VIRTUAL LEARNING COMMUNITIES: AN ONLINE PROFESSIONAL DEVELOPMENT RESOURCE FOR STEM TEACHERS

OVERVIEW
The Center for Elementary Mathematics and Science Education (CEMSE) at the University of Chicago proposes an exploratory, three-year Discovery Research K-12 (DR K-12) project to design, develop and test a virtual learning community (VLC) with potential to enhance the ability of first- and fourth-grade teachers to provide mathematics education. This project directly answers the third challenge of the DR K-12 program: enhancing the ability of teachers to provide STEM education. In particular, it deploys cyberlearning technologies to allow teachers to interact with one another and with experts across the United States. This project addresses the discipline of mathematics and an audience of elementary teachers and other educational researchers and stakeholders who are interested in designing professional learning opportunities for teachers.

GOALS AND PURPOSES
The goal of this project is to produce a prototype of a VLC for Everyday Mathematics teachers, with an initial focus on first- and fourth-grade teachers. Using a design, develop and test cycle, we aim to:

- **Design** a VLC that integrates three primary elements:
  - (a) learning objects rooted in practice,
  - (b) community-building tools, and
  - (c) content focused on specific teacher learning goals;
- **Develop** this VLC by drawing on:
  - (a) the professional and practical knowledge of teachers, and
  - (b) the content, curricular, and pedagogical knowledge of experts; and
- **Test** this VLC against two metrics of the VLC’s utility and quality:
  - (a) teachers’ sustained participation in the VLC, and
  - (b) changes in teachers’ “professional vision” (Sherin & van Es, 2009) while using the VLC.

This project builds on and differs from previous online professional learning efforts in STEM in three ways. First, it integrates three elements in its design, elements that are included, but rarely integrated, in existing efforts. Second, it positions teachers as central partners in the development of the VLC. Third, it engages teachers with a specific curriculum, Everyday Mathematics, and curriculum experts from CEMSE, allowing teachers to deepen their understanding of mathematics teaching in the context of a shared instructional system.

The hypothesis of this project is that integrating these three primary elements and including teachers in the development process will lead to a VLC that has utility for teachers and sufficient quality to allow teachers to learn. To test the accuracy of this hypothesis, we will design and develop the VLC over two years and then begin to test the utility and quality of the VLC in year three of the project, using two existing metrics for utility and quality (these metrics are sustained participation and “professional vision”; see Research and Development Design for more). This project will accordingly address three research questions:

- (a) Does a VLC that integrates learning objects, community-building tools, and focused content promote teachers’ sustained participation and changes in professional vision?
- (b) If so, how should each of the three elements of the VLC be designed to produce these outcomes?
(c) How can teacher voices be effectively marshaled to create such a VLC?

**Potential Impact**

The development of this VLC prototype will have a *broad impact* both within and beyond *Everyday Mathematics*. First, the prototype VLC, developed to have both utility and quality, will later be expanded from 1st and 4th grades to all grades from Kindergarten to 6th. Given that over 185,000 classrooms use *Everyday Mathematics*, this project could result in widespread use of the VLC (McGraw-Hill School Education Group, 2009). Second, this project will result in an accessible venue for teachers in diverse, sometimes isolated locations to interact with experts and other teachers around learning objects from which they can reflect on content, curricula and pedagogy in mathematics. Participating teachers will certainly have the opportunity to share expertise with a national community. Finally, this project will produce a model for a VLC that could be used to create other VLCS that promote high-quality mathematics pedagogy either within another curriculum (outside of *Everyday Mathematics*) or without a specific curricular focus. In particular, each learning object developed for the VLC will be categorized as engaging multiple types of teacher knowledge, from curriculum-specific knowledge of *Everyday Mathematics* components to knowledge of mathematics teaching more generally, as described by the National Council of Teachers of Mathematics (NCTM, 1991, 2000).

This project also has *intellectual merit* that should interest educational stakeholders and STEM researchers. First, we plan to articulate research-based principles regarding how a VLC can be designed to promote sustained participation and improved professional vision, which will be useful for others who either create VLCS or study teachers’ professional learning. Second, the development of the VLC will provide us new knowledge about how to design and integrate each of the three primary elements, which should interest researchers and professional developers who consider such issues as teacher learning with video and teacher community. Third, we hope, by engaging both teachers and experts in the development of the VLC, to develop a new understanding of how to bridge scholarly and practitioner voices to make educational interventions both practical and rigorous. In particular, we wish to elaborate a process in which teachers can be central drivers of their own professional learning.

**RATIONALE**

Teacher quality and preparation are major issues facing the field of STEM education. Teachers are indeed crucial for student learning (Haycock & Crawford, 2008; Rivkin, Hanushek, & Klain, 2005), especially in mathematics education (National Mathematics Advisory Panel, 2008). President Obama’s recent calls for improvements and innovations in STEM education (Obama, 2009, November) highlight existing weaknesses in the preparation and quality of mathematics teachers. This problem can actually be exacerbated when teachers use a curriculum like *Everyday Mathematics* that promotes attention to reform-oriented pedagogical practices and students’ mathematical thinking.

Professional learning activities are one solution to this problem. These activities can have an impact on the quality of teachers’ instruction and, consequently, student learning (Blank & de las Alas, 2009; Cochran-Smith, 2006; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). Of course, not all professional learning activities lead to these successes, and disagreement persists about what constitutes high-quality professional learning (Guskey, 2007; Yoon et al., 2007). However, there is an emerging consensus about three high-quality elements of professional learning, and it is these three primary elements—learning objects, community building tools, and focused content—that we seek to integrate in our proposed VLC.
Learning Objects
Math education experts agree that professional learning should be centered in artifacts of teachers’ practice (Ball & Cohen, 1999; Borko, 2004; Borko, Jacobs, Eiteljorg, & Pittman, 2008; Crockett, 2002; Darling-Hammond & McLaughlin, 1995). These artifacts of practice can be as diverse as lesson plans or “lesson study” (Fernandez, 2002; Hiebert & Stigler, 2000), student work (Crockett, 2002; Franke & Kazemi, 2001), lesson videos (Brophy, 2004), and teaching portfolios (Xu, 2003). Such artifacts of practice situate teachers’ learning in real classroom experiences and allow them to discuss shared issues of practice.

Brophy (2004), in summarizing the literature commonly used to support emphasis on video and other artifacts in professional learning, identified “case studies” as key to professional learning. Explaining how other professions like law and medicine train future practitioners, Shulman (1986, 2005) described a “case study” method of induction, in which students learn about and critique cases of illness or legal proceedings. He argued that education must adopt similar case study methods to grow as a profession. Using this method, teachers would engage with “cases” that represent common issues or exemplary practices and explicate what was done by the teacher in the case and what might be done instead. These cases, Shulman argued, could be supported by a national videobank of cases that could be shared across teacher education institutions. The NSF-funded Video Cases for Mathematics Professional Development (VCMPD) project utilized this idea of lesson videos as cases to create videos designed to enhance teachers’ understanding of linear functions and mathematics teaching (Seago, 2004).

With the advent of Web 2.0 technologies (see Dede, 2008, 2009), which allow users to both view and edit objects on the Internet, artifacts of practice can be viewed, edited and shared online as “learning objects” (Busetti et al., 2007) for teachers. For instance, the website Curriki (http://www.curriki.org) allows teachers to post lesson plans as resources for other teachers. Lesson videos have been widely embraced by online professional learning efforts for teachers, most notably in the NSF-funded Inquiry Learning Forum (Barab et al., 2001; Moore & Barab, 2002). Teacher-driven spaces like Teacher Tube (http://www.teachertube.com) have emerged as a method for sharing ideas and content.

Despite the enthusiasm for these learning objects, many questions remain about how to use artifacts for teacher learning effectively, particularly on the web (Borko, Whitcomb, & Liston, 2009). Crockett (2002), for instance, found that the use of artifacts did not automatically evoke a useful critical stance amongst mathematics teachers. Out of all the types of artifacts, the use of lesson videos has perhaps engendered the most robust set of questions about what teachers learn from video and how they learn it (Sherin, 2004). Research on video cases has indicated promising outcomes for teachers, such as improved “professional vision” (Sherin & van Es, 2009), beliefs about mathematics teaching (Chval, Lannin, Arbaugh, & Bowzer, 2009), and improved understanding of student thinking in mathematics (Borko et al., 2008). However, major unresolved issues remain, including:

- How should video cases in mathematics education be selected—should they illustrate exemplary practices (Brophy, 2004); allow teachers to showcase and reflect on their own practices (Barab et al., 2001; Borko et al., 2008); represent trends of practice (Miller & Zhou, 2007); or present dilemmas and pedagogical alternatives (Ball, 1996; Chval et al., 2009; LeFevre, 2004; Seago, 2004)?
- Which viewpoint(s) should be selected for filming and editing, and how should videos be segmented and edited into watchable clips (LeFevre, 2004; Miller & Zhou, 2007; Seago, 2004)?
- How, if at all, should video viewing be facilitated to ensure that teachers: develop a critical stance (Borko et al., 2008; Crockett, 2002; Fernandez, 2002); watch videos purposefully (Brophy, 2004;
• How should videos be supplemented with other artifacts and teacher commentary (Barab et al., 2001; Borko et al., 2008; Shulman, 2005)?
• How should teachers interact with video to enhance analysis (Rich & Hannafin, 2009)?

Many of these questions could be applied to other artifacts, like student work and lesson plans, as well.

Thus far, professional developers have answered these questions based mostly on their professional experience and intuition. They have constructed artifacts, presented them to teachers, and then tested the effects of the artifacts on teachers’ learning. Although this process has resulted in intermittently successful professional learning endeavors, it has not answered enduring questions about how artifacts can be structured towards different aims of professional learning. The advent of the Internet affords an opportunity to answer these questions, as the artifacts can be easily structured as a variety of diverse, web-based “learning objects” and studied as teachers interact with them. However, such a process does require the developers to give up some control, allowing teachers a voice in the construction of their own learning objects. This is what we plan to do as part of developing the VLC.

**Community-Building Tools**

The second consensus in the literature on teachers’ professional learning is the importance of community-building tools. Community is important for three reasons. First, communities sustain participation in professional learning over a longer period of time. Sustained participation has been identified as a critical structural component of professional development efforts that improve teacher learning and student outcomes (Darling-Hammond & McLaughlin, 1995; Goldenberg & Gallimore, 1991; Yoon et al., 2007). In particular, Yoon et al. (2007) found that teachers’ engagement in over 14 hours of professional development was linked to improved student outcomes.

Second, communities provide a means for teachers to become critical of their teaching practices and learn from others. Such collaborative, authentic learning communities of teachers foster the development of teaching practices that are publicly scrutinized and refined, rather than enacted in isolation without reflection (Barab et al., 2001; Borko, 2004; Borko et al., 2008; Darling-Hammond & McLaughlin, 1995; Moore & Barab, 2002; Webster-Wright, 2009). These communities promote what Ball (1996) referred to as the “critical stance” towards teaching.

Finally, community can allow teachers to marshal a collective voice about their learning goals and needs, which can result in a shift from passive professional development to more active professional learning (Webster-Wright, 2009). Such communities value the experiential knowledge that teachers have, something that is often forgotten in the current era of telling teachers “What Works” (Biesta, 2007). Over time, communities can become sustainable “communities of practice” (Lave & Wenger, 1991; Moore & Barab, 2002), in which teacher learning is situated in the community and conducted by teachers (Franke & Kazemi, 2001). Such “active learning” by teachers has been linked to changes in instructional practices (Desimone et al., 2002).

In the Web 2.0 era of social networking, teachers have begun to build communities online for various purposes, resulting in a crop of “virtual communities.” TappedIn (http://tappedin.org/) is one such community, designed for teachers to attend webinars on educational issues, network and seek job opportunities (see Schlager et al., 2009). Other communities have more specific foci, such as the technology-in-education community Classroom 2.0 (http://www.classroom20.com) and the English-teacher community English Companion (http://englishcompanion.ning.com/). According to a recently
released study (PBS & Grunwald Associates LLC, 2009), 26% of teachers are involved in online teacher communities, and more than half of the surveyed teachers expressed comfort with Web 2.0 tools like rating, tagging and commenting on web-based objects.

Questions remain, however, about what teachers learn from any community and how a community should be structured to maximize teacher learning. As Bryk (2009) pointed out, just bringing teachers together in a community does not improve their practice. Instead, professional learning communities of teachers must have a shared instructional focus. For online communities, the ease of use, novelty and personalization in the design of web portals and learning objects can influence whether teachers use and interact within communities (Barab et al., 2001; Busetti, Dettori, Forcheri, & Ierardi, 2007; Matsuo, Barolli, Xhafa, Koyama, & Durresi, 2008; Rasseneur-Coffinet, Smyrnioú, & Tchounikine, 2007). A transparent interface is particularly important for teachers involved in virtual communities, as is a guarantee that the site is secure and private (Hur & Hara, 2007).

Yet even the best-planned virtual communities can fail to sustain participation over time. The NSF-funded Inquiry Learning Forum, which also featured learning objects, found that participation in the forum was difficult to sustain (Barab et al., 2001). Noting this issue, Hur and Hara (2007) studied a successful Korean teachers’ virtual community and found that several factors contributed to sustained community. These included the teacher’s sense of ownership in the community, including the enactment of various roles—like “welcomer”—assigned to teachers, a belief that the site provides useful resources and learning opportunities for practice, and a feeling that the site helps overcome teachers’ isolation.

These aspects of community cannot be built into a site directly, but have to be nurtured over time. A core group of committed, conscientious participants is as necessary to a virtual community as a live one. Because of this, top-down efforts by professional developers to produce communities without the agreement and enthusiasm of teachers will likely fail (Hur & Hara, 2007). For this reason as well, we seek to include teachers from the outset in developing learning objects and the VLC community itself.

**Focused Content**

The previous two elements—learning objects and community-building tools—concern the structure of professional learning. Although most research on professional learning is devoted to structure, the content of the professional learning experience is at least equally, if not more important (Kennedy, 1998). Most professional development efforts develop content to provide teachers opportunities to enhance their knowledge. Shulman (1986, 1999) separated the types of teacher knowledge into three useful categories: (1) subject matter content knowledge, (2) pedagogical content knowledge, and (3) curricular content knowledge. Teacher education expert Borko (2004) outlined similar realms for teacher learning, emphasizing knowledge of subject matter, instructional practices, and—in lieu of curricular knowledge—student thinking.

Examples of professional development addressing each category abound in mathematics education and are beyond the scope of this proposal. Efforts that have particularly influenced this proposal include:

- For subject matter knowledge: Online courses at PBS TeacherLine and the Math Forum at Drexel
- For pedagogical knowledge: The NSF-funded VideoCases for Mathematics Professional Development (LeFevre, 2004; Seago, 2004); Project Challenge (Chapin & O’Connor, 2004)
- For knowledge of student thinking: The Supporting the Transition from Arithmetic to Algebraic Reasoning (STAAR) project (Borko et al., 2008); The Cognitively Guided Instruction (CGI) approach (Franke & Kazemi, 2001); Kazemi (2007) usefully summarized others.
Exploring the content of professional learning for mathematics teachers, Kennedy (1998) found that programs which provided teachers information about how students learn a subject without making teaching prescriptions had the greatest effect on student outcomes in mathematics. These outcomes included both basic skills and mathematical reasoning. However, others (notably Ball & Cohen, 1996; Bryk 2009) noted that professional learning communities are most productive when they are rooted in a specific instructional system or curriculum. Teachers in these focused communities can discuss and map pedagogy, student thinking, and content onto a shared, influential context. Thus, we propose that the VLC have focused content—content that is designed around *Everyday Mathematics* and pushes teachers to consider content, pedagogy and student thinking in a shared instructional system.

The direct services currently offered at CEMSE (see [http://cemse.uchicago.edu/node/13](http://cemse.uchicago.edu/node/13) for more information) represent such an attempt at focused content. CEMSE seeks to improve all types of teacher knowledge by situating teacher learning in the shared context of *Everyday Mathematics*. For instance, one key aspect of CEMSE’s direct services work in mathematics is collaborative coaching. Developed by veteran teachers and direct service providers Ellen Dairyko and Cheryl Moran (both key personnel on this project), collaborative coaching involves three stages:

a) *Planning*, in which a team of teachers, other school personnel, and a CEMSE coach co-plan an *Everyday Mathematics* lesson, paying particular attention to lesson content, pedagogy (pacing, questioning, assessment, differentiation, management), and other areas identified by participants;

b) *Teaching and Observing*, in which the team observes one or more of the teachers enacting the planned lesson, and observations are focused on student interactions and thinking during the lesson. Multiple teachers are encouraged to teach the lesson subsequently, and the emphasis is on student, not teacher, actions;

c) *Debriefing*, in which the team reflects on the lesson—particularly regarding the evidence of student interactions—and plans follow-up interactions.

This collaborative coaching model, like other CEMSE direct services work, engages many aspects of the knowledge required to teach mathematics and is representative of the kind of focused content we will seek to provide on the VLC. However, we will aim not only to transfer direct services practices to the VLC, but also to explore how to use learning objects and community-building tools to provide focused content for teachers while allowing teachers a say in their professional learning.

**Integrating the Elements Virtually**

The previous sections introduced the research base for learning objects, community-building tools, and focused content—three elements of a high-quality professional learning community. For each element, we also provided examples of efforts to produce the element virtually. Clearly, more and more professional learning is being conducted on the Internet (PBS & Grunwald Associates LLC, 2009). Teachers, formerly isolated in their classrooms and schools, can now interact across the United States with other teachers to share expertise, concerns and advice; can search for resources; and can contact content, pedagogical and curricular experts online.

As yet, few of the examples of online professional learning experiences in mathematics we provided actually integrate the three elements described in this section. The hypothesis of this project rests on the assumption that the integration of these three elements combines and enhances the individual strengths of each. For instance, the use of video as a learning object has strengths (as in the Inquiry Learning Forum), but only if a community of teachers actually collaborates to critique and construct
practice (Barab et al., 2001; Crockett, 2002). Likewise, one can have learning objects and a community, as in TeacherTube, without goal-focused content regarding what teachers should know or learn. Combining all three elements should create a more powerful learning experience.

CEMSE’s live direct services with *Everyday Mathematics* teachers already seek to integrate these elements, with positive results. The collaborative coaching model introduced above not only has focused content, but engages teachers in a small community and in discussing practice (observed lessons). Additionally, CEMSE manages a relatively large and busy listserv for teachers and math coaches using *Everyday Mathematics*, in the hopes of building a national community of *Everyday Mathematics* users. It is a natural next step to move what we know about high-quality professional learning in *Everyday Mathematics* to the Internet, where a wider variety of teachers can have access to a community of committed mathematics educators, and to enhance our practices by exploring the development of Internet-based learning objects and community.

However, we recognize the challenges of reproducing elements of live professional development on the Internet. For instance, the nature of collaborative coaching will be changed dramatically by having to use video rather than live observation; by using reflective online discussion rather than immediate face-to-face debriefing; and by taking the human contact out of the coaching model. We will also need to develop learning objects and community tools specifically for the Internet, and find new ways to produce focused content in these elements. To that end, we propose a development process that will allow us to experiment with moving and structuring elements of live professional learning online and with involving teachers in developing and leading a virtual community, thus informing the design of the VLC elements.

**RESEARCH AND DEVELOPMENT DESIGN**

To create the VLC, we are relying on a design, develop and test cycle. As explained in the previous section, the VLC will be designed to integrate the three primary elements—learning objects, community-building tools, and focused content. We recognize two challenges to this design: (1) the need to answer lingering questions about how to structure each of these elements successfully in a virtual forum and (2) the need for teachers to be involved in the design and development of the VLC from the beginning.

To meet these challenges, we propose to use an “educational engineering” approach (Bryk, 2009; Burkhardt & Schoenfeld, 2003) in developing the VLC. The educational engineering approach places practitioners in the center of the development process—we will work together with practitioners to develop innovations, try them in context, and refine them. It also involves selecting careful outcomes for the innovation and measuring how and why the innovation meets them (Bryk, 2009). The involvement of teachers in the development process will allow them to give us direct feedback on the development of the VLC and also to collect data on how teachers are progressing towards the desired outcomes of the VLC.

By using such an engineering approach, developers can answer questions not only about whether an innovation “works,” but about how, why and in what circumstances it works (Bryk, 2009), questions that Dede, Ketelhut, Whitehouse, Breit, & McCloskey (2009) remarked are central to developing quality online professional learning activities. We use the engineering approach to answer three questions, with two carefully selected outcomes and measures:

(a) Does a VLC that integrates learning objects, community-building tools, and focused content promote teachers’ sustained participation and changes in professional vision?
(b) If so, how should each of the three elements of the VLC, particularly learning objects and community-building tools, be designed to produce these outcomes?
(c) How can teacher voices be effectively marshaled to create such a VLC?
The engineering approach we propose will take three years. The first two years will involve two simultaneous cycles of work. One cycle will concern the development of the learning objects, and the other cycle will involve the development of community-building tools. The development process in both cycles will be guided by a focus on the content, pedagogical, student thinking and curricular knowledge needed to teach *Everyday Mathematics*. It will involve teachers and other experts in the process. The third and final year will be the “launch year” of the VLC, in which we will engage a larger group of teachers in the community, carefully study their activity, and test the effects of the community on these teachers. This year will also allow external experts to evaluate the VLC. Table 1 summarizes this research and development plan.

Table 1. Research and Development Work Plan

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<tr>
<th>Proposed Work</th>
<th>Expected Duration</th>
<th>Anticipated Partners</th>
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<tr>
<td>Develop learning objects</td>
<td>June 2010 to June 2012</td>
<td>CEMSE staff, Teacher partners, Teacher panel, Advisory panel</td>
</tr>
<tr>
<td>Develop community</td>
<td></td>
<td>CEMSE staff, Advisory panel</td>
</tr>
<tr>
<td>Launch and test VLC</td>
<td>June 2012 to June 2013</td>
<td>CEMSE staff, Advisory panel</td>
</tr>
</tbody>
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In the remainder of this section, we describe each part of the research and development design. We begin by introducing our partners in this work, as listed in the final column of Table 1. We will then describe the Learning Objects Development Cycle and the Community Development Cycle and end by explaining the Launch Year.

**Anticipated Partners**

Four distinct groups of people will be involved in the development of the VLC:

CEMSE Staff: CEMSE staff members will participate in the three years of this project and represent a variety of expertise. This expertise includes experienced *Everyday Mathematics* professional development providers, educational researchers, videographers, computer programmers, graphic designers, educational technology consultants, and clerical staff. See *Expertise* for more on the names and backgrounds of these staff.

Teacher Partners: Seven exemplary first- and fourth-grade *Everyday Mathematics* teachers have agreed to serve as partners on the VLC from the outset of the project, assuming they receive the same grade level and approval from their administrators next year (three teachers have provided signed letters in the *Letters of Commitment*). These “exemplary” teachers were selected by Ellen Dairyko and Cheryl Moran, key personnel on this project, based on years of experience working with *Everyday Mathematics* teachers. They defined these teachers as those who teach *Everyday Mathematics* with fidelity, those who illustrate refined judgment and vision in the classroom and those who use research-backed instructional practices. We plan to expand this group to 12. These teachers will provide learning objects for the VLC, help us plan and refine the VLC, and serve as core members of the virtual community. These teachers have also agreed to have lessons videotaped by the CEMSE staff for use in the VLC. They understand the challenges of securing permission to videotape classrooms and students and will aid us in explaining the project to students and parents.
Advisory Panel: Several external experts have agreed to serve as advisors on this project (see *Letters of Commitment*). They will be responsible for attending an initial meeting on the design of the VLC, visiting the VLC, and meeting with CEMSE staff annually to formulate recommendations for revisions of the VLC design. Each of these advisors will also serve an evaluation role on this project in the third year. Please see their *Letters of Commitment* for more information on the advisory duties each will assume and *Evaluation* for the names and expertise of each member of the panel.

Teacher Panel: 75-100 teachers will participate in the development of the VLC during the first two years as a Teacher Panel. Unlike the Teacher Partners, whose purpose is to provide materials to become learning objects for the VLC, the Teacher Panel’s role will be to respond to those materials and help us shape them into useful learning objects. The teacher panel will visit the VLC, view, edit, and comment on learning objects, and participate in the community. They will also give feedback on the VLC and allow us to collect data on their use of the VLC. The feedback and data will be used in the development process. An initial posting about the Teacher Panel to the *Everyday Mathematics* email list garnered expressions of interest from over 100 teachers; in the first 24 hours after the posting, 64 unique teachers responded with enthusiasm. We will take care to ensure that all the panel members are (a) legitimate educators (e.g., teachers, curriculum coaches or specialists) to protect the students and teachers in the lesson videos (see Moore & Barab, 2002) and (b) representative of diverse school settings and teacher backgrounds across the United States, to ensure that the VLC meets diverse needs.

**Learning Objects Development Cycle**

During the learning objects development cycle, we will gather artifacts of practice that can be developed into learning objects, edit these artifacts internally, display these artifacts for use and critique by others, and redesign these artifacts based on feedback. For the proposed prototype, we have chosen to collect learning objects that pertain to first- and fourth-grade number and operations lessons in *Everyday Mathematics*. These lessons, dealing with number sense, whole number arithmetic, fractions, and conceptualization of operations, help lay the groundwork for learning algebra, as recommended by the National Mathematics Advisory Panel (2008). We chose a primary and an intermediate grade to assure the applicability of our model to all elementary school grades.

We will begin the learning objects development cycle by collecting, creating or adapting the following:

2. Video courses from CEMSE’s direct service providers, including workshops, model *Everyday Mathematics* lessons and collaborative coaching sessions.
3. Video courses on mathematics content, provided by University of Chicago mathematicians and mathematics educators.
4. Examples of student work that illustrate student thinking.
5. Annotated lesson plans with teacher-provided notes, tips and differentiation activities.
6. Repositories of teacher-provided tips, links and resources for *Everyday Mathematics*.

We anticipate that our Teacher Partners and Panel will also provide ideas for artifacts to collect. We will continue to collect artifacts throughout all the years of the project, to ensure that the VLC consistently has new material for teachers to discuss, and will seek additional funding to develop learning objects beyond the scope of this project’s budget.

After each artifact is collected, it will go through an editing and review process by CEMSE staff to identify content most likely to engage teachers with the *Everyday Mathematics* curriculum and with
knowledge of subject matter, pedagogy and student thinking. CEMSE staff will utilize a critical components framework for categorizing the artifacts, derived from a model developed by CEMSE colleague Jeanne Century in her NSF-funded project on the fidelity of implementation of standards-based mathematics and science curricula (NSF Award #0628052). The critical components of a given set of curricular materials include structural (or procedural) and instructional (or pedagogical) components that are important to a curriculum’s enactment. CEMSE staff will edit artifacts so that they illustrate critical components of Everyday Mathematics instruction. Our Teacher Partners will also advise us regarding the aspects of the learning objects (especially video) that they feel are particularly indicative of high-quality instruction or practical dilemmas in teaching and responsive to their needs, and we will provide “tags” for them to use to mark artifacts as exemplars of NCTM and other Standards.

In addition to this content editing process, we will also experiment with different ways of presenting each artifact as a web-based learning object. This presentation will be especially critical to lesson video clips. We will film each lesson from at least two viewpoints, with one viewpoint always filmed by a CEMSE professional developer who will focus the camera on important mathematical or pedagogical moments (see Seago, 2004). For each clip that illustrates a critical component, a multi-step process will occur that will include treating the video for sound and picture quality, determining alternate beginning and end points, identifying different ways to supplement the video with information, and choosing ways for teachers to interact with the video. We will select both examples of excellent teaching and examples of problems in practice, and we will focus supplementation of the clips on different types of teacher knowledge, including questions to guide teachers’ understanding of student thinking. We have found in past work that focusing on student thinking is a fruitful avenue for critical discussions of video that avoid “teacher criticism.” Other artifacts like student work will go through a similar, if less detailed, process.

After initial preparation and editing, each artifact will be moved to the VLC web interface. We will invite selected Teacher Partners and Panel members via email to interact with these artifacts and give us direct feedback. An online “Work Queue” will be utilized to distribute the work among teachers equitably and permit individual teachers to accept or decline particular “assignments.” Different versions of a single learning object will automatically be assigned to different panel teachers for feedback. The feedback requested will be direct (e.g., teachers will be asked to give advice on editing, changing or tagging a learning object) and indirect (e.g., teachers will be asked a question related to what they notice in a learning object, and different versions of learning objects will be compared for what they relate about teachers’ “professional vision”). (See Launch Year for the definition of professional vision and a justification for its use as an outcome measure.)

New objects will be placed in the Work Queue as soon as they have cleared the internal CEMSE editing process. After teachers have viewed and given feedback on a particular learning object, we will analyze the feedback data internally and decide in which form we will ultimately post the learning object. We will also seek to identify patterns in teacher feedback that can inform our process for editing future learning objects. The Advisory Panel will meet with us annually to review these patterns, our process for making recommendations based on the feedback data, and examples of learning objects created through this process. This work of developing learning objects through internal editing and the teacher-driven Work Queue will continue for two years.
Community Building Development Cycle

We will build and adapt Internet-based tools for community-building and engage teachers in using these tools and giving feedback on them for our revisions. CEMSE is already working on several Internet applications for other projects, and many of these applications are potentially transferrable to the VLC, including:

1. Discussion boards for each learning object and for general topics of interest.
2. Chat rooms where live messages can be left for current or pending entrants to the site.
3. Office hours for CEMSE staff and Teacher Partners to chat with teacher participants.
4. Interface personalization tools for teacher participants, such as profiles and avatars.
5. Tools for tagging, rating and commenting on learning objects.
6. Repositories for teacher participants to share materials, resources, links and articles.
7. Calendars and newsfeeds for jobs, live meet-ups, conferences, webinars and office hours.
8. Weblogs of teachers’ activities in the site for them to view upon exiting the site.
9. Monitoring tools that can track teachers’ preferences for page viewing and make recommendations for teachers regarding pages they may wish to visit.

We anticipate that our Teacher Partners and Panel members will have additional ideas for community-building tools that we will incorporate over the two-year process. We will launch these applications as they become ready.

We will retrieve feedback on these community-building tools in three ways. First, many of these tools—such as discussion boards and rating/tagging mechanisms—will be connected to specific learning objects. As teachers select these learning objects from the Work Queue, they will be urged to engage in and give feedback on the community-building activities connected to the learning object they are viewing. In this sense, the community-building tools will become part of the Work Queue.

Second, we will place a Newsfeed on the VLC interface, along with the Work Queue. This Newsfeed will display available community activities (like recently updated discussion threads) and encourage teachers to participate. The Newsfeed will send automatic alerts to teachers who are logged into the site regarding any synchronous activities, such as office hours or webinars. For instance, teachers who are on the site at 3:00 P.M. on a Tuesday will see an automatic alert in the corner of their screen that David Beer is currently holding office hours. Teachers can click on the activity in the Newsfeed to attend it. After attending an activity in the Newsfeed, teachers will be able to give commentary on it. These synchronous activities will also be recorded and developed into learning objects.

Third and finally, teachers’ use of the tools will be analyzed. We will track the general use of community-building tools using web analytics. Teachers will also be presented with a weblog of their activity upon logging out of the site or closing the web browser. They will be asked to view and respond to their activity by making comments on the individual activities they did or by suggesting activities they would like to have done. Although they will not be required to complete this weblog questionnaire before leaving, it will pop up each time they leave the site to remind them to give occasional feedback.

CEMSE staff will participate in the VLC as community members, spurring conversation and adding threads to discussion boards. Our Teacher Partners will also use the VLC regularly and act as core community members, encouraging other members of the Teacher Panel to participate. We will review feedback on the community-building tools on a quarterly basis and make recommendations for new community-building tools or changes to the existing tools. These recommendations will be presented to the Advisory Panel on an annual basis. This work of developing community will continue for two years.
**Launch Year**

The third year of the project will be devoted to launching the site. We will prepare for launch by advertising the site with existing *Everyday Mathematics* users. We will advertise on the *Everyday Mathematics* website, which receives over 6000 visitors a day, in the University of Chicago School Mathematics Project newsletter, which has a circulation of 40,000, and on the active *Everyday Mathematics* listserv. We will also work with our publisher, McGraw-Hill, to notify district leaders and professional developers. Interested educators will be able to visit the site and apply for full membership by providing information about their professional backgrounds, including their education, education-related employment history, years teaching *Everyday Mathematics*, and information about their schools and school districts. Once we have determined that they are legitimate educators, they will be granted access to the full site. They will not be asked to perform the review tasks the teacher panel performed and will be treated as normal visitors to a website.

We will treat the launch year as a test of the utility and quality of the VLC. As mentioned previously, we hypothesize that the integration of three elements in the VLC design and the involvement of teachers in the development process will produce a VLC that has both utility and quality. It is beyond the scope of this exploratory study to test this hypothesis fully. Quasi-experimental studies of any changes in indices of long-term quality—such as student achievement or classroom practice—will form part of a future project to study the effects of the VLC.

In lieu of measuring long-term outcomes, we will test the utility and quality of the developing VLC against two shorter-term metrics that are associated with long-term changes in teacher practice. These two metrics include (a) sustained participation by teachers in the VLC and (b) changes in teachers’ “professional vision” (Sherin & van Es, 2009). Methods and instruments for data gathering and analysis associated with these metrics will be implemented and tested during the first two project years, while the smaller Teacher Panel interacts with the VLC.

*Sustained participation* can serve as an indicator of utility because teachers will continue participating in the site only if it has utility for them and their practice (Hur & Hara, 2007). We will track a number of kinds of data to understand the nature of participation on the site. We will use web analytics (Webtrends™ or Google™ Analytics) to gather data on teacher web behavior (which site pages are visited and for how long, etc.) for all VLC pages, including pages accessible to interested parties without passwords, and pages for which a password is needed. CEMSE staff already use these tools to monitor public use of the *Everyday Mathematics* website. Comparing the behavior patterns of teachers who join the site with those who do not will permit us to analyze rates of subscription and patterns of behavior related to joining the site.

Once teachers have joined the site, we will log each visit by username, allowing us to link episodes of VLC use and to search for patterns of individual website use. We will record and analyze data such as frequency of visits to the VLC, duration of those visits, and patterns of activity during those visits (e.g., what types of pages teachers visit, for how long, and where they go when they leave those pages). These data will help us to determine how long it takes for individual site users to settle into patterns of site use that are stable for two or more months and provide data to permit us to describe those patterns. Our current estimate is that this will happen for most users by 60-90 days after registration.

Having established a post-registration day by which users are likely to have a stable pattern of use, we will reorganize the data to study usage patterns of participants that have reached their stable pattern of use. For most participants this will give us 3 to 6 months of sustained site usage data to analyze. We will analyze in detail the site behavior of these participants, paying particular attention to the
frequency and duration of their visits, as well as the particular pages they visit and the order of those visits. We will seek to correlate professional and personal characteristics (e.g., number of years teaching, age), garnered when the teachers first joined the VLC, with characteristics of VLC use (e.g., frequency of visits). We will use multiple regression analysis to analyze the relationship between professional characteristics and site use, treating characteristics of web behavior (e.g., rate of use, length per visit) as dependent variables and professional and personal characteristics as independent variables. Together, these analyses should help us obtain an understanding of VLC patterns of use over the first year of site use, and enable us to have a preliminary indication of whether the VLC as developed is utilized by teachers in a way that can be characterized as sustained.

Professional vision, a construct defined by Miriam Sherin, a member of our advisory committee, will be used as a metric of quality because it is closely related to changes in teachers’ practices over the long term (Sherin & van Es, 2009). Professional vision refers to “the ability to notice and interpret significant interactions in a classroom” (Sherin, Russ, Sherin & Colestock, 2008, p. 28). Sherin & van Es (2009) have examined professional vision in teachers’ conversations surrounding artifacts. They looked at (1) whether teachers talk about students or teachers, (2) the topic of the conversation (classroom management, math, pedagogy), (3) how teachers talk about the artifact (describing, evaluating, etc.), and (4) how teachers talk about student thinking. We will be able to examine these aspects of teachers’ conversations in the comments they leave on artifacts and discussion boards. Individual teachers’ comments will be tracked over time, enabling us to monitor changes in professional vision while using the site. Comments related to professional vision will be analyzed for teachers who use the VLC on a sustained basis and represent a variety of backgrounds.

To obtain a more systematic idea of changes in professional vision that may be related to VLC use, we will develop and administer an online professional vision instrument to teachers who participate in the 3rd year of the project. Teachers will have the opportunity near the beginning of their participation in the VLC to watch a clip of classroom video and then respond to questions about what they have observed. A second opportunity to watch and respond to the same video will be provided near the end of the third project year. We will compare the responses to see whether there is change in any of the four components of professional vision described in the previous paragraph. While, absent a comparison group, positive results from this measure will not demonstrate that the VLC is the cause of changes in professional vision, they will certainly provide data to suggest that a controlled study would be worth conducting. If we are able to induce participants who discontinue participation in the VLC to complete the same instrument, we may be able to provide comparison data from a similar teacher group. In either case, it will also be interesting to analyze the relationship between growth in professional vision (dependent variable), patterns of utilization (independent variable), and possibly (depending on the outcome of the patterns of utilization study) professional characteristics (independent variables).

The results of these studies of sustained participation and changes in professional vision during our launch year, combined with our development cycle, will allow us to determine if our hypothesis was correct. It will also allow us to answer the three research questions.

EVALUATION

Eight experts have agreed to serve on our Advisory Panel, which will also conduct the evaluation of this project. These advisors include (1) Miriam Sherin of Northwestern University, who is an expert on video as a learning object for mathematics teachers and developed the idea of “professional vision”, (2) Michelle Perry of University of Illinois, who is an expert on pedagogy and student thinking in
mathematics and has used learning objects to engage mathematics teachers, (3) Kathryn Chval of University of Missouri, who is an expert on reform-oriented curriculum and pedagogy in mathematics and is a teacher educator with experience using and testing the effects of learning objects on teachers, (4) Linda Sims of University of Illinois, who is a veteran teacher, teacher educator, professional developer, and curriculum writer, (5) Gary Stager of Pepperdine University, who is a veteran teacher, professional developer, and educational technology specialist, (6) Lisa Emond, Elementary Instructional Specialist with the New York City Department of Education, who oversaw the implementation of Everyday Mathematics in the New York City schools, (7) Sasha Barab of Indiana University, who is an expert on educational technology use and founded the NSF-funded Inquiry Learning Forum, and (8) Jim McBride of University of Chicago, who is an Everyday Mathematics author, statistician, and CEMSE co-director.

The Advisory Panel, as detailed earlier, will play a role in the research and development process. They will meet with CEMSE staff at the beginning of the project and at least once annually to review data analyses and changes to the VLC design. They will also conduct the evaluation of this project, based on their areas of expertise. Please see the Letters of Commitment, in which each advisor detailed his possible area of expertise for evaluation of the VLC.

Specifically, we will ask the Advisory Panel to evaluate seven key questions about our work, including:

1. Did the CEMSE team do what they said they would do? Did they include and integrate the three elements of the VLC, and did they engage teachers in the development process?
2. Does the VLC reflect sound content, curricular, and pedagogical knowledge for teachers?
3. Is the VLC useful and practical for teachers? Would I recommend it to teachers I work with?
4. Does the VLC represent sound professional development practices?
5. Did the process for analyzing the feedback on the website fairly balance respect for teachers’ voices with the drive for high-quality content?
6. Are the patterns they identified in developing each element of the VLC grounded firmly in the data and useful as principles for developing other virtual communities of teachers beyond Everyday Mathematics? Are these principles groundbreaking in the field?
7. Did the CEMSE team add relevant new technologies to the website as they emerged?

The Panel’s answers to these questions will be used to determine whether the VLC should be continued and, if so, what changes need to be made to maintain and develop the VLC for a broader audience.

**DISSEMINATION**

In creating a VLC, we are creating an automatic mechanism for disseminating this work. CEMSE, as the authoring and research arm of the Everyday Mathematics curriculum, has access to a nationwide network of teachers, school leaders and district personnel. We will disseminate the VLC to these individuals and encourage the community to grow to a national level. In addition, this project has support from McGraw-Hill, the publisher of Everyday Mathematics, and potential synergies for dissemination would exist on that end (see Letters of Commitment).

In CEMSE’s direct services work, we conduct live professional development across the country. We could potentially move portions of that existing work onto the VLC, building further bridges with the districts that seek our direct services and disseminating the VLC. In addition, we can share briefings about the principles for developing a VLC with local professional developers at those sites, allowing them to build their own local virtual communities based on sound principles for a VLC’s structure and content.
Finally, we will seek to disseminate our work in the research community. We will communicate directly with those interested in the issues raised in this proposal, particularly concerning how to structure video and other learning objects for teachers’ learning, how to build teacher community, and how to maintain a high-quality content focus. We will also present the results of this work at conferences and in scholarly and practitioner journals.

**EXPERTISE**

CEMSE staff members will contribute to this effort, bringing a variety of expertise to bear on the project. *David Beer*, PI, a cultural anthropologist, is an *Everyday Mathematics* curriculum author and spearheaded CEMSE’s efforts to support the New York City Department of Education in their implementation of the curriculum. Beer worked closely with Lisa Emond (see advisory committee letters) in capturing well over 100 hours of *Everyday Mathematics* classroom video and in its preparation and use in professional development; he also worked with Emond and a group of about 20 teachers and math coaches in New York City to develop a website for NYC elementary school teachers using *Everyday Mathematics*. He is experienced at working with teachers and educational evaluation efforts, and has developed and successfully deployed a number of online questionnaires, teacher logs, and feedback instruments. *Dae Kim*, Lead Researcher at CEMSE, has extensive experience teaching and applying statistical methods to the analysis of educational data and to the assessment of the impacts of educational interventions. He will participate in the design and testing of project instrumentation during years 1 and 2 and will conduct statistical analyses of data in project year 3.

*Ellen Dairyko* and *Cheryl Moran* have years of experience as *Everyday Mathematics* curriculum authors and as direct services providers working with teachers around the country. They developed the collaborative coaching model used by CEMSE direct services and have utilized video in this coaching and in other direct services practices. They both taught at the elementary level prior to working on *Everyday Mathematics*. They are experts in professional development practices. *Meg Schleppenbach*, Project Director, was trained as an educational psychologist and has experience researching mathematics education. Schleppenbach is familiar with a breadth of qualitative and quantitative educational research methods and has published analyses of mathematics classroom discourse and pedagogy. She previously worked on an NSF-funded project that aimed to engage teachers in videos of Chinese and U.S. elementary mathematics lessons.

*Margaret Sharkey* and *Jarrett Colby* form the technology department at CEMSE. Both have extensive experience developing web applications for educational use and online research instruments. Sharkey also has previous experience as a mathematics teacher. *Diana Barrie* is a graphic designer and videographer, with decades of experience taking video from rough cut to finish. She has been the technical artist for the *Everyday Mathematics* curriculum for multiple editions.

*Regina Littleton* and *Rick Robertson* will provide administrative support for this project. Robertson has experience recruiting teachers for projects, collecting teachers’ data, and organizing it for analysis.

**PRIOR NSF SUPPORT**

None of the senior personnel on this project have been PIs or Co-PIs on previous NSF-funded projects. *Everyday Mathematics* itself was developed based on funding from NSF and is now used in approximately 185,000 classrooms nationwide (McGraw-Hill Education Group, 2009).