Motivation in Project-Based Classrooms: New measures better coupled to students' experiences

Phillip Herman, Louis Gomez
School of Education and Social Policy, Northwestern University
Email: herman@northwestern.edu, l-gomez@northwestern.edu

Abstract: Project-Based Science (PBS) has traditionally been proposed as a comprehensive approach to classroom teaching and learning that is designed, in part, to better motivate students to learn. As PBS units became more widespread in schools, initial evaluations of their impact focused primarily on documenting important learning outcomes such as performance on unit assessments and standardized exams (Herman, Mackenzie, Sherin, & Reiser, 2002). The motivational impact of PBS units is not so well documented. In particular, little has been done to study motivation across PBS units or across school years. Traditional measures of motivation, first developed primarily by educational and developmental psychologists, were essentially inherited by the learning sciences community and have not been efficient indicators of the impact of curricular innovations on student motivation. We argue for new motivation-related measures that are more closely coupled to the actual experiences of students in projects and report on our initial attempts to develop such measures.

Introduction

This article reports on our efforts to document the motivational patterns of 7th graders in an urban school setting whose teachers implemented one or more PBS units during the 2003-2004 school year. Each project was developed either by the Center for Learning Technologies in Urban Schools (LeTUS) or the Investigating and Questioning our World through Science and Technology (IQWST) group. Each of these collaborations works to develop curricular units that support project-based learning in science classrooms. Each unit was designed to: align with local, state, and national standards, be contextualized in real-world problems, allow for sustained student inquiry, embed learning technologies, foster collaboration, and provide educative materials for teachers (Schneider, Krajcik, & Marx, 2000). These projects were relatively long-term (6-12 weeks), problem-focused, and they integrated concepts from a number of disciplines or fields of study (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palinscar, 1991).

Motivation in Project-Based Science Classrooms

PBS units are designed to be motivating. Though curriculum designers might disagree about how explicit increasing student motivation should be as a goal of PBS curriculum design, it is clear that, at least initially, PBS was advanced as an alternative to typical science classrooms that were viewed as formulaic and not necessarily supportive of student motivation. Features of the work that students do in PBS classrooms, such as using computers and the Internet to study real-time Earthquake data patterns, are intended to foster interest and cognitive engagement. By focusing on formative rather than summative assessment, students might be more willing to take chances, be more intrinsically motivated, and be less peer-comparative. By studying authentic problems, such as why some finches on the Galapagos Islands die while others do not, students may be more goal-directed in their learning, report being more self-regulated, or have higher levels of self-efficacy in regards to arguing from and about real-world data. Though such motivation claims are plausible, they have not been extensively documented in large numbers of classrooms. To some extent, this may be due to the prevalence of a design-based research paradigm (Design-Based Research Collective, 2003) in PBS settings. In design-based research, the curricular design team typically works closely with teachers and students to support implementation of the unit, provide professional development to teachers, "work out the kinks" in the technology or activities, and study the overall implementation. Researchers and teachers often report that students are "more interested" or "engaged" during the projects -- a finding that is typically documented using qualitative methods, such as teacher and student interviews, classroom observations, and analyses of student work and artifacts. These qualitative studies have been critical in understanding the subtle ways in which motivation and learning are related in these classrooms. However, this intensive, qualitative approach is typically limited to a few of the "first enactors"; that is, these studies are limited to teachers working closely with university researchers who provide ongoing access to their classrooms. Few motivation-focused studies have included large numbers of classrooms, and even fewer have studied the motivational impact of enacting multiple or multiyear PBS curricula. High-quality qualitative studies of motivation in PBS classrooms require a sustained commitment that is expensive and time consuming once the number of implementing classrooms rises into the hundreds. Significantly, such work also requires a deep understanding of the designers' intentions, each teacher's pedagogical priorities for the units, and the context of each classroom implementation. Though each PBS unit varies considerably in its focus, design, and implementation, efforts such as IQWST are working to develop a comprehensive PBS middle school curriculum that has some key elements in common across projects. These elements include focusing on performance assessments, working with real data, analyzing models, and constructing scientific arguments. As such comprehensive PBS curriculum efforts grow, it will become more and more important to develop instruments that are both sensitive to the motivational impact of student participation in multiple PBS units and practical enough in their administration to allow for a better understanding of the motivational impact of PBS units on thousands of middle grades students.

We have worked to understand the motivational impact of PBS on 7th graders for several years. In order to understand how innovative units are impacting student motivation, it is important to understand, and account for, the longitudinal trends in student motivation during the middle grades. Maehr and Midgley (1991) and Pintrich (2000) have documented how motivation typically declines as students move from upper elementary to the middle grades. Students report that they are less intrinsically motivated, have lower levels of self-efficacy and self-concept, have less interest in school in general, and have less interest in particular subjects such as science. If motivation is in decline in the middle grades, what are the implications for the learning sciences, and how should those of us concerned with motivation think about and document changes in motivation associated with participation in PBS units that are, in part, designed to be motivating?

New Measures of Motivation

We argue that new measures need to be developed that are more closely coupled to the work that students do in PBS classrooms, and that such measures be sensitive enough to account for multiple implementations of PBS units or even multiple-year implementations of innovative middle grades science curricula. Based on prior work, we have noted the inconsistent relationship between typical measures of motivation, such as scores on scales from the Patterns of Adaptive Learning Survey (PALS) (Midgley et al., 2000), and student achievement as measured by unit tests or standardized exams. For example, in some cases, a Mastery goal orientation predicts achievement; in others it is unrelated to achievement. Interest in science does not necessarily increase during a PBS implementation. Such inconsistencies make it difficult to argue that participation in the PBS units is motivating to students. Some of this inconsistency is likely due to problems with student self-reports and administration of the surveys, with the variation in implementation of the PBS units, with declining motivation in the middle grades. But, some of the inconsistency is likely attributable to the content of the measures and the fact that these measures were not necessarily intended to measure the motivational impact of innovative learning environments, but rather to describe developmental trends in motivation. So, measures that may be good indicators of whether 7th graders are more or less intrinsically motivated than 8th graders may not be good indicators of whether students who participate in PBS units in 7th grade are therefore more intrinsically motivated than their 7th grade peers who do not.

In order to better document the motivational impact of participation in PBS units, we developed and piloted new measures that we hoped would be more closely coupled to the work that typically occurs in PBS classrooms and that would predict student performance on a variety of indicators. Specifically, we believed that students who successfully engage in activities, such as representing and arguing from real-world data, should report higher levels of self-efficacy when queried about their confidence to perform such a task. We also believed that PBS classrooms, because they are so different from more traditional classrooms with which teachers and students are familiar, might be perceived as more confusing to students than regular classrooms. That is, students may be less clear about what is expected of them in PBS classrooms -- in which students are investigating, representing data, engaging in inquiry, identifying problems and solutions, etc. -- than in more traditional classrooms in which they can more easily intuit what is expected of them. We base this conjecture on teacher interviews and comments over several years in which teachers worry that their students are more confused if the teachers move from directing instruction to being more like guides to learning in the classrooms. We developed items that we believed addressed both the self-efficacy of students in these classrooms and the degree to which they expressed confusion or negative affect about classroom expectations. In total, we developed 3 new scales (Self-efficacy for Science Inquiry, Know how to do, and Confused/Negative Affect) that we hoped might more consistently relate to achievement and that would be more closely coupled to the work that students do in PBS classrooms. Table 1 lists the items that make up each of the scales.

Table 1: Items that comprise each of the scales

"Self-efficacy for Science Inquiry" scale (12 items) **Stem: "How confident are you that you can…."**
• Design an experiment that would test a hypothesis?
• Make a graph or chart to present science data?
• Give an oral presentation to your class about a scientific problem?
• Explain to someone how a graph you made presents important information about some science question?
• Challenge a statement made by another student or your teacher using data as your evidence?
• Work together with other students to study a scientific problem?
• Use the Internet to find data about a scientific problem you are studying?
• Use the computer to analyze data about a problem you are studying?
• Come up with a scientific question to investigate?
• Figure out the answer to a hard scientific question, without being given the answer by a teacher or finding it in a book?
• Figure out what kind of data you would need to answer a science question or problem?
• Identify a scientific question or problem that you could investigate?
"Know how to do" scale (5 items)
• I know what to do when we write science papers and reports in this class.
• I know what to do when we make presentations in this class.
• I understand the assignments in this class as well as the other students.
• I know how to analyze data in this class.
• I know how to use data to support what I say about a science question or problem.
"Confused/Negative Affect" scale (4 items) (Reverse scored)
• I'm not sure I have the skills to do well in this class.
• I don't understand what I need to do to be successful in this class.
• Sometimes I'm confused about what my teacher wants me to do in this class.
• My teacher pushes me too hard.

Methods

Surveys were administered to 587 7th graders in October of 2003 and to 174 of those same students in May/June of 2004. It was impossible to get all teachers to agree to re-administer the same survey at the end of the year because of time constraints. Science teachers administered the surveys. Items on the survey included our scales listed above and items from the PALS that measured Academic self-efficacy, Mastery, Performance Approach and Performance Avoid goal orientations, Classroom Mastery, and Teacher Press for Understanding. Science interest was measured using a scale developed by LeTUS researchers at the University of Michigan. Each of these items included a 5-point Likert-type scale ranging from “Not at all true” to “Very true”. Valuing Science (Eccles & Wigfield, 1993) measured how useful students thought science was for their future plans. Self-concept was measured by adapting Marsh’s (1991) self-concept scale to focus on science self-concept. We collected student scores on the 7th grade Standardized Science Exam (ISAT) which represents our achievement outcome for the current study. The ISAT was administered in early April of 2004.

Results

We report correlations between motivation measures and student achievement in Tables 2 and 3. We use both the survey data from October and May/June in order to examine how consistently any of the scales are correlated with achievement. That is, if there is an initial correlation from the presurvey in October, is the pattern of correlations similar at the end of the year? Are the correlations reasonably consistent across time? Table 2 shows that all three of the scales we developed are correlated with performance on the ISAT as are measures of Self-concept, Approach and Avoidance Orientation, Classroom Mastery, and Self-efficacy. Individual Mastery, Valuing Science, Science Interest, and Teacher Press for Understanding did not predict performance on the ISAT. On the postsurvey (Table 3), “Know how to do” and “ Confused/Negative Affect” were again correlated with achievement. Self-efficacy for Science Inquiry was not included on the postsurvey. On the postsurvey, Avoidance orientation and Classroom Mastery were no longer correlated with achievement on the ISAT, though they were on the presurvey. Scale reliabilities (Cronbach’s alpha) were .88 for Science Inquiry, .81 for “Know how to do”, and .64 for “Confused/Negative Affect”.

Table 2: Significant Correlations between scales and performance on a Statewide Standardized Science Exam (ISAT) at Pre: N=587 (7th grade)

Scale	Significant correlation with ISAT ($p<.05$)
Science Inquiry Self-Efficacy	.33
Know how to do	.25
Confused—Reverse Scored	.36
Self Concept	.46
Approach orientation	-.23
Avoid orientation	-.24
Self-Efficacy	.18
Class mastery	-.09

Not significant is Mastery, Science Interest, Teacher Press, Valuing science

Table 3: Significant Correlations between scales and performance on a Standardized Science Exam (ISAT) at Post: N=174 (Subset of the same 7th graders)

Scale	Correlation with ISAT
Science Inquiry Self-Efficacy	Not on post survey
Know how to do	.36
Confused—Reverse Scored	.38
Self Concept	.48
Approach orientation	-.16
Avoid orientation	Not significant
Self-Efficacy	.26
Classroom Mastery	Not significant

Not significant is Avoidant orientation, Classroom Mastery, Valuing science, Individual Mastery, Science Interest, Teacher Press for Understanding

Summary of Results

The measures we developed to indicate students self-efficacy for inquiry, the degree to which they know how to do certain inquiry and classroom tasks, and their affect towards the work and their teachers all predicted achievement on a high-stakes science exam. The pattern of correlations was similar pre to post, except in the case of self-efficacy that was not included on the postsurvey. The correlations were higher than most other motivation-related measures such as goal orientation, general self-efficacy, and science interest. As a first step, these results are encouraging and warrant further empirical development of these types of measures.

Discussion

We argue for a renewed focus on the motivation-related impact of participation in PBS curricula. As the Learning Sciences matures, we will have to develop better and more efficient ways of measuring motivation in designed learning environments in order to not only inform design but also to convince stakeholders of the value of participation in such units. Just as efforts to understand and document student learning in PBS classrooms were influenced by students' *opportunities to learn* (Porter, 1993), we think it is important to better understand and document students' *opportunities to be motivated* during implementation of innovative curricula. It is a given for many curriculum designers that these environments are more interesting or motivating to many or all students. However, relatively little large-scale work has documented the motivational benefits of such participation. It is important to do so and to better understand the connection between motivation and learning in these environments. It is challenging to develop surveys, or other easily administered measures, that are reliable, valid, and helpful to document student motivation at one point in time. It is even more difficult to develop measures that can reflect meaningful changes in student motivation over time. That is, it is hard to develop measures that are sensitive enough to show change within a school year or over the course of a relatively short project. If projects are 10-12 weeks in length and students participate in two projects a year, what kind of motivational changes should or could be expected? We do not have the answers to this problem but argue that we need to develop measures that can help us understand such changes for a large number of students. The measures we propose are first steps. Much empirical and conceptual work needs to be done to develop theoretically and psychometrically strong measures. But that work is important.

Motivation and Learning

The value of participation in PBS units should not just be measured solely in terms of learning outcomes. Higher student motivation, including perhaps a positive affect towards learning science, might be of equal importance as specific learning outcomes. PBS units require fairly high levels of student motivation to facilitate the kind of learning we care about. If students are unmotivated, they will not engage in the projects at the heart of PBS work. Motivation and learning must work in concert so that the PBS work can reach the desired level of cognitive complexity that designers originally intended. Motivation is not unidimensional. It is more useful to develop profiles of students' motivation that might include a number of factors, such as engagement, interest, self-beliefs, goals, and affect. In some cases, participation in PBS might engender increased levels of student self-efficacy to interpret data presented in graphs. In other cases, if students have had a positive learning experience in science, and they recognize it as a positive experience, at the end of the year they might reflect on their experience in science class and make the judgment that "I enjoyed that class, I learned a lot and I would be willing to take a science class like that in the future." Such an outcome would have apparent value above and beyond the learning that occurred. Krarabenick (2005) labeled that phenomenon a "residue" that exists at the end of the experience and argues that supporting such beliefs is an important goal of teachers and therefore should be a goal of curriculum designers. We do not assert that motivation is more important than learning but rather that the two are inextricably linked. In fact, the kind of motivation we most care about is in the service of learning. We do not want students merely to be interested in computers. We want them to be motivated to use computers in service of their learning. We developed measures that we believe are moving in that direction. They measure motivation-related constructs in a way that is specific to the work that students do in one PBS unit but are general enough that, if there is enough similarity in the design and implementation of the units, the measures should allow for documentation of the cumulative effects, if any, of participation in multiple enactments of PBS units.

Distal/Proximal distinctions in motivation

The work of Ruiz-Primo and colleagues (Ruiz-Primo, Shavelson, Hamilton, & Klein, 2003) has influenced our thinking as we try to develop the right motivation-related measures for PBS classrooms. Though their work focused on assessing learning at various levels of distance from the implementation of any curricular unit, we think there is an analogous distance that needs to be accounted for when studying student motivation in similar settings. Such a frame requires documentation of what students were exposed to during implementation and a matching to several assessments that are at varying levels of remove from the initial experiences during implementation. Some experiences are more common during implementation and might be more influential on student motivation. Therefore, we might expect that levels of self-efficacy around working with data might change over the course of a data-intensive implementation but that a student's valuing of science for future goals might be harder to change. Similarly, when looking for the motivational impact of participation, we would expect that assessments that are proximal to implementation (such as teacher's perceptions of student interest) should show higher levels of student interest than assessments that are more distal, such as end of the year surveys that ask students if they are interested in science. Such a framework is only beginning to influence our work, but we believe that the proximal/distal distinction, and the distinction between measuring specific self-efficacy for a well-defined task and measuring more general self-efficacy for "science" (Pajares, 1997), will help us develop measures that can more accurately describe the motivational impact of participation in PBS activities. We propose that all such measures be coupled to the work that students are likely to do, and to do consistently, in PBS classrooms. Traditional measures of motivation are often unsuitable for the purposes of curriculum designers, and that designers should be cautious in using measures that have been developed for other purposes. Much work needs to be done to document motivational improvements in the middle grades during a period of overall motivational decline.

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