

Performance Assessment of Collaboration and Communication Skills: A Work in Progress

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Cary Sneider, Portland State University
Debra Brockway, Stevens Institute of Technology
Kathy Comfort, WestEd

Abstract

A performance assessment is currently being tested as a means for measuring students' communication and collaboration skills learned through engineering units integrated with high school biology and chemistry courses. The instrument consists of a 45-minute activity, known as a "jigsaw." Teams of students are given a problem to solve, and each student is given a different piece of information critical to solving the problem. Students have a brief period of time to discuss the problem and share their ideas. Then each student is assessed on their ability to recall the information provided by the other team members, as well as the reasoning behind the group's final solution to the problem. The results provide a measure of the extent to which the students were able to collaborate and communicate information during group problem solving.

Introduction

"Several lines of research have shown that teams are more productive than individuals for generating solutions to many kinds of problems, provided team members are effective collaborators." –National Assessment Governing Board, 2009, p. 2-33

There has been growing recognition in recent years that communication and collaboration are essential skills for everyone, and should therefore be included as educational goals. For example, *A Framework for K-12 Science Education*, a consensus report from the National Research Council (NRC 2012), includes communication and collaboration among a list of practices that all students should develop during thirteen years of schooling.

The *Technology and Engineering Literacy Framework for the 2014 National Assessment of Educational Progress* (National Assessment Governing Board 2009), quoted above, also includes communication and collaboration among a short list of essential practices. And the Partnership for 21st Century Skills includes collaboration and communication among the most important skills that everyone needs to thrive in the 21st century, along with two other Cs—creativity and critical thinking. 21st century skills are widely expected to become even more important for all professions in the coming decades (National Research Council, 2008, 2012).

As pointed out by Clark (2009), there is a very close connection between scientific practices such as arguing from evidence and the 21st century skills of communication and collaboration. When scientific

practices are embedded in a social framework that addresses real world situations and problems, more advanced skills—e.g., solving problems, collaboration and communication—are required. When students engage in scientific practices that are embedded in a social framework, they use the discourse of science, and work with scientific representations and tools (NRC, 2008, p. 34).

In order to measure progress, and to be clear about the meaning of 21st skills, assessment instruments to operationally define and measure degrees of collaboration and communication are needed to determine the extent to which students are gaining these skills (or not) as a result of instruction. The need for such an assessment is especially important in the context of our current project—to test the effectiveness of two engineering design units to teach relevant science concepts and develop students' 21st century skills in high school chemistry and biology courses. The overall project has been described in previous papers (Brockway et al. 2011, 2012). An important aspect of the engineering unit is that the students work together in collaborating teams to apply biology concepts in order to solve real-world problems. According to Soller & Lesgold (2007), when students learn in effective teams, they benefit through enhanced learning of the task and the improvement in social interaction skills that they will need throughout their lives.

In this paper we describe the assessment instrument that we will be testing to determine whether or not the engineering unit is better than traditional biology teaching at developing students' abilities to communicate and collaborate in a group problem-solving situation. Although we have developed two versions of the instrument—one related to chemistry and one related to biology—both assessments follow the same procedures for administration and scoring. In order to be concise this paper will focus on the biology assessment.

The instrument can best be described as a “performance assessment,” or “authentic assessment.” Performance assessments require students to demonstrate their understanding to solve a real world problem and to accomplish a task. Skill level is then assessed with a scoring rubric. In other words, performance assessments measure students' abilities to actually *do* something, as opposed to typical written tests that determine what students know *about* something. In contrast, most existing assessments, which consist primarily of multiple-choice, or short constructed response items, measure only whether a student possesses a particular piece of content knowledge, not whether the student can analyze this information, evaluate its utility, or create new knowledge from it—the core of both 21st century skills (Silva, 2008), and of scientific and engineering practices (NRC, 2010).

Before turning to prior research it is worth mentioning that in the literature on 21st century skills the twin skills of communication and collaboration are not defined and measured separately. It is difficult to collaborate without communicating, and vice versa, so we have not attempted to separate these skills in our assessment instrument.

Prior research

There is a significant body of literature on “authentic,” or “performance-based” assessments. One of the most eloquent authors to describe authentic assessments is Grant Wiggins, who defined such instruments as follows:

“Assessment is authentic when we directly examine student performance on worthy intellectual tasks. Traditional assessment, by contrast, relies on indirect or proxy 'items'—efficient, simplistic substitutes from which we think valid inferences can be made about the student's performance at those valued challenges.” (Wiggins, 1990, p. 2)

In the early 1990s, authentic assessment gained ground as a means for assessing what matters most in education—students' abilities to apply what they have learned, and to demonstrate higher levels of

thinking across a wide range of tasks. The state of California developed the first statewide authentic assessment instrument—the California Learning Assessment System (CLAS)—for students. However, as education became more politicized authenticity gave way to accountability, and the CLAS model was abandoned in favor of high stakes tests with multiple-choice items that measure lower order thinking skills (Kirst, 1996).

Nonetheless, performance assessments continue to be of value in small-scale studies in which the researcher wishes to measure higher-order thinking skills, and there are a great many studies that use authentic or performance assessments to measure the effectiveness of a treatment. The current study fits within this tradition.

We have been unable to find studies on the assessment of communication and collaboration skills in the context of high school engineering instruction. However, we have identified a study of teachers' perceptions concerning engineering in the classroom that is relevant to our current work. McMahon (2012) undertook a research project to create a “foundation upon which future studies about curriculum and professional development for engineering education can be based.” The purpose of the study was to find out what teachers think happens in engineering design classes and to compare their perceptions with those of professional engineers. Although the subjects of the study were elementary students, the teachers' perceptions provide helpful insights.

Twelve upper elementary teachers took part in the study: six teachers who were using a kit-based science program (FOSS) and six teachers who had been teaching engineering using materials developed at Tufts' Center for Engineering Education and Outreach. A third group consisted of professional engineers, including the study author who had worked as an engineer as well as a teacher and teacher educator.

The study procedure consisted of an extended interview in which the interviewee first described his/her teaching practice, then watched a 20-minute video entitled “Deep Dive,” in which a team of designers from the firm Ideo created a new design for a shopping cart. The video demonstrates several engineering principles, such as “fail often in order to succeed sooner,” “fresh ideas come faster in a fun place,” and “enlightened trial and error succeeds over the planning of the lone genius.” The teacher being interviewed was then asked to respond to prompts concerning how they might use the video in their own classroom, and explained their responses in a semi-structured interview. The engineers, including some from Ideo, responded to similar questions.

All groups commented about the social component of the engineering design process that was highlighted in the video. In fact the norms for group participation were posted in the workplace and commented on by the narrator: “one conversation at a time, stay focused, encourage wild ideas, defer judgment, build on the ideas of others.” However, there was a difference in perspective on the issue of communication and collaboration between the teachers and engineers. The engineers naturally assumed that the adults they work with would understand and comply with group norms. Consequently, their focus was primarily on the design process itself. The teachers, on the other hand, recognized that the students needed to learn how to work as a team, and that such learning needed to be intentional. They therefore saw engineering design as a classroom activity that could be used as a vehicle for teaching these important interpersonal skills.

The authors of this paper share the teachers' perspective described in McMahon's (2012) study. That is, communication and collaboration skills are important, need to be taught, and can be learned by participating in engineering design challenges. In order to determine whether or not students have developed these skills in the context of high school engineering modules presented in science classes, a performance assessment is most appropriate. The instrument developed for that purpose is described below.

Overview of the Instrument

Each of the two versions of the assessment is expected to take about 45 minutes to administer.

Part I. Task Scenario and Pre-Assessment (About 5 minutes). In the biology task the students are asked to imagine that they are environmental engineers who work for a company called CarbonLock. Although there is no such company today, there might be at some time in the future. The teacher then hands out a short reading assignment in which the students read about the company's business model that involves using one of two strategies for sequestering carbon in order to offset the carbon dioxide produced by a different company. After the students read the task scenario they are given a short assessment with open-ended questions. These questions are used to determine the baseline knowledge students have regarding the topic prior to engaging in the assessment activity, which will provide students with information to be used in the group decision-making process.

Part II. Pros and Cons (About 10 minutes). Next the class is divided into teams of four students. Each student in the team reads a different brief with unique information about one of the two recommended strategies for sequestering carbon. One of the briefs describes "pro" arguments and the other provides "con" arguments for that method. To help the students process what they have read they are asked to list key ideas for or against using that method, so that they can later share those ideas with the other students in their group.

Part III. Teamwork (About 20 minutes). After all of the students have read their brief the groups are given about 20 minutes to share ideas, decide which of the two methods to recommend, and be prepared to justify their rationale. The students are not told explicitly to share their information before making a decision; but teams who have had experience applying science to solving engineering problems should realize that sharing all four briefs is essential in helping the team make the best decision.

Part IV. Post-Assessment (About 10 minutes). When the timed discussion is up, the students are given a written post-assessment that consists of a series of questions intended to determine whether or not they have heard and can remember the three arguments given by their colleagues plus the one they read. Finally, students are asked to evaluate their team's effectiveness in communicating and collaborating by responding to a series of 12 questions.

Scoring

The primary document that will be used to measure students' communication and collaboration skills will be the post-assessment. We will use a rubric to score each paper based on: 1) the extent to which they incorporate ideas from each of the other three players; and 2) a full explanation that justifies their group's decision, calling on evidence provided by the other three individuals on their team. Once the papers are scored we will develop a composite score for each team. Responses to the questions about communication and collaboration will provide a further check on group process. It will be interesting to see if teams who thought they communicated and collaborated well actually did do well in sharing all of the information and using it to reach a conclusion.

In order to judge the effectiveness of the biology unit in fostering students' communication and collaboration skills the scores from teams involved in the engineering design unit will be compared with scores from teams who took the traditional course that covered the same material but without the engineering design group problem-solving context.

Discussion

This instrument is being field tested in more than 60 classrooms during the 2011-12 academic year. As the data collection is still in progress, we initially thought it best to wait before publishing an article about it. However, when we received an invitation to submit a paper for the 2nd P-12 Engineering and Design Education Research Summit we decided it would provide an excellent opportunity to share our ideas with colleagues, receive their critical comments, and learn of similar works-in-progress. It is unfortunate that the most important skills for students to learn are also the most challenging to measure. We therefore look forward to an engaging discussion with our colleagues on how best to measure communication and collaboration skills in a manner that can be standardized and used on a large scale.

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