that continue the idea created by another person.</td>
<td>Your responses are primarily agreement.</td>
</tr>
<tr>
<td><strong>Participation</strong></td>
<td>You write at least three or more substantive comments (using the above criteria) based on the discussion assigned.</td>
<td>You write fewer than three substantive comments.</td>
<td></td>
</tr>
<tr>
<td><strong>Time of Posting</strong></td>
<td>Your posts are spread widely during the discussion.</td>
<td>You post at two significantly different times.</td>
<td>Your posts are clustered within a short period of time.</td>
</tr>
<tr>
<td><strong>Posts Read</strong></td>
<td>You have read at least 75% of the posts in the discussion.</td>
<td>You read at least 50% of the posts in the discussion.</td>
<td>You read less than 50% of the posts in the discussion.</td>
</tr>
<tr>
<td><strong>Clarity</strong></td>
<td>You use standard grammar and spelling and your meaning is clear.</td>
<td>Your posts have some grammar or spelling mistakes or your meaning is not entirely clear.</td>
<td>Your posts have significant grammar or spelling mistakes or your meaning is not clear.</td>
</tr>
</tbody>
</table>
Wiliam: A Framework for Formative Assessment

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Where the learner is going</th>
<th>Where the learner is right now</th>
<th>How to get there</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Clarifying learning intentions and criteria for success</td>
<td>2 Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding</td>
<td>3 Providing feedback that moves learners forward</td>
</tr>
<tr>
<td>Peer</td>
<td>Understanding and sharing learning intentions and criteria for success</td>
<td>4 Activating students as instructional resources for one another</td>
<td></td>
</tr>
<tr>
<td>Learner</td>
<td>Understanding learning intentions and criteria for success</td>
<td>5 Activating students as the owners of their own learning</td>
<td></td>
</tr>
</tbody>
</table>

Dylan Wiliam, *Embedded Formative Assessment*, Solution Tree (2011)
1. Clarifying, Sharing, and Understanding Learning Intentions and Criteria for Success

• Rubric Dichotomies:
  • Task-specific vs. generic rubrics
  • Product-focused vs. process-focused
  • Official vs. student-friendly Language

• Rubric Design:
  • Three key components in presenting learning intentions and success criteria to students:
    • WALT: we are learning to
    • WILF: what I'm looking for
    • TIB: this is because
  • Make explicit progressions within rubrics, and progressions across rubrics

• Students and Rubrics:
  • Have students look at samples of other students' work, then rank them by quality
    • Students become better at seeing issues in their own work by recognizing them in others’ work
    • Not a “somebody wins” exercise, but rather a quality exercise that engages students
  • Have students design test items, rubrics
2. Eliciting Evidence of Learners' Achievement in the (Extended) Classroom

• Asking questions in class:
  • Chosen to act as a discussion/thinking trigger
  • Should provide info for varying instruction on the fly and in the long term
• Examples:
  • ConcepTest
  • POE (Predict-Observe-Explain)
  • TPS (Think-Pair-Share)
  • Virtual Whiteboard
3. Providing Feedback that Moves Learners Forward

• The feedback process must provide a recipe for future action

• Feedback should:
  • Be more work for the recipient than the donor, i.e., not just right/wrong – make them think about what did not work
  • Be focused: less is more
  • Relate explicitly to goals/rubrics

• How:
  • Scores or praise alone do not provide this; comments do
  • Supplying minimal scaffolded responses (i.e., where the student got stuck) >> supplying a full response to the problem
    • This emphasizes the crucial role of the draft object and process
  • Oral feedback >> written feedback
    • Consider using recordings
  • Create (sometimes together with students) process rubrics that embody this scaffold
  • Provide time for students to use this feedback

• Minimize grading:
  • Avoid false stopping points
  • Avoid ratchet effect
4. Activating Students as Instructional Resources for One Another

- Two key elements:
  - Group goals
  - Individual accountability

- Effectiveness due to (in order of importance):
  - Personalization
  - Cognitive Elaboration
  - Motivation
  - Social Cohesion

- Reciprocal help only works when it takes the form of elaborated explanations:
  - Not simple answers or procedures
  - Looks to the upper levels of Bloom for both participants

- Reciprocal help is more effective (by a factor of up to 4) if the product being assessed is the result of the aggregate of individual contributions, rather than just one group product
5. Activating Students as Owners of their Own Learning

• Effective self-assessment is up to twice as effective as other-assessment

• Two key components:
  • Metacognition:
    • Metacognitive knowledge: know what you know
    • Metacognitive skills: what you can do
    • Metacognitive experience: what you know about your cognitive abilities
  • Motivation:
    • Traditionally viewed as a cause (intrinsic/extrinsic), but is better viewed as an outcome:
      • Flow (M. Csikszentmihalyi): the result of a match between capability and challenge
        • Students are motivated to reach goals that are specific, within reach, and offer some degree of challenge

• Three sources of info for students to decide what they will do:
  • Perceptions of the task and its context
  • Knowledge about the task and what it will take to be successful
  • Motivational beliefs

• The role of the draft process and object resurfaces as a crucial component here

• Important Tools:
  • Learning logs and journals
  • Learning portfolios
## Dimensions of Computational Thinking

<table>
<thead>
<tr>
<th>Computational Concepts</th>
<th>Computational Practices</th>
<th>Computational Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Being Incremental and Iterative</td>
<td>Expressing</td>
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<tr>
<td>Loops</td>
<td>Testing and Debugging</td>
<td>Connecting</td>
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<td>Events</td>
<td>Reusing and Remixing</td>
<td>Questioning</td>
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<tr>
<td>Parallelism</td>
<td>Abstracting and Modularizing</td>
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<td>Conditionals</td>
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<td>Operators</td>
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<tr>
<td>Data</td>
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</table>
## Computational Thinking in Math and Science

<table>
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<tr>
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<tbody>
<tr>
<td>Collecting Data</td>
<td>Using Computational Models to Understand a Concept</td>
<td>Preparing Problems for Computational Solutions</td>
<td>Investigating a Complex System as a Whole</td>
</tr>
<tr>
<td>Creating Data</td>
<td>Using Computational Models to Find and Test Solutions</td>
<td>Programming</td>
<td>Understanding the Relationships within a System</td>
</tr>
<tr>
<td>Manipulating Data</td>
<td>Assessing Computational Models</td>
<td>Choosing Effective Computational Tools</td>
<td>Thinking in Levels</td>
</tr>
<tr>
<td>Analyzing Data</td>
<td>Designing Computational Models</td>
<td>Assessing Different Approaches/Solutions to a Problem</td>
<td>Communicating Information about a System</td>
</tr>
<tr>
<td>Visualizing Data</td>
<td>Constructing Computational Models</td>
<td>Developing Modular Computational Solutions</td>
<td>Defining Systems and Managing Complexity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Creating Computational Abstractions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Troubleshooting and Debugging</td>
</tr>
</tbody>
</table>

Hippasus

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