Supporting Teachers Adopting an Engineering-Based, PBL Middle School Science Curriculum

Sabrina Grossman, Mike Ryan, Brian Gane, and Marion Usselman
Center for Education Integrating Science, Mathematics and Computing (CEISMC)
Georgia Institute of Technology

Abstract

This paper reports on the implementation of an NSF-funded, DR K-12 project to create, implement, and study the effects of an 8th grade project-based inquiry learning curriculum on student learning. Students solve problems and design challenges using engineering design practices and concepts, LEGO NXT robotics, and inquiry. To support teachers as they implement this curriculum, we created a professional development system to support teachers and assess the challenges to implementing the curriculum. This system employs educative curricular materials, innovative teacher editions, face-to-face workshops, and an online collaborative space. In this paper we describe our professional development efforts. We then focus on one particular aspect; video tutorials posted in the online collaborative space, and analyze how teachers used these video tutorials while planning and teaching with our curriculum.

This research was supported by the National Science Foundation grant 0918618.

Correspondence concerning this paper should be addressed to Sabrina Grossman, Center for Education Integrating Science, Mathematics, and Computing, Georgia Institute of Technology, Atlanta, GA 30332-0282. E-mail: sabrina.grossman@ceismc.gatech.edu

Paper presented at the 86th National Association for Research on Science Teaching annual international conference, Rio Grande, Puerto Rico, April 2013.

Supporting Teachers Adopting an Engineering-Based, PBL Middle School Science Curriculum

Science Learning Integrating Design, Engineering, and Robotics (*SLIDER*) is an NSF-funded, DR K-12 project to create, implement, and study the effects on student learning of an 8th grade physical science project-based inquiry learning curriculum. Built upon the foundation developed as part of the NSF-supported *Project-Based Inquiry Science (PBIS)* (Kolodner, Krajcik, Edelson, Reiser, & Starr, 2010; Kolodner et al., 2003), the curriculum challenges students to solve engaging problems using engineering design practices and concepts, LEGO Mindstorm robotics, and inquiry. The Framework for K-12 Science Education (National Research Council, 2011) and the draft Next Generation Science Standards markedly increase the profile of engineering practices and concepts within the domain of K-12 science education. This proposition creates a challenge for curriculum developers to create experiences that continue to ensure that students learn core science concepts and practices, while concurrently exposing students to key tenets of engineering (design, constraints, modeling, and evidence-based decision-making).

SLIDER Curriculum

The SLIDER instructional materials are grounded in a problem-based learning (PBL) model of instruction. PBL is a cognitive-apprenticeship approach with roots in medical school training (Barrows, 1985; Collins, Brown, & Newman, 1989). During PBL-based instruction, students work collaboratively to solve problems, thereby learning in a group setting as well as individually. Students identify what they know, what they need to learn more about, plan how they will learn more, conduct research, and deliberate over the findings all together in an attempt to move through and solve a challenge or problem. Several studies have found that PBL affords: more active learning of content; the development of problem-solving skills; increased ownership in learning; greater understanding of the nature of the scientific endeavor; more flexible thinking; improved collaboration skills; and opportunities for students to gain expertise in STEM (Boaler, 1998; Cognition and Technology Group at Vanderbilt, 1997; Hmelo-Silver & Pfeffer, 2004; Krajcik et al., 1998; National Research Council, 1999).

The SLIDER curriculum is composed of *learning sets,* which are two to three week instructional sets that revolve around a design *challenge* that students try to solve. Each learning set is divided into individual lessons called *sections*. Each section spans one to three days and focuses on a specific set of concepts and practices. As students progress through a learning set, student groups iteratively design and improve their solution to meet the criterion of the challenge. Students design experiments and investigations to collect data and information germane to the challenge. The results of these investigations inform decisions that create or improve their solution, and enable students to experience science explicitly to learn the disciplinary concepts targeted in the learning set. Over the course of a curricular *unit* (multiple learning sets), students engage in the behaviors and activities of designers, engineers, and scientists

The two major components that differentiate our curriculum from the traditional eighth grade physical science curriculum are the use of curriculum structures and LEGO robotics to teach science content and process skills.

Curriculum structures. A key component in both the PBIS and SLIDER curricula is the use of *ritualized activity structures* (Kolodner, Gray, & Fasse, 2003, Koldner et al, 2003). The current PBIS materials now refer to them as *PBIS Practices*. The structures are often collaborative, involving all members of the class, but each structure has dimensions that require individual student work. These structures serve as moments for students to connect their more recent or smaller experiences to the larger challenge; they help students share information, reflect on what they have learned, and develop new ideas and connections to pursue during the challenge. For the teacher, the structures reveal student understanding and conceptions – they serve as moments of formative assessment. As students iteratively engage in the structures over time within and across learning sets, the nature of the assessment can be more summative. Each structure has a specific protocol that the teacher engages to facilitate the desired outcome of the structure. The SLIDER version of these have been streamlined into six distinct structures, each with its own action and protocol: 1) *Organize the Challenge*, 2) *Explore,* 3) *Share*, 4) *Add to Your Understanding*, 5) *Explain*, and 6) *Reflect & Connect* (Ryan & Usselman, 2012). Our curriculum refers to these structures as *SLIDER Curriculum Structures* (*SCS*s) or, more simply, *structures*.

LEGO robotics. The SLIDER curriculum uses engineering challenges and LEGO robotics as the context to teach science content and engage students in curriculum structures. In each learning set, students are introduced to a challenge and then use LEGO-built devices through a series of investigations to gather data to develop solutions to this initial challenge. The use of LEGO materials during each learning set varies depending on context; sometimes students use LEGO simply as tool to gather data, while in other contexts, students are responsible for completing mini-design applications using LEGO models. Even though the use may vary, students complete many LEGO builds (e.g., a winch; a truck; a motorized emergency brake) and use the accompanying LEGO Digital Designer software.

Partner Schools and Teachers

There were a total of six teachers in three schools who implemented the SLIDER curriculum, consisting of four learning sets in their 8th grade physical science classes during the first semester of the 2012-13 school year. The characteristics of these classrooms (see Table 1) led the curriculum developers to differentiate supports for individual teachers to encourage the enactment of a consistent curriculum. Participating schools, and even individual classrooms, varied in the: 1) number of inclusion classes where a co-teacher assisted with multiple students who had IEPs for varying reasons; 2) socioeconomic conditions and school resources; 3) proximity to researchers' home institution, and 4) number of students per class.

Table 1
Characteristics of Partner Schools and Teacher Classes

	Classes			
Teacher	Total	Inclusion	Accelerated	Avg. Class Size
School 1[a] (65% free/reduced lunch)				
A	2	0	2	28
C	5	2	1	29
D	5	0	0	27
School 2[b] (80% free/reduced lunch)				
E	4	1	0	21
F	4	2	0	23
School 3[a] (16% free/reduced lunch)				
B	5	0	5	21

[a]Schools located in the metro area of large southeastern city (within 30 miles of curriculum developers). [b]School located in a rural southeastern state (180 miles from curriculum developers).

Professional Development

As we developed our curriculum, we simultaneously created a professional development (PD) approach to support teachers' implementation and development. This included (1) face-to-face sessions where teachers were situated as learners to have the curriculum modeled for them, which included classroom observations and subsequent coaching, and (2) text materials (i.e., a teacher edition) that supplemented the student text and guided practice.

The face-to-face meetings allowed curriculum designers and teachers to work through curriculum activities together. This followed research suggesting that it was important to collaborate and have hands-on modeling due to the inquiry practices and the heavy use of robotics integrated within our curriculum (Schneider, Krajcik, & Blumenfeld, 2005). However, in working with three geographically diverse schools with different calendar schedules, there were significant time and place constraints to ongoing face-to-face professional development workshops throughout the school year. As such, most of our face-to-face professional development occurred during a week-long summer workshop (*SLIDER Summer Institute*). The goal of the institute was for teachers to reflect on their own pedagogy and practice as they learned about facilitating SLIDER units and to engage in discussion about learning and assessment. It was designed with the idea that professional development must help teachers move beyond "mechanical use" of curriculum to become facilitators of inquiry (Leiberman & Miller, 1990 as cited in Grant, 1996).

Additionally, during the first two years of the project, there was some evidence suggesting that SCSs could be educative for teachers: they scaffold students' activity and thinking not only for students, but for teachers, as well (Ryan & Usselman, 2012). We spent considerable time during our meetings coaching teachers in the use and purpose of SCSs.

To supplement our face-to-face meetings, we developed a traditional teacher edition (TE) text that provided a detailed chronology of each section. The TE text became a step-by-step instructional guide to the curriculum. The detail of TE text often made it a long and tedious document that was not easy for our teachers to navigate.

A review of the project following Year 2 found, perhaps not surprisingly, that teachers varied in their professional development needs to implement the SLIDER curriculum as intended. In various combinations, the teachers needed:

- Bolstering of their science content understanding
- Greater insight on the integration of engineering and science concepts
- Coaching for the LEGO builds and programming in our learning activities
- Assistance developing inquiry teaching skills

Despite the intentional design of the workshops, the educative nature of the SCSs, and the teacher edition texts, the research team observed a varied array of curriculum enactments among the teachers. The remainder of this paper describes a shift in our approach to professional development, including how the different PD elements evolved, and how they are intended to support teacher enactment of the curriculum. We describe the online collaborative space we created to support teachers' varied needs. In particular, we focus on the use of video tutorials and our preliminary analysis of teachers accessing these tutorials.

Design

From the beginning, there were no illusions that the summer institute alone would be sufficient to prepare teachers for full curriculum implementation. Effective professional development is not a single shot that "inoculates" teachers for the curricular activities that will be implemented during the school year (Grant, 1996). The teacher edition and the focus on the SCSs, however, were simply not enough to support the face-to-face meetings. In fact, there was a clear impression that the depth of information that the teacher edition provided was not mined with any regularity by the teachers. This obviously creates a problem. Project-based inquiry curricula are complex in many ways, especially for teachers that are only beginning to adopt the approach. Our summer institutes and periodic meetings cover a lot of ground, but they do not provide every detail teachers need to support their use of the SLIDER curriculum. In the end, the information in the teacher edition needed to be consumed thoughtfully and thoroughly.

In response, we developed a new approach to providing the critical teacher support content. Through the use of an online collaborative space (Georgia Tech's online learning management system, *T-Square*) and a re-formatting of the teacher edition, SLIDER researchers found ways to provide teachers with PD that provides "boosters" to our face-to-face inoculations throughout their curriculum implementation.

Professional Development Boosters

New teacher edition. The text materials provide teachers with a tangible document that can be used side-by-side with the student curriculum. There is a single 2-page (facing) document per lesson that includes a general section overview, notes on timing and preparation, materials management, an assessment matrix, and teacher tips. These *2-Pagers* provide guidance to teachers but are static and, in an effort to be user friendly, limited in length. Often, there is more guidance needed than can fit in this document, which motivated us to create additional curriculum resources.

Online collaborative space. Our curriculum team has prior experience providing professional development via facilitated online courses. Through a cooperative agreement awarded by NASA Education, we have been facilitating an online course sequence in project-based, inquiry learning (Alemdar & Docal, 2011; Alemdar & Rosen, 2011). Lessons learned through this ongoing experience inspired us to take a unique approach to meeting the needs of our teachers.

The development of our online collaborative space, *SLIDER Studio*, was based on research suggesting individuals prefer to determine their own learning needs, and that adults learn most efficiently when they initiate and plan their own learning activities (Sparks & Loucks-Horsley, 1989). Our online environment provides teachers flexibility in choosing professional development tutorials and posted resources to suit their needs. This flexibility provides teachers with the opportunity to learn about their students' conceptual development through enactment and then return to the teacher materials for additional guidance (Schneider et al., 2005). SLIDER Studio overcomes the time and distance barriers that typically govern face-to-face meetings by providing flexible, asynchronous, and just-in-time PD. SLIDER teachers can access the site from their school or home computers. By having a collaborative space that is accessible throughout the enactment of the curriculum, teachers have the opportunity to reflect on their needs and access continuous coaching and troubleshooting advice to facilitate immediate instructional decisions

We designed SLIDER Studio to serve many of the functions the previous teacher edition failed to deliver. T-Square has an array of tools that can be used to create a collaborative learning environment. We used the *Forums* tool which functions as an online discussion site. Each forum is hierarchical and contains sub-forums that contain different threads (see Figure 1). This allows us to organize discussion forums by learning set with sub-forums for each section.

Within the section sub-forum, each *thread* contains a specific professional development resource (see Figure 2). Each resource type is identified (as text or video) and listed as a separate thread. Teachers can click on a link to access resources that they feel support their implementation of the curriculum. This allows teachers to post and provide feedback on specific lessons and resources.

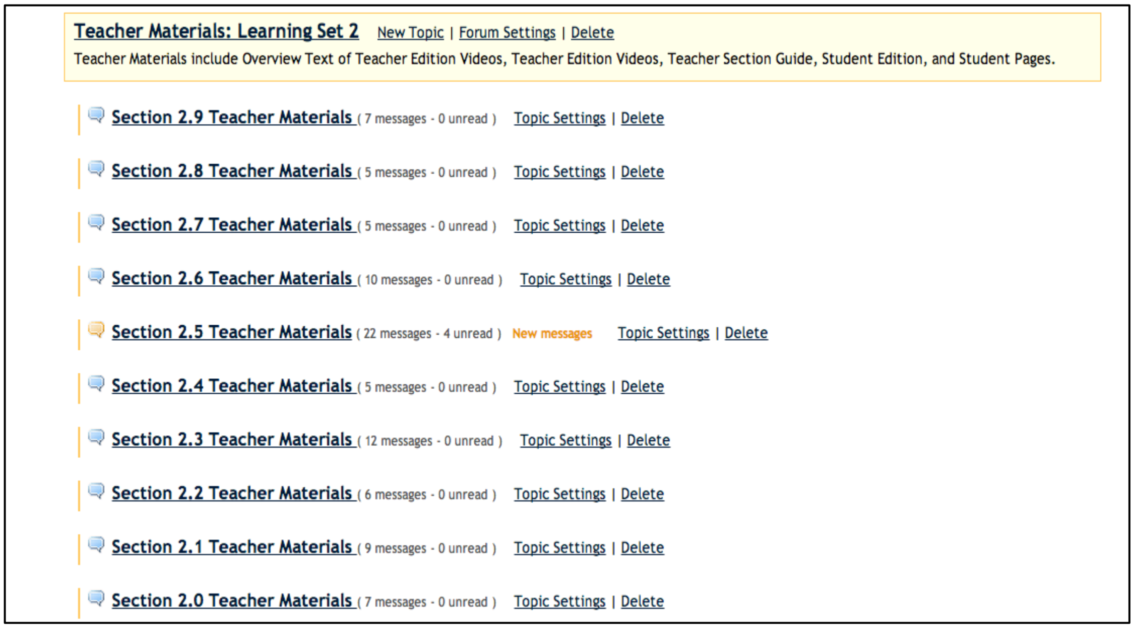

Figure 1. Screenshot of the forum for teacher materials for Learning Set 2. Within this forum, each section is linked as a sub-forum.

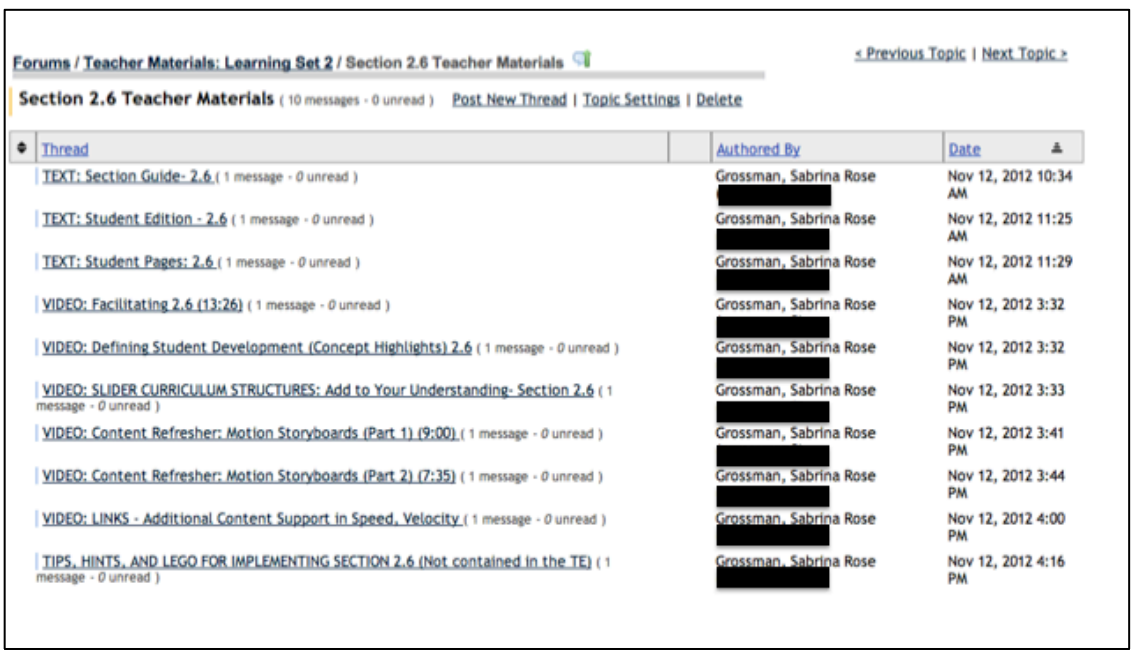

Figure 2. Screenshot of the sub-forum for Learning Set 2, Section 2.6, including threads for each professional development resource.

The section threads are a mix of teacher resources: teacher edition PDFs, student edition PDFs, video tutorials (intended for teacher viewing), LEGO-specific files, curriculum videos (intended for student viewing), and a *Tips and Troubleshooting Guide*. Curriculum developers determined the content for each sub-forum as they assessed the instructional goals of each section. Providing PDFs of all student and teacher editions online gives them an additional point of access. Using an online forum for tips and troubleshooting allows us to provide quick updates to all teachers as we receive feedback from teachers and observers in the field.

Table 2

Description of Videos Posted on SLIDER Studio

Type & *Audience*	Description	Purpose	Length (min)	Number of videos
Facilitation *Teacher*	Section overview Guides appropriate inquiry Discusses and suggestions for troubleshooting Demonstrates investigation set-ups with sample data	Instructional coaching Supplement to teacher text materials	10	22
Defining Concept Development *Teacher*	Describes level and indicator of understanding for each concept in Section Addresses possible misconceptions Assessment and grading opportunities	Instructional coaching Assessment and grading support	5-10	16
Content Refresher *Teacher*	Crash course in the primary science content covered in the Section Background information for facilitating Section	Support teachers' science content knowledge Support for addressing student misconceptions and questions	10-15	9
LEGO Support *Teacher & Student*	Build instructions LEGO "first aid" Programming assistance Digital Designer support LEGO organization tips	Support for building with and using LEGO Troubleshooting advice	5-20	10
SLIDER Curriculum Structures *Teacher*	Overview and purpose of curriculum structures Facilitating inquiry using these structures in curriculum	Instructional coaching (and modeling) of inquiry pedagogy	5	7
In-Class Videos *Student*	Multimedia portions of curriculum, providing challenge context	Create more realistic and rich PBL challenges	2-5	13

Video Tutorials

In order to simulate many of the characteristics of face-to face professional development, such as modeling and inquiry coaching, we created short video tutorials and posted them in SLIDER Studio. The video tutorials are a major focus of our online support as they provide modeling for teachers and fully support the 2-pager teacher edition. The videos mostly provide an inset of the narrator (curriculum developer as *talking-head*) with animated desktop capture of curriculum materials. The videos provide an overview of each section, with six categories of videos that cover topics that would be part of our face-to-face meetings (see Table 2).

Each section in the learning set contains at a minimum of two videos: Facilitation and Defining Concept Development. Depending on the content of each section and the curriculum development team's assessment of teacher needs, a section may contain all six categories and/or multiple videos of one category. Often, the videos are made after receiving feedback from teachers to provide additional real-time coaching. Teachers have access to all videos and the flexibility to view the ones that support their classroom needs for each curriculum section. The total number of videos per category for both Learning Sets 1 and 2 are listed in the Table 2. The variation in the number of videos produced for each category provides teachers with a different number of opportunities to access each type of video.

The curriculum development team has the ability to view teacher access of these videos through a statistics tool on T-Square. We were interested in exploring how we could use these video access data to understand more about how our teachers used T-Square, and whether T-Square usage patterns could give us insight into teacher needs.

Analysis & Findings

To understand how teachers were using the video resources we first calculated the total number of times teachers accessed videos as a function of the video category. This analysis focused on videos accessed for Learning Sets 1 and 2 only.

T-Square allows us to run "reports" of the resources that were accessed. This report gives the user ID, resource accessed, and a timestamp. Thus, if the same user accesses the same resource two times in one day, each of these resource access events is logged (and was counted in our data analysis as separate access events). Because we were interested in how the videos were used for professional development (outside classroom time), we omitted the in-class student video category; these videos are designed for students and are equivalent to textbook content.

General Patterns of Access

Table 3 shows Learning Set 1 and 2 videos accessed as a function of video category and teacher. The data show that teachers rarely accessed any Defining Concept Development videos or SLIDER Curriculum Structures videos. These are the videos that are designed to facilitate inquiry-teaching practices and inform teachers about types and goals for assessment.

The bulk of accessed videos were the Facilitation and LEGO Build videos. Only one teacher accessed the Content Refresher videos multiple times. The data also show variability in teachers' use of all of the video resources (median access = 5.5, min = 0, max = 19).

Patterns of Access by Section Content

We were also interested in whether the curriculum sections' content predicted teachers' video access. Anecdotally, it seemed that teachers were only accessing videos for the curriculum sections that emphasized LEGO or science content. We decided to see if we could use the T-Square log data to explore this hypothesis.

Table 3
Video Access as a Function of Teacher and Category

Video category	Teacher						Total
	A	B	C	D	E	F	
Facilitation	3	1	10	5	2	0	21
Defining Concept Development	0	0	0	1	1	0	2
Content Refresher	0	0	6	1	0	0	7
LEGO Builds	3	0	3	3	2	0	11
SLIDER Curriculum Structures	0	0	0	0	0	0	0
All videos	6	1	19	10	5	0	41

We began by coding the curriculum sections based on the nature of their content. Two of the authors (SG and BG, also curriculum developers) first created a four-point coding scheme (0 – 3) for each of the two categories: (a) LEGO use and (b) science content. The final coding scheme is presented in Tables 4 and 5; a higher rating indicates greater focus on that content.

The two authors then independently rated each curriculum section on the basis of (a) LEGO use and (b) science content. An initial check on interrater agreement showed only moderate agreement (% agreement = .67 and .50 for LEGO and science content, respectively). The two raters further refined the coding scheme, focusing on clarifying the difference between 0 and 1 on the LEGO scale and 0, 1, 2 on the science content scale. The raters then independently re-rated the curriculum sections. Using this revised coding scheme the interrater agreement was higher (% agreement = .94 and .78 for LEGO and science content, respectively). We considered this level of agreement satisfactory and the raters resolved the remaining discrepant ratings through discussion. Table 6 is a sample of our section ratings, showing how we rated the first five sections of Learning Set 1.

Table 4
Curriculum Section Ratings and Descriptors for LEGO Use Scale

Rating	Scale descriptors
3	Build, program
2	Using LEGO sensor, testing brake materials, etc. (“active” LEGO)
1	Using LEGO apparatus (“passive” LEGO)
0	No LEGO

Table 5
Curriculum Section Ratings and Descriptors for Science Content Scale

Rating	Scale descriptors
3	Heavy science content (extensive and in-depth disciplinary content knowledge; content knowledge explicitly addressed e.g., didactic)
2	Use/illustrate science content (applying disciplinary content knowledge; activity reveals content knowledge)
1	Connection to science content (disciplinary content knowledge forms motivation for activity but might not be explicitly stated, i.e., disciplinary content is "driving" the investigation)
0	No science content (disciplinary content knowledge absent, but science process skills might be present; teachers do not have to understand disciplinary content to make connections)

Table 6
Sample of LEGO Use and Science Content Scale Ratings for Learning Set 1, Sections 1 – 5

		Scale rating	
Section	SCSs within section	LEGO use	Science content
1.1	Organize the challenge; Share	0	0
1.2	Explore	0	1
1.3	Explore; Share; Add to your understanding	3	1
1.4	Explore; Add to your understanding; Reflect & connect	1	1
1.5	Add to your understanding	0	3

We then cross-tabulated our video access data with our curriculum section ratings. The scatterplot in Figure 3 uses the video access data presented in Table 3 and plots it as a function of the sections' LEGO and Science content ratings. Points are unique times a video is accessed. For example, suppose there are four videos in Section 2.2: one Facilitation, one LEGO Build, two Content Refresher, and one Defining Concept Development. One teacher watched the LEGO Build video twice and one teacher watched the Facilitation video once. Section 2.2 was (hypothetically) rated as '2' for LEGO and '1' for science content. This would produce three data points at X (LEGO use) = 2, Y (Science content) = 1.

Figure 3 shows that a large proportion of the videos accessed occur for those sections that scored a three on either the LEGO content or science content scales. Additionally, as revealed by the plot, the type of video accessed changed as a function of the section focus. The majority of the videos accessed in those sections with a high LEGO use rating were (unsurprisingly) the LEGO videos. The majority of the videos accessed in those sections with a high science content rating were the content refresher and facilitation videos. Sections with moderate to low scores for LEGO and science content ratings were associated with predominately Facilitation videos accessed.

Using Access Data to Reveal Challenging Sections

Additionally, we looked at the number of videos accessed as a function of the curriculum section. The three sections with the most videos accessed were Learning Set 2, Section 3 (access = 12), Learning Set 1, Section 3 (access = 8), and Learning Set 2, Section 5 (access = 6). Learning Set 2, Section 3 is one of the sections with the largest amount of new science content:

students are introduced to forces, learn how to represent force with force arrows and force action diagrams, and learn about the concepts of net forces and balanced and unbalanced forces. Learning Set 1, Section 3 is the first time that students build with the LEGO and run a procedure using the built LEGO apparatus. Learning Set 2, Section 5 is the first time that students attach a sensor to their LEGO apparatus and use it in their procedure to explore the effect of friction on movement. Each of these sections is demanding in terms of science content, LEGO use, or both. It appears that in these demanding sections our teachers were using the videos to assist with their planning and enactment. These data are also valuable in that they might help us identify which sections are challenging for teachers, and focus on these during next year's SLIDER Summer Institute.

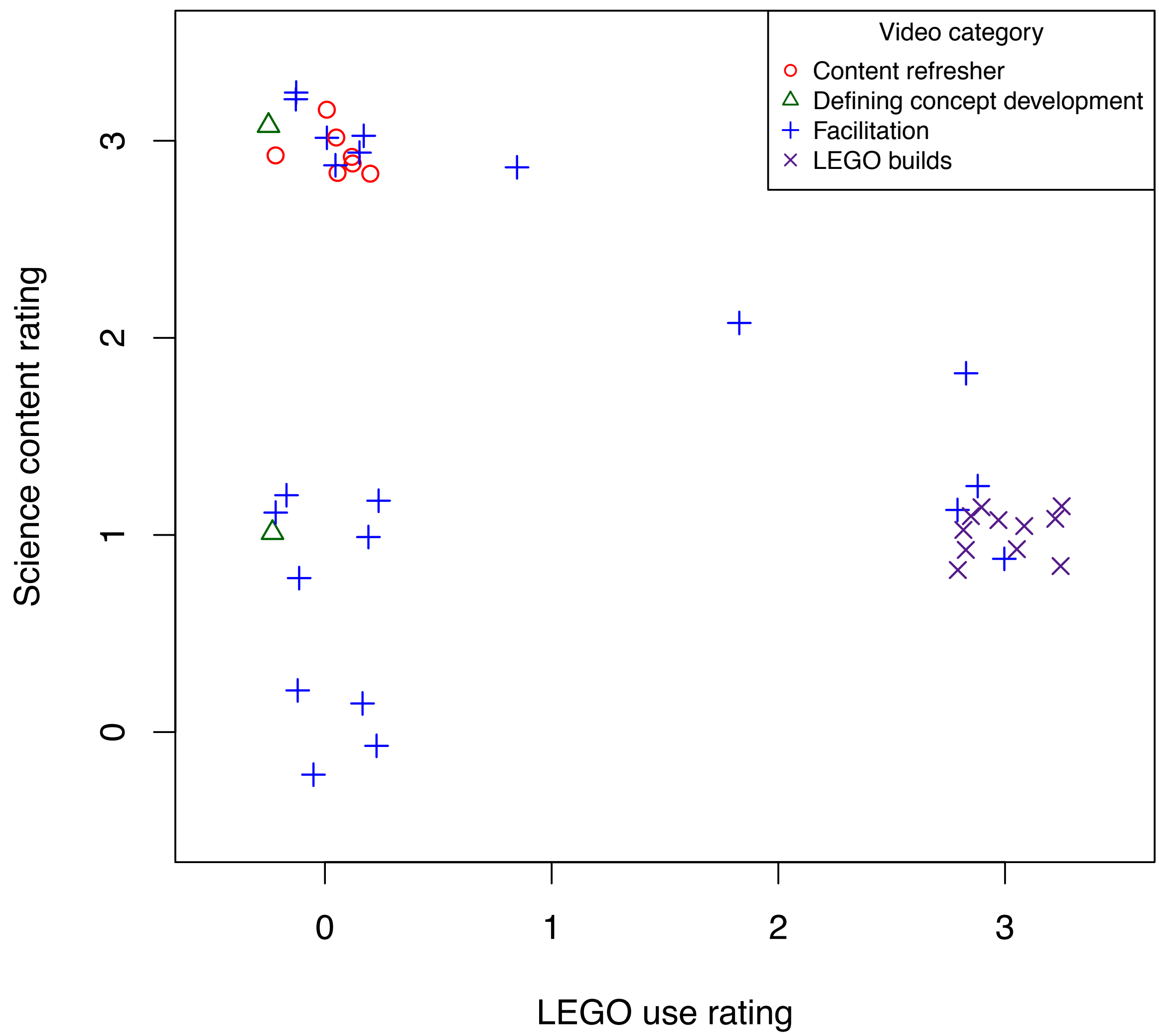

Figure 3. Videos accessed, as a function of the Section's LEGO use and science content rating. Each data point indicates a unique instance of a video being accessed. Both rating scales have integer values; to prevent overplotting data points were randomly distorted in the X, Y coordinate space.

Conclusion & Discussion

Through a combination of 2-pagers, face-to-face workshops, and SLIDER Studio we focused our efforts to address these four perceived teacher needs:

- Bolstering of their science content understanding
- Greater insight on the integration of engineering and science concepts
- Coaching for the LEGO builds and programming in our learning activities
- Assistance developing inquiry teaching skills

In our initial analysis of teacher access of video tutorials, we gained insight into how the teachers perceived these needs during their curriculum implementation. These data provide us with a greater understanding into the educative properties of different sections in our student curriculum, teacher perceived classroom and professional needs, and the desire to understand what variables may be affecting teacher access of these videos.

Implications for Designing Systems of Professional Development

Educative properties of curriculum. Through analyzing the video access data, we gathered evidence about which sections teachers perceive as most challenging. In the future, we can examine video access timestamps and classroom observation data to determine if teachers are accessing the videos for instructional support prior to the section or in response to student feedback after beginning the section. With this knowledge we could identify how to include more educative properties within the student text or provide additional guidance during our summer institute.

Teachers' perceptions of their needs. Teachers accessed videos in different combinations according to their perceived needs to create their own personalized plan to address their student and professional development. According to our data, the majority of videos were accessed in sections that we coded as high science content or LEGO use. In terms of our initial assessment of teachers' perceived needs, teachers are prioritizing bolstering their science content understanding and coaching for LEGO builds.

The Content Refresher and LEGO Build videos provide direct instruction to teachers in how to complete a LEGO build, present difficult content to students, or run an investigation. These are tangible elements of instruction that most teachers can easily identify as weaknesses in their ability to appropriately implement. For example, if students are having trouble drawing correct force diagrams to represent the motion of an object, teachers receive immediate feedback from their students' work, and can use the videos to review scaffolding methods for additional instruction on this topic. Likewise, if teachers struggle during a LEGO build, this difficulty is obvious; teachers can then use SLIDER Studio to access step-by-step instructions to complete this task. Accessing these videos demonstrates a request for assistance with "practical" elements of curriculum implementation.

In addition to considering the videos that were accessed through SLIDER Studio, we also consider videos that were *not* accessed. Teachers rarely accessed the Defining Content Development videos and the SLIDER Curriculum Structure videos. Accessing these videos would demonstrate a request for assistance with "abstract" elements of curriculum implementation, such as improving pedagogy and teacher practice. These videos are critical for successful enactment of the SLIDER curriculum as they emphasize core concepts of PBL and our curriculum structures.

In examining why these videos were not accessed, we suspect that teachers' understanding of SCSs and inquiry practices are harder to self-assess. Structures are practiced through entire learning sets and weaknesses might not be identified until students have already completed many sections with a structure. Additionally, teachers have different experiences in teaching in inquiry environments and therefore have different interpretations of effective inquiry instruction (relative to other teachers or the curriculum developers); this might make it more difficult for them to recognize a need for developing inquiry skills. Although it is important to provide teachers with the flexibility to view videos to suit their needs, our future professional development efforts will need to investigate how to provide teachers with appropriate tools to assess their SCS and inquiry needs.

Variables that affect video use. In addition to teachers' perceived needs not aligning with the curriculum developers' there are other variables that potentially affect teachers' use of SLIDER Studio. Due to school and classroom time constraints, teachers might believe that they do not have the time to watch all the videos. Although our goal is to keep the videos around 10 minutes, some sections have multiple videos at this length, meaning teachers would need to devote 30-60 minutes of video preparation for each section. For some teachers with limited planning periods throughout the day, this time becomes a constraint. In addition, some teachers still prefer the live support of the curriculum developers. Although within SLIDER Studio, there are discussion forums and chat rooms for teachers to pose questions, teachers have not used these tools; instead teachers tend to phone or email the curriculum developers directly looking for immediate feedback. In order to overcome some of these variables and challenges in teacher use of videos, we hope to develop new design features of SLIDER Studio that might give teachers the desired feedback to support their instruction.

Next Steps

This paper is a preliminary analysis of our SLIDER professional development system and how teachers used the video tutorials in our online collaborative space. Our next step is to conduct teacher interviews to investigate why certain elements of our system are being used more than others. Specifically, we will investigate why certain teachers view specific videos and how these videos support their implementation of the SLIDER curriculum. We want to understand what videos are most valuable to their instruction, where there might be gaps in our video tutorials, and what variables are preventing them from using all the videos provided for each section. In addition to interviewing teachers, we also hope to compare video access data with classroom observation data in order to examine if accessing video tutorials prior to implementing curriculum affected teachers' ability to enact the curriculum with fidelity.

In this initial examination of the SLIDER professional development system and its evolution, we were able to gather some valuable data about teacher access of professional development materials, teacher perceived needs when enacting the curriculum, and the educative value of curriculum structures in the curriculum. This continued analysis of our professional development system will provide insight into how to improve the system for SLIDER curriculum and other Problem-Based Learning curriculum enactments.

References

Alemdar, M., & Docal, T. (2011). Engaging K-12 teachers in technology tools to support electronic and mobile learning through an online professional development course. *Proceedings of the 118th American Society for Engineering Education annual conference and exposition.*

Alemdar, M., & Rosen, J. (2011). Introducing K-12 teachers to LEGO Mindstorm robotics through a collaborative online professional development course. *Proceedings of the 118th American Society for Engineering Education annual conference and exposition.*

Barrows, H. S. (1985). *How to design a problem-based curriculum for the preclinical years*.

New York: Springer.
Boaler, J. (1998). Open and closed mathematics: Student experiences and understandings. *Journal for Research in Mathematics Education, 29*, 41-62.
Cognition and Technology Group at Vanderbilt. (1997). *The Jasper project: Lessons in curriculum, instruction, assessment, and professional development*. Mahwah, NJ: Erlbaum.
Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.) *Knowing, learning and instruction: Essays in honor of Robert Glaser* (pp. 453-494). Hillsdale, NJ: Lawrence Erlbaum Associates.
Grant, C. M. (1996). Professional development in a technological age: New definitions, old challenges, new resources. *Technology infusion and school change: Perspectives and practices* [Research monograph]. Cambridge, MA: TERC. Retrieved from http://lsc-net.terc.edu/do/paper/8089/show/use_set-tech.html
Hmelo-Silver, C. E., & Pfeffer, M. G. (2004). Comparing expert and novice understanding of a complex system from the perspective of structures, behaviors, and functions. *Cognitive Science, 28*, 127-138. doi: 10.1016/s0364-0213(03)00065-x
Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., . . . Ryan, M. (2003). Problem-based learning meets case-based reasoning in the middle-school science classroom: Putting Learning by Design™ into practice. *The Journal of the Learning Sciences, 12*, 495-547.
Kolodner, J. L., Gray, J., & Fasse, B. B. (2003). Promoting transfer through case-based reasoning: Rituals and practices in Learning by Design™ classrooms. *Cognitive Science Quarterly, 3*, 119-170.
Kolodner, J. L., Krajcik, J. S., Edelson, D. C., Reiser, B. J., & Starr M. L. (2010). *Project-Based Inquiry Science™ (PBIS) Series*. Armonk, NY: It's About Time/Herff-Jones.
Krajcik, J., Blumenfeld, P. C., Marx, R. W., Bass, K. M., Fredricks, J., & Soloway, E. (1998). Inquiry in project-based science classrooms: Initial attempts by middle school students. *The Journal of the Learning Sciences, 7*, 313-350.
National Research Council (1999). How people learn: Brain, mind, experience, and school. Committee on Developments in the Science of Learning. J. D. Bransford, A. L. Brown, and R. R. Cocking (Eds.). Commission on Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.
National Research Council. (2011). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.
Ryan, M., & Usselman, M. (2012, March). *Facilitating and assessing science learning within an engineering design-focused project-based learning curriculum.* Paper presented at the 2012 National Association for Research on Science Teaching annual international conference, Indianapolis, Indiana.
Schneider, R. M., Krajcik, J., & Blumenfeld, P. (2005). Enacting reform-based science materials: The range of teacher enactments in reform classrooms. *Journal of Research in Science Teaching, 42*, 283-312. doi: 10.1002/tea.20055
Sparks, D., & Loucks-Horsley, S. (1989). Five models of staff development for teachers. *Journal of Staff Development, 10*(4), 40-57.