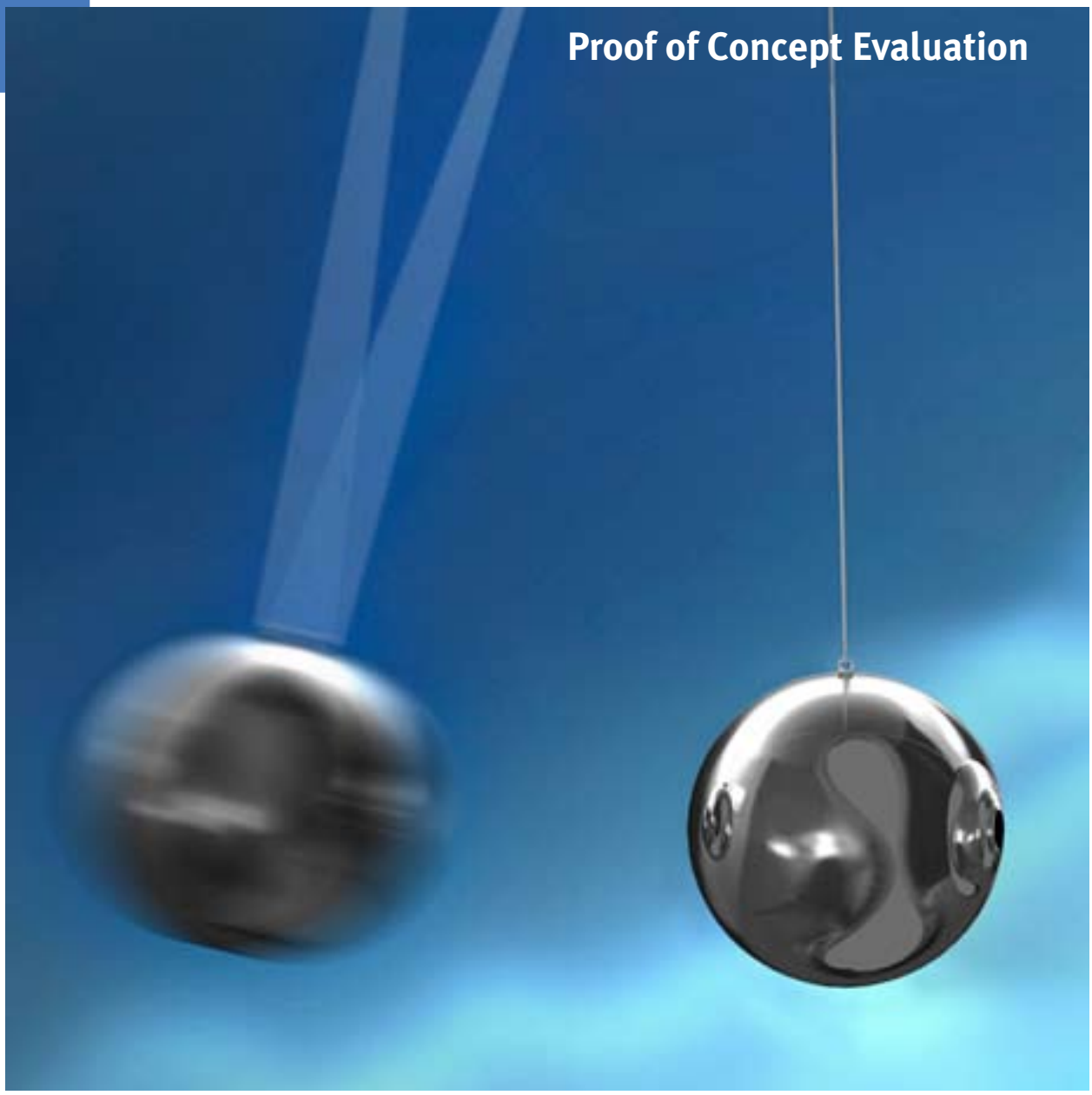
Virtual Learning Magnet for Space Science and Mathematics

Proof of Concept Evaluation



Submitted by: Kathlyn M. Steedly Ph.D.

Executive Summary

The Council of Chief State School Officers launched the Virtual Learning Magnet (VLM) for Space Science and Mathematics Proof of Concept in early 2009. The VLM Proof of Concept sought to increase access to space science and mathematics instruction for all students with the desire to explore space science and mathematics, create an interest-driven educational environment, and build bridges between traditional schools and virtual schools. This Proof of Concept evaluation serves as an investigation of work and a picture of the efficacy of a participatory virtual learning model.

Proof of Concept Overview

The Proof of Concept involved developing a technologically focused, content-rich, participatory, learner-driven environment. The VLM curriculum was composed of basic physics concepts organized in a standard scope and sequence, including content from a variety of open-source resources and a separate social network. The VLM involved high-school students from across the United States. **54 students enrolled in the VLM. 34 students were "active" in the VLM Learning Management System. Three students completed at least 50 percent of the curriculum (with one completing 68 percent, one completing 56 percent, and another completing 52 percent). 7 students finished between 10 percent and 40 percent of the curriculum.** Two teachers with experience teaching physics in a virtual learning environment guided the instructional process through implementation of learning sessions, responding to problem sets, and contributing to social networks. Technology within the VLM included two main components: The Learning Management System (LMS) and the Ning. The LMS functioned as the primary structure for the curriculum and the Ning served to facilitate the VLM social network.

Findings from the Proof of Concept

Students generally found the VLM to be of satisfactory quality. 64 percent of students found the teaching, assessments, and curriculum materials to be of either satisfactory (55 percent) or excellent (9 percent) quality. Similarly, 73 percent of students found the quality of the learning community to be either satisfactory (55 percent) or excellent (18 percent).

With respect to value, students viewed the VLM as useful. Specifically, 73 percent of students saw the teaching within the VLM as somewhat useful or useful. 64 percent of students found the learning community somewhat useful (54.5 percent) or useful (9.1 percent). Every student responded that the curriculum was somewhat useful or useful.

Student responses reveal several key ideas with respect to student engagement with the VLM curriculum. The majority of students viewed the curriculum as sufficiently thorough and challenging. Students felt they needed more instructional support within the VLM. More than half did not feel their traditional science coursework was improved by their involvement in the VLM. Students spoke to the value of a self-paced learning environment and the inherent challenge in working through the universe of difficult information.

Students clearly indicated the value of the social network within the VLM. More than half of the students felt they had established important relationships with teachers on the VLM. Students also agreed feedback was helpful and the tools available within the VLM are useful. Learning sessions were also viewed as important. Though integral to the VLM, and valuable to the overall objectives of the Proof of Concept, students also acknowledged the difficulty in taking advantage of social networking opportunities.

Recommendations and Conclusion

The VLM's continued success hinges on taking what was learned during the Proof of Concept, turning information into action steps, and taking those steps into planning and implementation. Several recommendations include: increase instructional support, strengthen the technological solution, establish clear curricular expectations, continue to build relationships with community resources, and maintain commitment to student-directed learning.

Introduction

SPACE SCIENCE AND MATH SKILLS ARE CRITICAL to responding to the questions of the still-young millennium. We live in a world where information explodes exponentially, challenges carry the weight of the future, and possibility is only limited by our skills and imagination. The Virtual Learning Magnet for Space Science and Mathematics (VLM) Proof of Concept sought to meet these urgent needs by piloting a learning model that would demonstrate the importance of community and collaboration in the learning process and foster a solid foundation of space science and math skills.

The Council of Chief State School Officers launched the Proof of Concept for the VLM in early 2009 in response to the need to coordinate and extend space science and math resources beyond the traditional confines of brick-and-mortar schools and standard virtual education. The philosophical thrust of the project was to inspire a new generation of learners to continue to channel their curiosity and intellect into math and science. Specifically, the Proof of Concept pursued the following broad goals, as stated in the Proof of Concept proposal:

1. Ensure that any student with a passion for space science has access and opportunity to develop the knowledge and skills that can lead to a career in that field
2. Motivate under-engaged or at-risk students with an interest in space science to achieve in STEM (Science Technology Engineering and Mathematics) disciplines in high school through interest driven experiences
3. Demonstrate that traditional school systems and virtual schools can collaborate across states to develop a learning delivery system for the education needs of a new century.

An evaluation of the Proof of Concept must revisit the original stated objectives in an effort to determine the strengths and weaknesses, successes and failures, and victories and defeats of the endeavor. This report seeks to clarify the way in which the Proof of Concept responded to the original tasks at hand. As both an investigation of a specific project and a framework and/or model for virtual learning, this Proof of Concept evaluation will shed light on past work and point to future possibilities.

Evaluation Strategy

The evaluation strategy for the proof of concept involved gathering data from a variety of sources. In an effort to determine the preliminary impacts and lessons learned, surveys were conducted and project artifacts and Proof of Concept participation data were collected. Follow-up conversations also took place with Project Directors, teachers, and technical support staff via phone and email. Though the scope of the data is limited, the utility of the information can be found in its ability to provide a baseline of feedback for future project development.

Surveys

13 students participated in a general survey that asked questions focused on basic demographics, engagement with curriculum, and response to technology. The survey was administered online and 45 students were invited, via an email link, to participate. The link was posted June 5, 2009 and removed June 29, 2009. Students were asked/reminded weekly to respond to the survey. In addition to the general survey, three students completed a comprehensive, short answer survey. The comprehensive survey was posted June 12 and removed June 29, 2009. The two teachers involved in the project were also surveyed with respect to their project experience.

Project Artifacts

Project artifacts were collected from across a variety of sources, primarily from VLM online resources and teachers and project directors. Project artifacts included data from the Learning Management System and NING, information from content area websites linked to within the VLM, and materials collected from teachers and project directors. Learning modules, supplemental PowerPoint presentations and videos, and a sample student written lab exemplify specific project artifacts.

Project Participation Data

Project participation data was collected as evidence of student engagement within the VLM. Data included the participation numbers tracked by the Learning Management System (LMS) and threaded discussion content from both the NING and LMS. Project participation primarily involved students completing Big Idea problem sets, taking Big Idea quizzes, and utilizing the social networking/discussion component of the Learning Management System and Ning.

Proof of Concept Overview

Part of the utility of the Proof of Concept evaluation is gathering information around what actually happened as the proposal was implemented. The first step in determining how things moved from the page to practice involves slowly walking through the elements of the project and providing flesh to the bones of the original vision. This overview looks separately at each element in the hope that in articulating the nuts and bolts, the broader implications of the VLM learning model will begin to be revealed.

Curriculum

The VLM curriculum comprised basic physics concepts organized in a standard scope and sequence, including content from a variety of open source resources and a separate social network. The basic physics concepts were called Big Ideas. Big Ideas mirrored standard high-school physics curricula, and included modules, problem sets, and assessments. Big Ideas covered such topics as kinematics, mechanics, gravity, energy and momentum, thermodynamics, waves, electricity and magnetism, and nuclear physics. Fundamental aspects of Big Ideas were articulated in terms of competencies (ideas students should understand after working through the Big Idea). Several Big Ideas included supplemental materials from physics-focused electronic resources. Assessments occurred at the end of each Big Idea. All work was done at the student's own pace. **Based on information tracked by the Learning Management System, three students completed at least 50 percent of the curriculum (with one completing 68 percent, one completing 56 percent, and another completing 52 percent). 7 students finished between 10 percent and 40 percent of the curriculum.**

Closely looking at a learning module will provide a window into the specifics of the VLM curriculum, and ground the evaluation data in the broader context and complexity of the Proof of Concept. The mechanics module exemplifies the breath and depth of VLM work. Learning competencies are outlined within every VLM module. Competencies for mechanics are as follows:

1. Constructing and interpreting free-body diagrams
2. Understanding the relationship between net force and acceleration
3. Newton's Laws
4. Torque and rotation

Each competency is supported by a document that points out specific electronic resources, primarily leading governmental and academic resources. The supporting document for mechanics competencies introduces students to the variety of NASA resources focused on forces, force diagrams, net force, and

ultimately to drawing free-body diagrams. (Other modules introduce resources from the space-science world such as materials from the Smithsonian Institution's collection and a physics course from the Massachusetts Institute of Technology.)

Competencies are supported by problem sets within each module. The mechanics module included 5 problem sets that asked questions like, "The Apollo 11 command module (mass 600kg) had three parachutes, each with a diameter of 25.4 m and thirty ropes 60 m long. The midlines of the three parachutes formed angles of 24 degrees from vertical. What was the tension in each rope as the CM descended at constant speed?" and "An astronaut (mass 180kg including his suit) working outside the International Space Station (mass 227,000 kg) pushes himself away from the ISS with a force of 250 N for exactly 2.0 seconds. What is the change in velocity of the ISS? What force does the ISS exert on the astronaut? What is the change in velocity of the astronaut? How much time is required for the two objects to be separated by exactly 100 meters?"

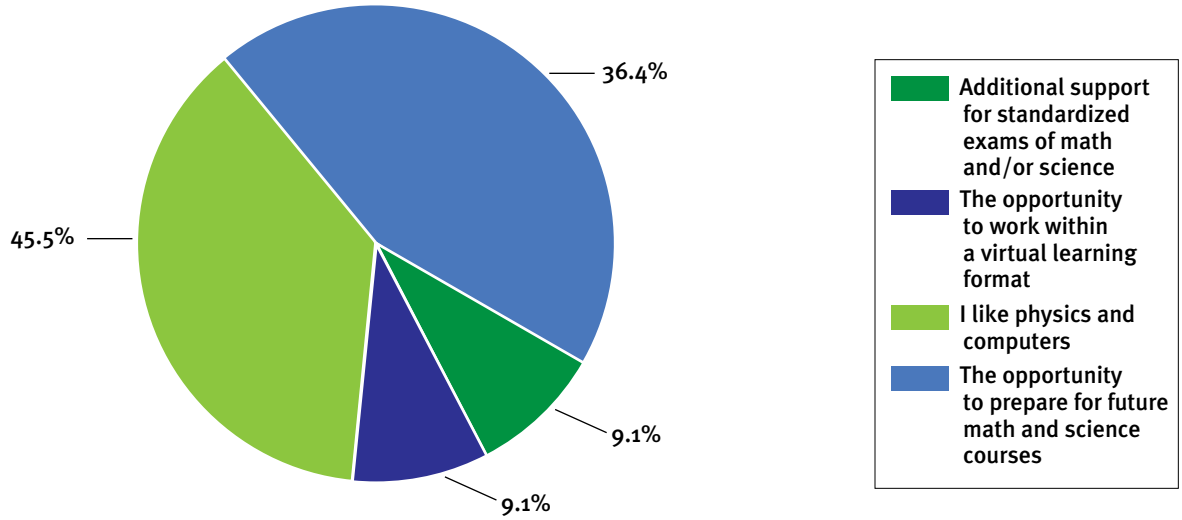
The mechanics assessment asks students to solve problems like, "Two masses in the figure below rest on a frictionless table. A force of 14 N is applied on A. What is the magnitude of the force that B exerts on A?" and "A 50 kg block at rest on a 15 degree slope. A force of 250 N is acting on the block up the slope parallel to it. If the block does not slide up the slope?" Within each question, students are given four possible multiple-choice responses. Assessments are immediately graded within the VLM system.

Students

The VLM was comprised of high-school students from across the United States. Student recruitment involved contacting state education agencies, focusing on those with strong virtual education offerings, and making them aware of the VLM opportunity. Recruitment efforts sought to find students who were academically ready, previously successful in virtual learning environments, and genuinely interested in space science. **54 students enrolled in the VLM Learning Management System, and 34 students were "active" within the system.**

Based upon survey responses, some basic student characteristics can be gleaned. In general, participating students expressed comfort with techno logy and face-to-face collaborative learning environments. They had previous experience with physics. They were from a variety of geographic locations—evenly split between urban, suburban, and rural contexts. Their parents went to college and about half of the students had after-school jobs. The majority were involved with the VLM for three to five months. 24 percent of students spent less than one hour on VLM tasks per week and 18 percent worked 10 or more hours per week.

Primarily, I enrolled in the Virtual Learning Magnet for the following reason. Please select only one answer.



With respect to why they became involved in the VLM, 46 percent said they liked physics and computers, and 36 percent chose the VLM as an opportunity to prepare for future math and science courses.

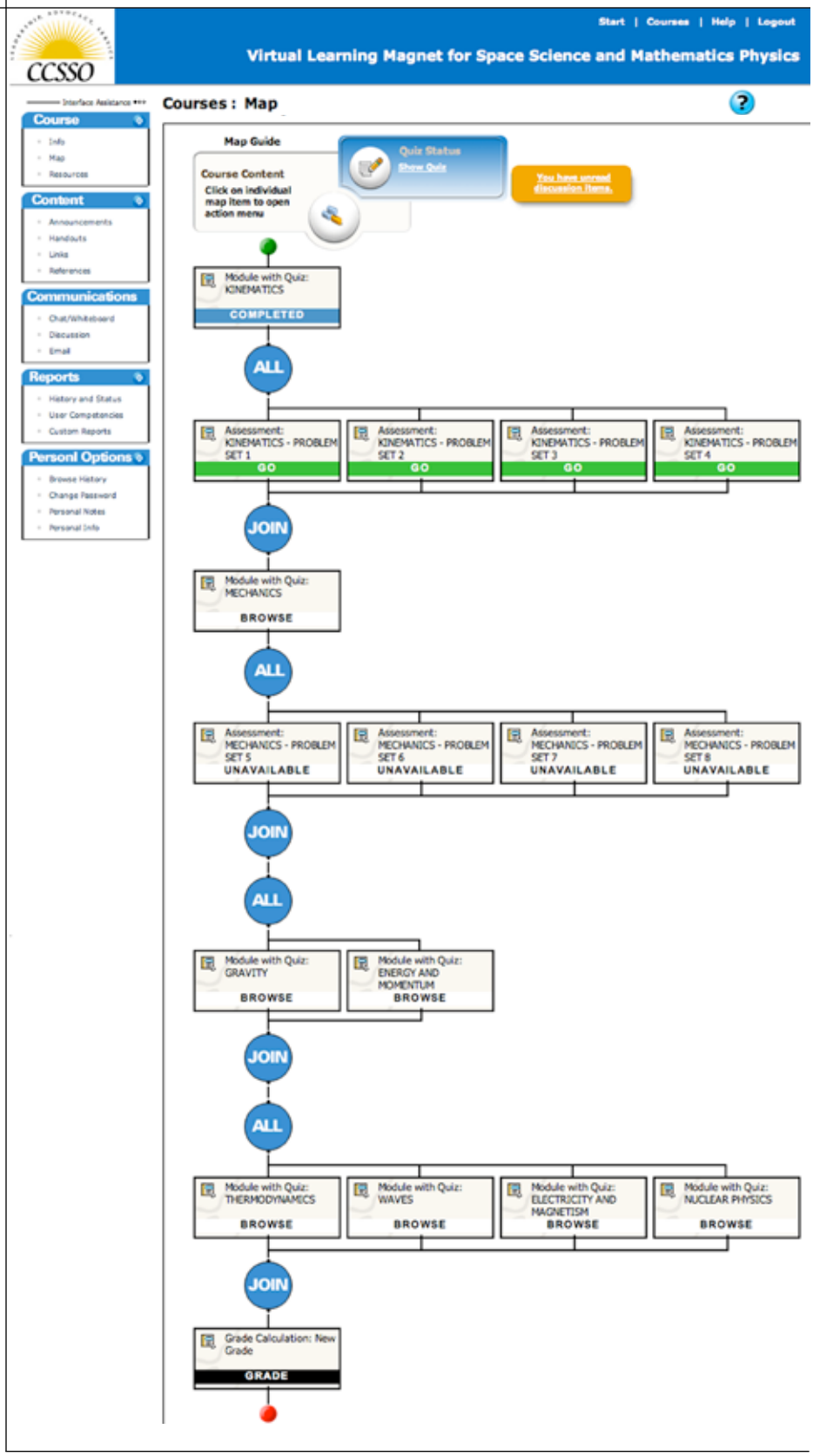
Teachers and Instructional Support

Two teachers with experience teaching physics in a virtual learning environment guided the instructional process in the VLM. Both teachers currently teach physics within a state virtual learning initiative. Instructional support focused on learning sessions and involvement within the social networking infrastructure. The teachers guided learning sessions, provided feedback on problem sets, and followed and contributed to threaded discussions posted within the VLM. 12 learning sessions occurred between April 1 and May 7, 2009. 7 of the sessions lasted between 30 and 90 minutes. Attendance ranged from 1 to 7 participants. The teachers rotated leading learning sessions. Sessions generally involved fielding student questions and concerns and guiding student participation as they used the VLM technology.

Technology

Technology within the VLM included two main components: The Learning Management System (LMS) and the Ning.

The LMS functioned as the primary structure for the curriculum. All modules, problem sets, and assessments were organized within the LMS. The LMS also provided a mechanism by which students could investigate content, participate in basic communication, and receive reports as to their progress through the system. The Map feature was particularly useful in that it allowed students to navigate their own path by seeing where they had been and where they had yet to go.



The Ning provided the social networking component of the VLM. Functioning separately from the LMS, the Ning was another place for students to engage within the VLM. The site gave students the opportunity to personalize their own pages, post pictures and videos, host events, blog, and link to resources. The Ning also allowed for the VLM to potentially become a more interactive and creative environment.

Findings from the Proof of Concept

General Response

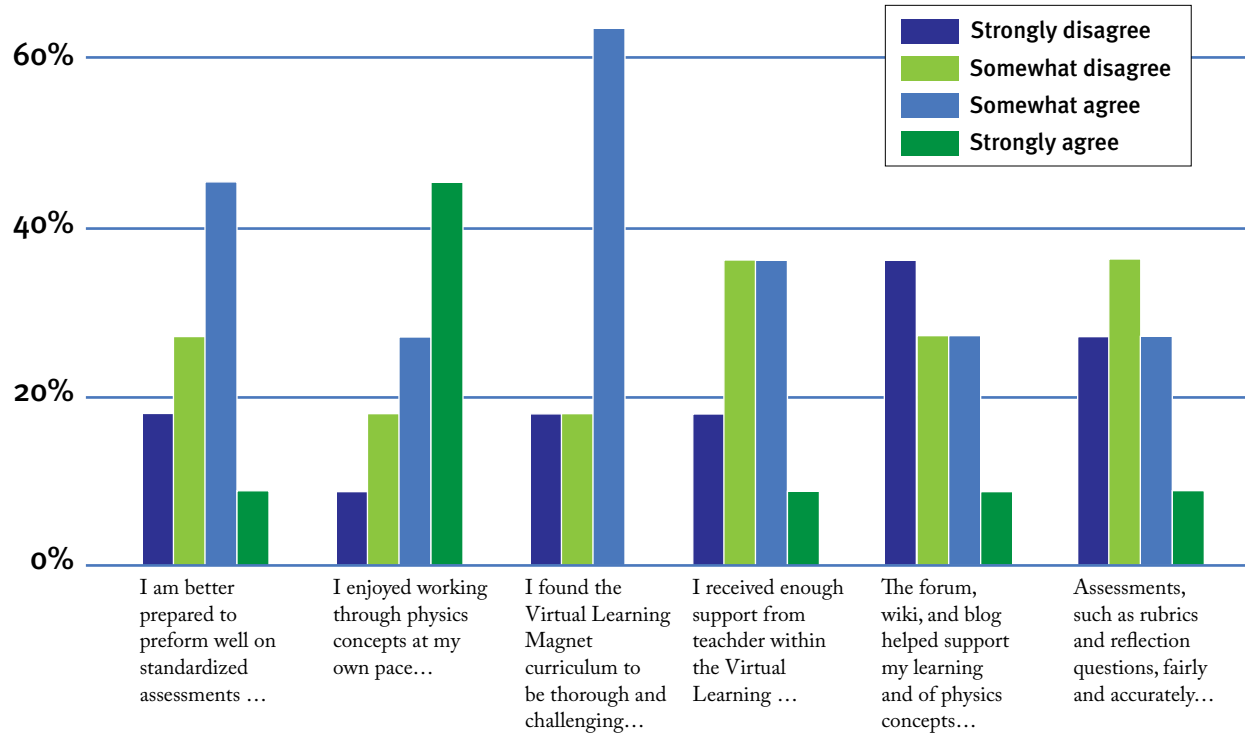
Students generally found the VLM to be of satisfactory quality. 64 percent of students found the teaching, assessments, and curriculum materials to be of either satisfactory (55 percent) or excellent (9 percent) quality. Similarly, 73 percent of students found the quality of the learning community to be either satisfactory (55 percent) or excellent (18 percent).

With respect to value, students viewed the VLM as useful. Specifically, 73 percent of students saw the teaching within the VLM as somewhat useful (46 percent) or useful (27 percent). 64 percent of students found the learning community somewhat useful (55 percent) or useful (9 percent). Every student responded that the curriculum was somewhat useful or useful.

Curriculum: Quality and [Un]limited Opportunity

The VLM curriculum attempted to bridge the worlds of instruction, content, technology, and resources. Within this framework, space science became the laboratory for a larger experiment in creating an organic, rigorous, flexible location for information sharing and learning. The VLM curriculum included the breadth of available space science content. Modules often included a resource sheet of introductory text and links to resources intended to support students as they worked through curriculum—often these list included 10 or more links.

Please respond to the following statements with respect to the Virtual Learning Magnet curriculum.



Student responses reveal several key ideas with respect to student engagement with the VLM curriculum.

- 64 percent of students somewhat agreed with the statement that the curriculum was thorough and challenging.
- 46 percent of students somewhat agreed with the statement that they are better prepared to perform well on standardized assessment as a result of their VLM participation.
- 45 percent of students either somewhat agreed (36 percent) or strongly agreed (9 percent) with statement that they received enough support from teachers within the VLM community to be successful
- 63 percent of students either somewhat disagreed (36 percent) or strongly disagreed (27 percent) with the statement that that assessments fairly and accurately assessed their knowledge of the VLM curriculum.
- 55 percent of respondents disagreed with the statement that their traditional science coursework had improved as a result of their VLM experience.

In distilling these main points, several ideas become clear. The majority of students viewed the curriculum as sufficiently thorough and challenging. Less than half of students felt they had received enough instructional support within the VLM. More than half of students did not feel their traditional science coursework was improved by their involvement in the VLM.

Student contribution of resources within the Ning exemplifies engagement within VLM curriculum. Several students contributed resources they had found in their journey through the VLM. One student posted "Handy dandy equations for quick and easy reference!" This post included a reference sheet that offered basic equations and guidance for students working through problem sets focused on motion in one and two dimensions. Though the VLM curriculum included a breadth of resources, moments when students found additional information themselves and contributed it to the community exemplify the type of solid interaction on which student ownership of learning and long-term impact can be based.

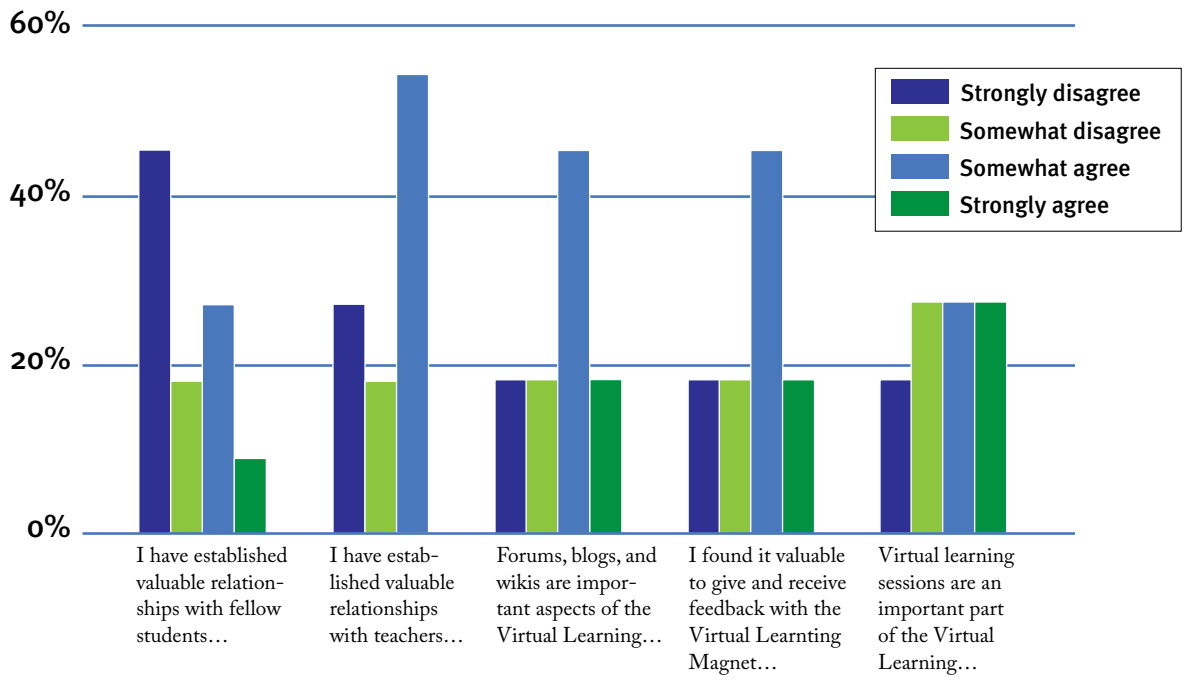
Another example of students engaging with and creating elements of the VLM curriculum is a paper-airplane lab. Two students authored the lab and submitted it to the teachers as evidence of learning. (Though introduced into the instructional process, rubrics and portfolios were not fully implemented within the VLM Proof of Concept.) The stated purpose of the Paper Airplane Lab was "to use various paper airplane designs to discover and demonstrate the effects of lift and drag forces." The lab was divided into background, purpose, procedure, material, data, and analysis. The basic experiment involved students creating different types of paper planes, throwing each plane, observing the plane in flight, recording the observation, and answering questions based on the experimental results.

Students spoke to the value of a self-paced learning environment and the inherent challenge in working through the universe of difficult information. With respect to pacing, one student thought, "The open-ended nature reminds me of my middle-school days which had a similar feel to it, and I frankly prefer this method of teaching more, because it allows the student to shine..." Another student spoke positively saying, "The freedom of choosing what to work on and what to focus [on] gives the VLM a sense of freedom that the traditional school system doesn't allow for." Offering a different perspective, one student explained, "I'm afraid that by providing so much freedom to VLM 'users,' or students, that we were all overwhelmed." Another student offered this candid assessment: "The assumption these classes [previous physics courses] and VLM made was that students could search out the appropriate lessons and then perform the work. The reason this does not work is that what is covered in basic physics varies and a teacher is needed to pick out the lessons and then test on what is taught in them. There were text-based materials and animations, but the challenge in teaching physics is not visualizing the problem, it's quantifying it. There were also help sessions provided by VLM as in the above courses, but an hour or so a week does not make up for class time." In sorting out these differing opinions, one thought becomes clear: The students craved both guidance and freedom.

Constructionism, Instruction, and the Social Construction of Knowledge

The VLM was founded on the constructionist notion that learning is not simply the transmission of information, but a meaningful enterprise deeply connected to student experience. Sitting squarely in the tension between theory and practice—in the "This is great, but will this really work with students given limited time and resources" space—the VLM sought to successfully function as a learner-driven environment in which knowledge evolves as a result of exploration, conversation, and experimentation. Through deliberate use of social networking, VLM students and teachers responded to highly complex questions, asking for help along the way. One student synthesized the value of the VLM community this way: "Not only was I able to see other peers different viewpoints, but I was also able to provide my own and learn by 'teaching.'"

Please respond to the following statements with respect to the Virtual Learning Magnet community.



Students clearly indicated the value they found in the social network within the VLM.

- 55 percent of students agreed with the statement they had established valuable relationships with teachers within the VLM community.
- 64 percent either somewhat agreed (46 percent) or strongly agreed (18 percent) with the statement that forums, wikis, and blogs are important aspects of the VLM.
- 64 percent either somewhat agreed (46 percent) or strongly agreed (18 percent) with the statement that it was valuable to give and receive feedback within the VLM environment.
- 54 percent of students either somewhat agreed (27 percent) or strongly agreed (27 percent) with the statement that virtual learning sessions are an important part of the Virtual Learning Magnet experience.

These main points highlight several key ideas about the VLM community. More than half of the students felt they established valuable relationships with teachers on the VLM. Students also agreed feedback was valuable and the tools available within the VLM are useful. Learning sessions were also viewed as important.

An example from a discussion thread within the LMS illustrates the way in which virtual discussion can be a vehicle for learning and understanding. A topic was posted in the Discussion section of the LMS asking the question,

"How can we design an experiment to determine the relationships associated with constant speed motion?" Four students responded to this initial question. One student suggested, "The basic way of seeing how variables in constant motion relate to each other is to use the formulas for 1D and 2D motion." Another student discussed "doing an experiment with a pendulum, setting it off with a wide circle." Several students also contributed by developing an experiment with cars.

In another example, this one from the Ning, a student was having trouble working through the kinematics module. He explained, "I know we have the infinite bounds of the internet to aid us in this course, but for some reason I am not catching on as well… Is there anyone who has been understanding the first few units? I'll be honest and say that I'm stuck on kinematics which is pretty depressing… I just don't seem to understand the questions and how to solve them…" One of the teachers responded to this dilemma by letting the student know there would be weekly online sessions to help. In addition to the teacher, two students chimed in offering information and commiseration.

Though acknowledged as integral to the VLM, and valuable to the overall objectives of the Proof of Concept, students noted the difficulty in taking advantage of social-networking opportunities. Speaking directly to the time involved in social networking, a student explained, "I participated perhaps more than anyone else in learning sessions and posting, but I found that I did not have the time to actually learn the material and when I sat down to try, I was not mastering the material and became frustrated."

Another point illuminated by a student was the need for consistent and thoughtful participation in the community. One student exclaimed, "If you give no minimum posting requirement, most people do not participate… When you give a requirement most do the minimum and do not read or participate in the discussion… perhaps just glancing over a few messages before giving a short reply."

A final point to ponder with respect to the complexity of cultivating community within a social network, and specifically within the VLM, centers on the comfort with finding support in virtual environments. One student simply states, "Friends and help are easier to access when in a classroom." This opinion, whether a product of habit or personal preference, points to the shift in thinking required to find comfort within a virtual learning environment, especially when investigating content such as space science where face-to-face instruction may ease some of the tension of learning especially complex ideas.

Beyond the Proof of Concept: Recommendations for Project Progress

In making sense of evaluation data from the VLM Proof of Concept, several things can be understood. The Proof of Concept successfully pushed the boundary of traditional math science curriculum and instruction in meaningful ways. Much like ancient explorers sought to navigate the globe using little more than the stars and determination, the VLM started out for the uncharted waters of student-driven, virtually-housed math science education with little more than a commitment to student success and a vision. As is often the case in developing new initiatives, the bike was built as it was being ridden. Just as successful global exploration includes creating better maps, and safe biking excursions depend upon sound equipment, the VLM's continued success hinges on taking what was learned during the Proof of Concept and turning it into action steps toward continuous improvement.

Increase instructional support

Students pointed to the need for more instructional support. Learning sessions were considered helpful but were under-attended. Instructional support within the VLM environment would not necessarily look like traditional classroom "hand-holding." Instructional support could include increased moderation of threaded discussion areas—posing thoughts that relate directly to problem sets, pointing out specific links and resources already identified within the learning modules that are found to be particularly useful, vigorous guidance of groups focused on Big Ideas, and consistently sharing additional resources discovered along the way. This could serve to increase participation in the previously implemented learning sessions and encourage the more interactive learning environment on which the success of the VLM relies.

Strengthen the technological solution

The VLM technology asked a great deal of students. Students, and people in general, gravitate to seamless technical solutions; online banking, social networking systems, and customer-service applications have acclimated users to a world where help, answers, and feedback are found in the same location. The VLM asked students to learn and use two environments. Students needed to follow the curriculum on one site and ask for help on another (though the LMS included a discussion feature as well). Finding and/or creating a technical solution that more fully integrates the social and the curricular is an important next step for the VLM in its quest to be more than simply traditional school via computer.

Establish clear curricular expectations

Clear curricular expectations are central to student success—knowing exactly where you need to go is important to getting there. Expectations need not take the form of grades, or even static, teacher-written rubrics. Expectations need to be established early in the project. Students must be central in the development of authentic and rigorous expectations. Success must be collaboratively defined within the VLM environment and clear perimeters for participation must be provided. For example, if success within the VLM is defined as completing a requisite number of problem sets, participating in X number of learning sessions, and posting/responding to X number of questions within the social network, students need to know these measures of success is in order to achieve it. The question of expectations also includes determining what constitutes course completion, and what type of "credit" will be offered within future VLM communities.

Continue to build relationships with community resources

The wealth of community resources available within the VLM is one of the model's greatest assets. The entire space science and math world is available to students within the virtual universe of the Big Ideas. The VLM should continue to build relationships with leading government, academic, and space science institutions. Relationships could expand to include the personal involvement of content-area experts, more extensive resource sharing, and collaborative efforts such as webinars and other virtual learning events.

Maintain commitment to student-directed learning

Students responded very positively to the idea they could choose their path along the VLM road. Choice is a primary way in which the VLM is different from traditional school. Within a broad understanding of choice, students desired both support and freedom. Achieving a balance between guidance and self-direction will depend upon development of effective instructional strategies that scaffold the enormous amount of resources available while still allowing students to ask questions, help one another, and receive help from instructional leaders and experts when needed. More effective technology and more consistent and targeted instructional strategies that capitalize on virtual advantages are the keys to creating a supportive environment in which students are behind the wheel.

Conclusions

Several points beg reiteration in concluding this Proof of Concept evaluation report. Based on the data collected, the VLM Proof of Concept successfully provided a student-driven, space science and math-focused virtual learning environment for students. Student found the curriculum thorough and challenging. They also desired to have guidance and choice within the curriculum. In addition, the social network was found to be useful and required support to encourage participation. As we move toward developing participatory virtual learning models, the information gathered in this Proof of Concept stands as evidence of the value, complexity, and importance of the endeavor.