Understanding the Value of Students Doing Projects

James M. Laffey
ciLaffey@showme.missouri.edu
Terresa Gibney
c611016@showme.missouri.edu
Center for Technology Innovation in Education
University of Missouri-Columbia, USA

Abstract: This investigation focused on building a view of the value of doing projects which emerged from student descriptions of their project work in an innovative high school science and mathematics curriculum. Qualitative coding methods yielded rules to describe student impressions of doing projects. These rules and their instances represent ways of understanding the efforts and achievements of students doing projects. These efforts and achievements are diverse in nature and their assessment cannot be separated from the context of performance, which includes interests, resources, skill at collaboration, and prior knowledge and skill. Five metafunctions are described as a potential beginning point for building an assessment model of student-centered projects. The metafunctions are resourcefulness, reflection, authentic, extension, and connectedness.

Introduction

[Roth & Bowen 1995] describe the misfit between science learning in schools and science learning in practice. Science learning in schools is decontextualized, fragmented, reliant upon textbooks and lectures, and represents inquiry as if it was like following a recipe. Our own personal experience, communication with colleagues and closer analysis of the real process of science [Knorr-Cetina 1992] tells us that innovation, discovery and learning itself is messy, chaotic, opportunistic and results from persistent exploration of ideas. Only in the last stages of understanding does the process of verifying our beliefs come to resemble the methods and practices taught to students of science. Many (e.g., [Gardner 1991] and [Brown, Collins, & Duguid, 1989]) argue for changing to more authentic, situated and project-oriented schooling. [Resnick 1987] calls for schools to be places of intellectual work which encompass more of the features of successful out-of -school functioning. Project-based learning [Blumenfeld et al. 1991] is one schooling strategy to encourage more authentic interaction, ownership and long-term engagement between the student and the subject.

Doing the Whole Project

Two teachers in Lee's Summit, Missouri, drawing from an educational component of Supercomputing '92, conceptualized and put into practice an integrated math and science course which includes a year long computational science project [Biggerstaff, Laffey & Nazworthy 1996]. The central goal of having students do a project is for them to learn to do research; not as a process that you carry out in a sterile and methodical manner as science textbooks seem to indicate, but rather as a challenging set of activities and problems that engage you intellectually, socially and viscerally in a meaningful pursuit. The teachers feel that students need "to do the whole project," which includes finding an engaging and meaningful project, carrying it out, and reporting the results. An example of a student project is the "Dominance Hierarchy Structure of Tomato Clown Fish". Students involved in this project set up a salt water aquarium and conducted a descriptive study of the dominance behaviors of the fish as they protected the territory surrounding their associated sea anemone. The students were able to observe, classify, and document several dominance behaviors of these fish. The behaviors were captured on video tape and digitized to be preserved on the project's world wide web site. Data on behavior were entered into a spreadsheet for analysis and representation. In addition to the documentation of the dominance behaviors the students also had to develop a system of maintaining the upkeep of the aquariums. An extension of this project could see the students building a computer simulation or Stella model of dominance behavior. To facilitate this type of learning experience the teachers had to create a new teaching-learning environment, which included a two-hour block for the course, a rich set of hardware and software technology, high bandwidth Internet connections, and a system of assessment based on contracts.

Problem

We need to learn more about the outcome of doing projects in schools and about how to assess and value the accomplishments of students doing projects. Assessment is always a challenge, but is especially complex when we ask the student to build a project around an authentic interest, wherein the particular subject matter of the project is of less interest to the educator than are the habits, competencies, skills and processes for doing research and carrying out a project. To create order and initiate a plan for the students' independent project work the teachers asked students to write contracts as a team and as individuals. The contracts between the teacher and student serve as good organizing tools, but primarily specify observable performances. A large inferential leap is necessary to make sense of the higher order goals set by the teachers. [Raven 1992] describes a new paradigm for assessment of competence wherein he argues for the inseparability of competence, values, and interests. We would add the necessity for understanding the role of opportunity, context, and cognitive artifacts [Norman, 1993]. We begin our process of understanding by trying to articulate the perspective of the student for the course, efforts and achievements. The primary question of this investigation has been: What dimensions do the students use to describe and make sense of their project-based learning course experience?

Method

Twenty-four students (fourteen male, ten female) were interviewed in December (about half-way through their projects). The interviews were video taped and the students were asked to describe what they liked and did not like about having projects be a major part of the class. Eighteen of these same students completed a written follow-up survey (nine male, nine female) in February. The surveys asked the student to describe how their projects were going, as well as to discuss their skills and strengths, and how those were being developed by working on the project. The survey also asked the students to describe if the project had influenced their long-term goals and if they felt their projects had any "real-world" benefits.

Three experimenters used a qualitative coding method based on the work of [Glaser & Strauss 1967] and [Lincoln & Guba 1985] and described by [Maykut & Morehouse 1994]. Using this method, the transcribed interviews were unitized (units of meaning in the data were identified and separated); a discovery phase was conducted (interviews were reread as a whole and reoccurring phrases, words, and concepts were identified); provisional categories were created, based on the identifications made in the discovery phase, and the unitized data was sorted into the categories; once a provisional category contained enough data to describe it in more detail a rule for inclusion was developed and the provisional category name was rewritten to reflect its rule. Initial coding concluded once all unitized data were categorized and given a rule for inclusion. The final coding phase involved the review of all categories, adjustment and refinement of categories, refinement of rules, and identification of relationships and patterns across categories.

During the coding process, if a student's response included more than one unit of data within the same category (under the same rule for inclusion), a single count was made for the category. For example, if a student reported that the class was different from other classes because there was no homework and then later, the same student reported that the class was different from other classes because the student decides what work will be done, then both of these responses (units) would be coded under the first rule for inclusion listed in the Results section. The student would only be counted once under that rule for inclusion.

Results

The coding process yielded six rules to describe student impressions of doing a project as a significant part of a course. The rules and instances of their representation are presented in Table 1. The instances of Table 1 are primarily drawn from student descriptions of their work on the projects and from their statements of likes and dislikes for the course. The access and use of resources (tools, collaborators, knowledge) is a dominant issue for students. Success was only possible if students found sufficient resources and learned to use them well. The teachers had done a remarkable job of building a rich technology environment to support students, but every project had to extend beyond the resources available in the school lab or library. The most productive projects found, usually via the Internet, a mentor or mentors who facilitated identifying, accessing and using other resources. The finding of a mentor, who was interested in the project, provided technical assistance, but perhaps even more importantly it created expectations of success and validated the project idea in the eyes of the student. To a great extent the students were disappointed with their access and use of resources. Results did not come easily, and often plans had to be changed once some experience was developed with the resource. The early plans of students tended to expect things to work smoothly; revisions to these plans recognized more uncertainty about time and results.

Rule	Count	Instances
Resources are important	18 (75%)	Prior experience with technology or project topic Internet, mentor, library, teacher Disappointment with availability and effectiveness
Is different from other classes and is valued	16 (66%)	Ownership Creative Students decide what and when to work Year long project Learn through their own research efforts Apply knowledge to learn more Use tools Obtain more education
Requires too much of my time	14 (58%)	Project is in addition to rest of course Not enough in class time devoted to project Students have many activities outside of class
Employs the use of groups	12 (50%)	Get more accomplished with group effort Working in groups outside of class requires coordination
Is similar to how people learn and work in "real world"	6 (25%)	Knowledge gained could be applied in "real world" Experiences in class mirror experiences in "real world" Resources used in class are same as resources used in "real world" Uncertainty about what will happen next
Grading format does not make sense	4 (16%)	Expect assessment practices to change as teaching/learning practices change Confusion about how the person and the group would be graded

Table 1 : Student impressions of doing a project

Students had a positive sense that the projects were unlike typical school and represented interesting "real world" work. Enthusiasm came from self-control and decision making for the projects and from the use of resources (especially computer tools and access to mentors). To a great extent the students took on the responsibility of making the projects work, not just meeting school expectations for turning in something. The students described a compelling, authentic learning experience. However, they never lost sight of the context of being in school. It is different, but it is still school! Students continue to worry about grades, meeting teacher expectations, and so on. Project based learning, wherein the students have control and responsibility for the project creates disequilibrium and to a certain extent students are not sure how to deal with it. One student considered dropping the course early in the fall, because he said that he had too many things going on and could not afford to get interested in something in school. There is clearly a tension between (1) students' desire for school "as usual" wherein the requirements are understood up front, life is certain and manageable, and the teacher takes the responsibility, and (2) students enthusiasm and engagement in authentic, creative work for which they take ownership. Male and female students provided different emphases in their statements valuing the experiences of the class. The males emphasized ownership and freedom to choose and criticized the imposition on their time. The females accented the potential for creativity and flexibility and somewhat contradictorily were concerned with a lack of clear expectations set up front.

The challenge and problem of projects requiring too much, as well as uncertain time demands, is a critical dimension. Groups whose membership enabled them to meet easily outside of class time had a great advantage, as well as groups who had a good time manager as a leader. The students in our study believed that school should not take as much time as these projects were requiring and the balance of in-class to out-of class time seemed unfair. An interesting aspect of time was the students use of two time measures. "School time" was class time which tended to be something that you passed and was used to meet near term requirements. "My time" was time spent with your group outside of class, which was described as something for which you had to be organized and for which you tried to be efficient.

Students came to appreciate the value of working in groups; more was accomplished, groups skills were developed, and the work was more enjoyable. Groups, however, tend to exacerbate the time problem and can yield disappointments and confusion. The students discussed the need to clarify roles and commitments as essential for successful projects. The groups were formed on the basis of common interests for projects which insured at least a minimum level of commitment to the project and provided for self-selection. Additional group problems would be expected if they had been formed by the teacher. Working in groups became a key success factor for the students and their increased interpersonal abilities became a key product for several students.

Follow-up Survey

When asked if the project experience has influenced their goals beyond high school, eight described positive changes, three mentioned that the projects confirmed their plans, and seven said that their plans had not been changed by the project experience. Some examples of the responses are presented in table 2.

Student	Value	Comment
Female	positive	I am now planning to pursue a career in this field.
Male	positive	They have changed totally, because I have changed what I want to do for a living --- Computer Science
Female	positive	It makes me interested in pursuing a career in scientific research or possibly working with computers
Male	confirm	It has strengthened my goals toward a career in science (medicine)
Female	confirm	I now have more experience on computers. This will help me in my goal to become a mechanical engineer.
Male	no change	It hasn't really changed my goals
Female	no change	It really has not.

Table 2: Response about project influence on goals

When asked about their personal skills on the follow-up survey 16 of the 18 respondents spoke of improved skills. The dominant area of growth was in the use of technology. One typical male student expressed his development, “I am very familiar with the Internet and how to use this resource to get information even for classes outside the block class. My knowledge of computers has grown immensely as a result of the project.” A second area in which the students recognized growth was with group work and interpersonal skills, “You learn how to work with other people.” A third area can be categorized as the ability to carry out projects. One student summarized, “Working together with people and delegating responsibility and fulfilling responsibility. These skills are necessary to get anything done so I had to acquire them or fail.”

Seventeen of the 18 respondents saw their projects as positively benefiting others. They reported envisioning other students able to expand on what they had accomplished or using it as a learning aide. Some saw their work as providing a tool for helping people accomplish tasks. One female saw her project impacting the general public. "The public will understand what nuclear energy is, it's extreme benefits, the efficiency it provides, and they will realize how much nuclear energy can do." A male counterpart of the same project believed, "Some other kids might get to run the program and learn a little about nuclear rockets." Only one of the students did not have a vision for how the project would live on after the course was over. The students took pride in accomplishing something real.

Discussion

What do these reports of experience tell us about the value of projects to students and about how to assess that value? First we will discuss two key points we have derived from the student reports and then we will present a list of categories for looking at the diverse accomplishments described by the students.

Students learn valuable competencies and begin to build a mental model of what it means to do research projects when you are serious about your project and when people take your project seriously.

A program for most of the projects could go something like this:

do project task
    plan,
    try,
    fail,
repeat project task

To be sure, this is a time consuming program. But, because the students owned their projects, were given time to fail, and were motivated to succeed; they learned from each failure. Their experiences with finding a researchable idea, using mentors and knowledge, using technology, working in a group, and making progress on a project provided many powerful instances of learning. Equally important the students recognized the value (to an extent) of these instances of learning.

Students have difficulty adjusting to situations where they own the problem and have responsibility for the outcome.

Project-based learning is happening in the midst of their school-life. The teachers did a good job of setting conditions for success. Making a two-hour block, providing high quality technology resources, having confidence in the students, and setting expectations that project revisions were appropriate and common. Without these factors it is unlikely that the students would have made the commitments to owning the projects, investing "my time", and taking responsibility for project outcomes. Yet still tension persists between school expectations and doing meaningful projects. The students like the power to make decisions, but it would be simpler for the teacher to tell you what to do. The students like the opportunity to be creative, but it would be easier if the teacher told you what a project was supposed to be and you just did it.

The Students are Diverse, the Projects are Diverse, the Accomplishments are Diverse.

When we look at the accomplishments described by students in this course, we appreciate the connectedness of the achievement to the context, the opportunity, and the resources. We often think of assessment as trying to measure what the student is capable of doing on their own, just using their knowledge, skills, competencies. What becomes apparent by listening to these students is that their ability is connected to their interest, to their access to resources, to their opportunity for and skill at collaboration, and to their prior knowledge and skill. Five metafunctions emerge from the descriptions provided by students:

1. Resourcefulness -- Is the student able and persistent at finding resources and learning to use them for the task at hand?
2. Reflection -- Does the student learn from experience?
3. Authentic -- Does the student seek real problems and challenges which test his/her ability and contribute to the "real world"?

4. Extension -- Does the student have ideas and plans for how the work can be continued and extended?
5. Connectedness -- Does the student make connections between the project experience and other significant parts of his life or community, such as personal goals and solving community problems.

There are many sub skills, such as using the Internet to search for information, using data analysis software, leading a team meeting, writing a report, etc., which are demanded, tested, and can be assessed during the process of doing a project. In general these can be organized by:

1. Research and problem solving competencies
2. Project management competencies
3. Group and interpersonal competencies
4. Technology tool using competencies
5. Communication competencies
6. Subject matter (project topic) knowledge and competencies

The student reports of their experiences and our method of analysis has led us to a clearer understanding of the issues and to an emergent model of the value and achievements which students take from these projects.

References

[Biggerstaff, Laffey & Nazworthy 1996] Biggerstaff, J., Laffey, J.& Nazworthy, J. 1996). Computational Science at Lee's Summit High School. In Z. Berge & M. Collins (Eds.), The Online Classroom in K-12: Perspectives and Case Studies. Hampton Press.

[Blumenfeld et al. 1991] Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*(3 & 4), 369-398.

[Brown, Collins, & Duguid, 1989] Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher,* 32-42.

[Gardner 1991] Gardner, H. (1991). *The Unschooled Mind.* New York: Basic Books

[Glaser & Strauss 1967] Glaser, B. G. & Strauss, A. L. (1967). *The Discovery of Grounded Theory.* Chicago, IL: Aldine.

[Knorr-Cetina 1992] Knorr-Cetina, K. D. (1992). The couch, the cathedral, and the laboratory: On the relationship between experiment and laboratory in science. In A. Pickering (Ed.), *Science as practice and culture* (pp. 113-138). Chicago, IL: University of Chicago Press.

[Lincoln & Guba 1985] Lincoln, Y. & Guba, E. (1985). *Naturalistic Inquiry.* Beverly Hills, CA: Sage.

[Maykut & Morehouse 1994] Maykut, P. & Morehouse, R. (1994). *Beginning Qualitative Research: A Philosophic and Practical Guide.* Bristol, PA: Falmer.

[Norman, 1993] Norman, D. (1993). *Things That Make Us Smart..* Reading, MA: Addison-Wesley.

[Raven 1992] Raven, J. (1992). A Model of Competence, Motivation and Behavior, and a Paradigm for Assessment. In H.Berlak, F. Newman, et. al. (Eds.), *Toward a new science of educational testing and assessment.* (pp. 85-116.). SUNY Press.

[Resnick 1987] Resnick, L. (1987). Learning in school and out. *Educational Researcher,* 13-19.

[Roth & Bowen 1995] Roth, W. & Bowen, G. (1995). Knowing and Interacting: A Study of Culture, practices, and resources in a Grade 8 Open-Inquiry Science Classroom Guided by a Cognitive Apprenticeship Metaphor. *Cognitive Instruction,* 13(1), 73-128.

Acknowledgments

Support for this work was in part provided by the National Science Foundation under an award from the NIE program. We thank John Biggerstaff, Jim Nazworthy, and their students for the inspiring teaching and learning they have created. We also thank Lorie Feldenberg and Sara St. Clair for their assistance in data collection and analysis.