Video Cases for Mathematics Professional Development

Module 1 -- *Teaching Mathematics: Developing Understanding of Linear Functions*

Lessons Learned from the Pilot Test

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August 2002

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I. INTRODUCTION

Background and Purposes

Inverness Research Associates has served as the evaluator for the Video Cases for Mathematics Professional Development (VCMPD) project since it was funded in 1997. During the first three years of the project, the evaluation efforts focused on studying the research and conceptualization of video case professional development materials and providing formative feedback both on a formal and informal basis.

By the summer of 2001, the project had developed a complete module (eight 3-hour sessions) that was ready to be piloted in the field. At that time, the evaluation focus and tasks were reviewed and revised in order to meet the project's current needs. The evaluation was split into three strands[1] each studying a particular set of questions during the pilot testing of the first module. Inverness Research, it was decided, would focus on implementation questions – studying the actual use of the materials, the supports required for facilitators to be able to use them well, and the implementation issues that arose as the module was used in local settings. It is clearly a necessary, but not sufficient condition that the module be feasible for local facilitators working in real professional development contexts, and that they have the needed supports to implement the materials as designed. Hence, our part of the overall evaluation is to make sure that the materials are workable and useful when used by typical professional developers in real reform project and district contexts.

Over the past year, Inverness Research has studied in-depth the facilitator training as well as the use of the VCMPD Module 1 in various settings across the country. Our work has focused on two key questions:

- What supports do facilitators need to use the module effectively in their local settings?

[1] Of the two other strands of the evaluation work, one was conducted by Horizon Research, Inc. (HRI) and focused on evaluating the impacts on teacher participant learning. The University of Michigan organized the third strand that studied the professional development materials and how the use of them contributes to teacher content knowledge gains and changes in classroom practice.

- What are the benefits and challenges of the VCMPD professional development module?

This report provides a summary of findings from our study of the VCMPD Module 1 pilot. There are two purposes for this report. One is to help the project document its work and provide evidence of its effectiveness to the funder and other external audiences. The second purpose is to provide the program with an external perspective on its work and assist program leaders in a formative fashion.

VCMPD and Module 1

The goal of the VCMPD project is to design and develop professional development materials that have at their core real video images of mathematics classroom teaching and learning. During the first three years the project was immersed in the research and development phase of its work. This involved thoughtfully selecting and editing videos of real classrooms, then structuring professional development activities around those videos. Through strategic design and scaffolding, the images of classroom practice and the accompanying materials are meant to help teachers deepen their understanding of both mathematics content and classroom pedagogy.[2]

Module 1, *Teaching Mathematics: Developing Understanding of Linear Functions,* is a series of eight 3-hour sessions that build sequentially to enrich teachers' ability to teach linear functions and deepen their own understanding of the topic. Each session has at its core one or two digital video clips of a mathematics classroom. These clips are unedited segments selected from real classroom footage of unstaged mathematics lessons, representing a wide range of grade levels, geographic locations and student populations. Another central element of each session is an opportunity for participants to collaboratively complete a mathematical task grounded in the video. In all of these tasks, pictures (e.g., growing dots or logos) are used to represent linear change or growth – a non-standard method for introducing linear functions. Other elements include a thorough discussion of the mathematics in both the task and the video, related readings, and a linking to practice component. Over the course of the sessions some classrooms and problems are revisited, maintaining the theme of earlier sessions while considering variations. Lesson transcripts, lesson graphs, commentaries, multiple solutions, selected examples of student work, and teacher interviews are also provided. Software developed by LessonLab makes it possible to readily access any moment in the video and to display subtitles while viewing. The software also provides a web-based discussion forum for facilitators, allows each participant to experience the sessions via their own computer, and offers an on-line distance learning option. The Facilitator Guide contains a wealth of information: a complete overview of the materials, explanations of the vision and specific goals, agendas and guidelines for

[2] This project has a theoretical base to its work which is reflected in a paper the project leaders presented at AERA in April 2002 entitled, *The Promises and Challenges of Using Video as a Tool for Teacher Learning.*

sessions, lists of references and useful resources, tips for facilitation, mathematician commentaries, and excerpts from a facilitator's journal.

The Pilot

By the fall of 2001, the project had recruited 14 professional development providers interested in learning about the VCMPD materials and possibly piloting them in their local settings. They represented ten different school districts and/or reform efforts from around the country and a range of grade levels in terms of teaching and professional development experience. To prepare for using the module, they participated in a three-day facilitator training offered by the project leaders. From that initial group, five facilitators representing four sites participated in the "supported pilot."[3] One team of facilitators joined the supported pilot after the facilitator training. As part of the supported pilot, facilitators agreed to use the materials as designed, attend three follow-up support meetings, and participate in the evaluation studies. Facilitators received ongoing support from the VCMPD project leaders and were given a stipend for their participation. In total, seven facilitators from five sites were part of the supported pilot. The chart below lists each site and the audience for the Module 1 field test.

VCMPD Module 1 Supported Pilot Sites

District/Reform Effort	City and State	Primary Audience for Pilot
Pittsburgh Public Schools/ PRIME: Pittsburgh Reform in Mathematics Local Systemic Change Project	Pittsburgh, PA	Middle School Mathematics Teachers
Creating a Community of Mathematics Learners Local Systemic Change Project	Redmond, WA	High School Mathematics Teachers
Chandler Unified School District	Chandler, AZ	Sixth -- Eleventh Grade Teachers
SDSU/San Diego Math Project Algebra Institute	San Diego, CA	Fifth Grade -- Geometry Teachers
New York City District 2	New York City, NY	Teachers, Professional Development Providers, and Administrators

Evaluation Activities

[3] Originally, there were six facilitators who joined the supported pilot. One facilitator dropped out after not getting enough response to the professional development sessions. Due to an administrative delay, information about the offering was not sent out until a week before the sessions were to start.

The findings in this report are based on the following evaluation tasks conducted by Inverness Research from August 2001 to July 2002:

- Interviews with participants prior to the facilitator training
- Providing project leaders with a brief summary of the pre-training interviews
- Attending the entire three-day facilitator training in September 2001
- Conducting follow-up interviews with participants after the Facilitator Training
- Attending the follow-up meetings for supported pilot facilitators
- Monitoring LessonLab usage
- Observing selected supported pilot site sessions – at least one session per pilot site
- Observing usage of the materials by a site not participating in the supported pilot
- Conducting periodic debriefs with project leaders
- Administering and analyzing participant surveys
- Compiling data from facilitators who had administered end-of-course evaluations
- Interviewing facilitators during and after module usage
- Watching selected videos of pilot sessions
- Attending the facilitator/advisory board meeting

Organization of this Report

The remainder of this report is organized into the following sections:

II. The Feasibility and Quality of the Materials
III. Design Issues and Lessons Learned
IV. Benefits to Participants
V. Recommendations
VI. Summary

II. THE FEASIBILITY AND QUALITY OF THE MATERIALS

For any field test, the first order question is one of feasibility. Are the materials useable in the real world? The overall finding from this first pilot test is that the Module 1 materials are feasible for use by local facilitators in real settings. The supported pilot sites represent a good cross section of urban and suburban districts from across the country. In addition, there was great variety across the teacher participant groups: teachers from nearly every grade level attended the sessions, from second grade teachers to high school teachers. Some were veteran teachers; others were new to the profession. At one site, the group consisted of a combination of teachers, professional development providers, and administrators. Although the pilot sites were quite different, all of the facilitators were able to implement the materials and conduct VCMPD sessions within their local settings. In general, the facilitators themselves considered the sessions to be successful and worthwhile. As one facilitator stated:

> *The goals of the VCMPD are very ambitious and truly extend beyond the goals of the typical staff development. We see great potential in the use of this model and these particular materials for accomplishing a variety of objectives.*[4]

Another critical factor in a pilot of newly developed materials is one of quality. Do users perceive the professional development curriculum to be well designed and generally of high quality? The VCMPD materials also passed this test very successfully. Every facilitator judged the materials to be of high quality, thoughtfully designed and coherent. Overall, the professional development curriculum and support materials are also seen to be quite strong. Facilitators were very appreciative of the wealth of materials provided. The complete package contains the digital video, supplementary video, PowerPoint slides, articles, references, a facilitator guide, lessons graphs, transcripts, mathematician commentary, agendas, prompts, homework tasks, etc. A high level of thoughtfulness and care is apparent in the design of these materials.

> *I thought that the materials that Judy and Nanette gave us were very well developed and it really was very well thought out. I felt supported going in completely.*

Unique to the VCMPD professional development materials is the use of digital video. This component truly sets apart the VCMPD professional development from almost all others. From the beginning, prior to the facilitator training, facilitators resonated with the idea of video cases used in mathematics professional development. The very idea of having their own local teachers use video to study and learn from classroom practice was an inherently attractive idea to the facilitators. All believed it would be a valuable and unique addition to the menu of professional development offerings in their district. As we learned through the pilot, this premise proved to be true. Both facilitators and participants valued the experience of seeing – and then discussing – video clips of classrooms. It is one thing to talk <u>about</u> classroom teaching during professional development; it is quite another to have the professional development grounded in real, observable examples of classroom teaching. The concrete images of mathematics classrooms gave participants real examples that served as a catalyst to consider issues of mathematics content, teaching, and learning.

> *I am 100% a cheerleader for this type of professional development – an approach that is situated in practice, having the teachers get involved with some tasks, some content-based tasks so they can learn some more mathematics, but then also situate the teaching in some real concrete settings – and video is an excellent medium to do that.*

In summary, the pilot testing of the first module has shown that it is possible for this project to create a high-quality set of professional development materials. The test also shows that these materials are feasible for use by real professional developers in real settings. And, finally, the pilot test explores the whole notion of video-based

[4] For the remainder of this report, unless otherwise noted, every statement in italics is a direct quote from one of the facilitators.

professional development and provides a promising "proof of concept" for the theory that underlies this project. Thus, the materials are not only feasible, but also show promise for the concept and encouragement to continue the exploration.

III. DESIGN ISSUES AND LESSONS LEARNED

In the previous section, we confirmed that the materials have passed a general feasibility and value-to-the-user test. Now we want to look at the materials in greater detail and consider issues that arose during the pilot. We believe that the examination of these issues will provide important information to the project leaders as they revise the materials and plan future work. Below we list a set of findings and propositions that highlight key design issues.

- The facilitator training was critical to the level of success of the professional development.

The goals of the curriculum are quite sophisticated, and require skillful facilitation of discussions around the use of the video. Hence, it is not surprising that the VCMPD curricular materials require personal training in order for facilitators to use them to achieve those goals. The VCMPD materials represent a marked change from the standard professional development offered in schools and districts. They are multi-faceted and complex – interweaving the use of technology, viewing images of classroom practice, facilitating thoughtful discussions, building mathematical content knowledge, addressing issues of pedagogy, and promoting deep reflection about one's own teaching. Most professional development addresses only one or possibly two of these aspects. It takes a significant amount of time and experience for facilitators to become familiar with the curriculum and the technology, not to mention what it takes to move beyond this initial stage to developing a level of proficiency facilitating the sessions.

All the facilitators who attended the initial training emphasized its importance in preparing them to use the VCMPD materials. During the three-day training in September 2001, facilitators had the opportunity to become familiar with the materials themselves, discuss issues of facilitation, learn the necessary technology, review and broaden their own mathematical knowledge, and consider issues of pedagogy and teaching styles. Many mentioned the extreme value of this experience and how essential it was to their success in piloting the materials.

> *I don't think I would have been effective without the training. I think it would have compromised my effectiveness tremendously.*
>
> *I think it would be very hard [for someone to use the modules who hasn't been to the training].*

According to our interviews and observations, the one pilot site whose facilitators did not attend the training clearly experienced more difficulties during their sessions using the module. Although many factors contributed to this, one element was that they did not have a thorough understanding of the components of the materials, the resources provided, and the overall coherency and integrity of the curriculum.

- A significant amount of time is needed to prepare for each individual professional development session.

The combination of new materials and innovative technology increased demands on facilitators who, in turn, found themselves spending considerable time preparing for each session. This is not a set of materials that can be reviewed briefly and then implemented. It takes time to work through the mathematics problem, consider multiple approaches to solving it; watch and re-watch the video segment; review and, if necessary, modify discussion prompts; set up and test the technology; and read the mathematician commentaries. While some facilitators spent a few hours on preparation, others reported spending between 4-8 hours, and another said it took almost 20 hours to prepare for a single session. The successful facilitation of a session requires deep familiarity with the videos and with the underlying mathematics; hence there is no real shortcut to achieving an intimate and thorough knowledge of the materials and ideas to be discussed.

> *Although the materials are especially well organized, this program still requires a significant amount of preparation for a non-mathematician like me. I needed (and enjoyed) working through the problems to see if I could come up with all the representations shown and shared. I watched, read through, and analyzed the video clips, and read the articles, commentaries, analyses, notes.*

The preparation time was considered well spent and worthwhile because it contributed to the overall success of the sessions. Facilitators understood that this was a field test of the materials and would require extra demands on their time. They knew part of their role was to provide feedback to the project about what it takes to use the materials in local settings. Many noted that it might not be feasible for professional development providers to spend such large amounts of time getting ready to use the materials. They suggested streamlining some of the technology elements and including in the facilitator's manual some guidelines about what to do prior to each session as a way to minimize preparation time. (Also, we should point out that the second and following uses of the videos will be infinitely easier; hence, this is a curriculum where the expertise of the facilitators will accumulate with continued usage.)

- The importance and difficulty of "mining the video" surfaced repeatedly.

The videos are the core of these professional development materials. They provide real images of mathematics classrooms, giving participants authentic examples to reflect

upon and further consider issues of mathematics teaching and learning. The potential for deep discussions around issues of mathematics and pedagogy is great. However, in order to provide this type of professional development experience, it is essential for the facilitator to "mine" the videos, extracting and thoughtfully working with the richness they offer. This requires that the facilitator know the video segments and underlying mathematics well, read his or her audience as they respond, and then use sophisticated facilitation skills to foster a productive discussion that leads participants to new mathematical and pedagogical insights. This is not a trivial task.

In fact, creating an opportunity to reflectively view the video and then fostering a meaningful discussion was one of the most difficult tasks for facilitators. Our observations of pilot sessions confirm this. Facilitators would generally show the video once and then follow the procedure in the facilitator guide that asks participants to identify important "mathematical moments," resulting in a discussion of the video segment that was quite often superficial. Most sessions fell into a similar pattern: participants identified the specific time that represented interesting or important mathematical moments while the facilitator charted the time codes on chart paper. Then the group went back through the list and each participant stated the reason for identifying the time code. There was very limited discussion, if any, that then built upon these observations. In a sense, the result was a litany of naming moments, instead of a meaningful discussion delving into issues of mathematics and pedagogy.

By comparison, throughout the majority of sessions we observed, more time was spent on doing and discussing the mathematics problem and its solutions than on watching and delving into the video.

> *By the end of this evening, [sessions 1&2] we were concerned that we had fallen into a routine of spending most of our time processing the mathematics involved in the problems, less time in conversation about the video clips.*

This time and emphasis reversal is a bit ironic in that the working of the problem was intended to set up a richer discussion of the video; instead, we saw the math problem supplanting rather than supplementing the discussion. This issue of mining the video can be broken down into two pieces: usage of the video itself and fostering a substantive discussion afterward. In most cases, the video was shown only once during the session. Thus, out of a three-hour professional development only 3-5 minutes was spent actually watching the video. This limited time and singular usage of video segments also raises questions about the sophisticated interactive digital technology that is employed. We believe that it is quite unlikely that participants will be able to identify and contemplate important issues of mathematics and pedagogy if they have seen the video only once. (In a few cases the participants were given a short break immediately after watching the video and then were asked to recall significant moments when they returned 15 minutes later.) In order to seriously mine the videos, it seems essential to view the video more than once, if not multiple times, during the

professional development session. And it seems that it would be desirable to foster a strong interaction between the discussion and the video so that subsequent viewings of the video would raise new questions, and new questions would provoke review of the video. In this pilot test we saw little of this kind of interaction.

The next step for the productive mining of a video is to facilitate a thoughtful discussion around the video. As we have mentioned earlier, this was one of the weakest parts of the sessions. It often took the form of listing noteworthy moments followed by limited conversation instead of a meaningful inquiry into mathematics teaching and learning. This is not an easy task, and many facilitators expressed concern that the discussion of the video was not as rich and substantive as they wanted it to be. They asked for more assistance and training in this area. They wanted to be able to effectively facilitate a deep, rich conversation around the video but acknowledged that they were not able to do that yet.

> *[The teachers] cooperated by listing interesting interchanges from the video, but the discussion was limited.*

We believe that training is critical if facilitators are to develop a deep understanding of what the videos offer and the skills to foster meaningful discussions. The facilitator's guide can only convey so much of what is intended and possible; the rest must come through skillful modeling and direct experience. This issue is exacerbated by the fact that participants (and facilitators) bring preconceived ideas and prior experiences of watching a video to the professional development session. These preconceptions and tendencies are often quite different than the intention of the VCMPD curriculum. Watching the video is supposed to be an engaging thought-provoking catalyst to generate discussion and reflection about important issues of mathematics teaching and learning and one's own classroom practice. This is asking participants to engage with video in a way that is quite different from what they experience as they watch video in their everyday lives, namely passively viewing the video and then moving on to something else.

> *The teachers seemed to see the video as a culminating experience after their own struggles with the problem.*

In many ways facilitators themselves might need to unlearn or set aside the common ways of approaching video and then learn to interact and inquire about the video. Once they reach this point, they can help participants get beyond this hurdle. This is new territory for most people. The VCMPD project leaders, along with a handful of others, are leading the field in creating professional development curriculum that uses digital video cases and technology, and training facilitators to use the materials effectively. During the VCMPD training, it is necessary to carefully model and spend time on the video part of the session so that facilitators have a very good example of what should happen. Perhaps even a video to be included in the facilitator guide of a substantive

discussion where a group is truly mining the video. All of these supports are needed for the type of discussion, analysis and thoughtful exploration of the video that the project intends.

But only part of the solution lies in training. The other part lies in a richer and more complex set of curricular supports such as prompts, questions, and activities. As we have noted, most of the facilitators took the written instructions on how to use the materials quite literally. They rely on what they experienced in the facilitator training and what the facilitator guide says to do. The prompts and suggestions provided were often insufficient to help facilitators have multiple approaches to guiding the discussion:

> *We need to think of more creative ways to stimulate discussion and interest in the video clips.*

Thus, if the video component is to be enriched, the project may want to consider further work on these two aspects: what facilitators are told to do in the written curriculum and what is modeled for them in training. Facilitators also need more explicit direction – a kind of general overview or gestalt – about introducing and framing the watching of the video and then selecting prompts for discussion. In the next iteration of its design the project may want to provide a step-by step guide for the video component of the session and a range of multi-level prompts from which the facilitator can choose depending on the group and the direction of the discussion. Clearly, this is the heart of the problem, and it is a challenging arena. We encourage the project to experiment actively in trying to solve this design challenge.

- The technology is useful but many issues still need to be addressed.

The digital video and accompanying software offer many advantages that a simple VHS tape does not.

> *The LessonLab software and being able to track the transcript and click on the times to go to that, to boot that section up on the video is excellent and that is really useful.*

However, facilitators encountered a number of barriers when using the technology. In half of our observations, facilitators had trouble using the technology during the professional development sessions. This was the case even when the facilitators had a successful run-through prior to the actual session.

> *My concern is that everybody's concentration is somewhat compromised because one thing happens [with the technology] and then I am changing it and then I am changing something else and you lose a few seconds before they [participants] get settled in and actually watch what we wanted to watch, which is what is happening on the video.*

Facilitators told us repeatedly that the materials would be easier to use and reach higher levels of success if the technology components were less time consuming, more user-friendly, and streamlined.

> *It would be nice if… when you start the video, it brings up the transcript automatically, because it is not likely that you are going to watch video without seeing the transcript, so it would be much more convenient if it was up there.*

> *In fact, [accessing and using the video] is something they are going to have to make simpler to access, because my two co-facilitators, neither of them has been able to run the videos off of their school computers.*

For those using the VCMPD materials on Mac computers there were additional issues. The software has less functionality on Mac systems. One major barrier was that the video could not be played full screen. The pilot site using Macs had a number of time-consuming technology problems. Since many schools and districts are Mac users, it seems important to have the materials work equally well on Macs and PCs. It is important to note that the software was still in the developmental stages at the time of the pilot. Project leaders were well aware of the technological issues and problems and were already making plans to address them in the next version.

The web-based, online component of the materials was not used very often. According to our interviews and observations, none of the pilot sites successfully accessed the video online for use during the sessions. One site planned to have some onsite meetings and some distance learning sessions where participants accessed the sessions online. Although much planning and training occurred for the online sessions, participants did not log in and submit any responses. If the project plans to publish an online version, much work is needed to make this element of the materials useful to both facilitators and participants.

- Guidance from the project would help facilitators adapt the professional development curriculum to their own settings.

In some cases facilitators were not able to teach the module exactly as designed. They were not able, for example, to offer eight, three-hour sessions. In these instances, facilitators made decisions about what sessions or parts of sessions to exclude. (This kind of adaptation is a very real issue, we note, for all well-designed coherent curricula.) We observed a number of instances in which facilitators made changes to the professional development curriculum based on rather arbitrary reasons (for example: "the problem in one session is similar to one we have already done so we can skip it"). In other observations, facilitators had less than three hours for the session and instead of adapting the time allotment for each component, they simply proceeded with the original agenda and ran out of time, completely leaving out the last pieces of the session. These changes compromise the overall integrity of the materials.

The project may want to think about providing guidelines for making modifications, rather than let them happen without such guidance. In particular, it would be useful to help facilitators with two different modification scenarios: 1) when facilitators cannot offer all eight sessions and 2) when they do not have a three-hour time block for an individual session. In both of these cases facilitators need help in making cuts – choosing what to include and what to exclude. This type of guidance can only come from the developers who are deeply knowledgeable about each piece of the curriculum and how they coherently connect within each session and across sessions.

- Better connections and transitions are needed between the major components of the materials.

By design the VCMPD professional development curriculum has four key components: situating the work, doing the math, watching and discussing the video, and linking to practice. We observed during the pilot sessions some disconnects between these components. They did not clearly connect with and reinforce each other within a given lesson. We have already mentioned this issue with regard to doing the mathematical tasks, and watching and discussing the video. We see a similar problem in the Linking to Practice component. The purpose of this element is to help teachers connect their learnings in the professional development sessions to their own classroom practice. The project does not want to leave to chance the consideration of and application to participant's own teaching. Yet, at this time, this part of the materials is the least developed both conceptually and in practice. As a result, what usually happened is that participants just used the mathematics problem from a session in their own classrooms. This is one way to have the sessions link to classroom practice but it is certainly not the only way.

> *This segment [Linking to Practice] is critical if our goal is to promote change in instructional practices, yet it was the most difficult to provide.*

> *For a bridge to practice, there needs to be a paper bridge if you will, that the teachers really are going to need to take the tasks back to their classrooms and do them, and then look at the student work and use that to inform what their practice is.*

The project could offer more specific guidance in this area. For example, participants could use another problem and emphasize multiple representations, or focus on having students explain their solutions to the class. In this way the bridge to practice could focus on the deep structures of mathematics (congruence of multiple representations, recursion, closed and open forms, etc.) and on deep structures of pedagogy (student thinking as a content of classroom focus). In this way, teachers would be tying in some of the more general and underlying mathematical and pedagogical ideas from the professional development directly to their classroom teaching. Again, it should be noted that from the outset the project leaders were very aware of this issue and planned on addressing it. They intended for the pilots to help inform the revision and improvement of this aspect of the materials.

IV. BENEFITS TO PARTICIPANTS

There was quite a bit of agreement from facilitators and participants that the VCMPD professional development was beneficial for the teachers who attended. Overall, teacher participants responded positively to the sessions. Facilitators reported that many participants told them that the professional development was interesting and worthwhile.

> *I think they thought it was worth their time, which is a big compliment. I even heard the expression, 'this is worth my time.'*

While we did not focus intensively on teacher learning, in this section we report on what we learned from facilitator interviews, participant survey, and our own observations. These findings fall into three categories: mathematics, pedagogy, and self-knowledge. Below we describe each of these areas in greater detail.

Mathematics

More specifically, facilitators felt participants had benefited in terms of increased learning both mathematically and pedagogically. When speaking about mathematical gains, many said the VCMPD materials gave participants an opportunity to review and also see anew the topic of linear functions. Linear functions was a familiar topic to most participants. Yet, the combination of doing the mathematics, discussing solutions, viewing videos of the teaching of linear functions and talking about them pushed participants' understanding to a deeper level and highlighted the relationships between various sub-topics of linear functions. When asked to what extent the VCMPD professional development increased their own understanding of linear functions, 78%

of the participants surveyed[5] responded with a rating of a four or five on a five-point scale with 1 indicating no increase at all and 5 meaning a great increase in understanding.

One major benefit for participants was a deeper understanding of the congruence of multiple representations. For many this was a major revelation. Several participants did not previously realize the value of using multiple representations – pictoral, graphic, and symbolic – and then showing their equivalence.

> *Based on the comments, the biggest benefit from the whole morning was an affirmation of the importance of multiple representations.*

When asked what was learned during the professional development, one participant commented:

> *Some great ideas … for making connections between functions, patterns, graphs and tables.*

It is important to note that teachers experienced this broadening of understanding about multiple representations in different ways depending on the grade level they taught. For high school and some middle school teachers, who were quite adept at using a T-chart and finding the formula, the benefit came in seeing the link and value between the equation and the visual representations. For other middle school teachers and the elementary teachers, they saw the connections between the drawing they made to solve the problem and the graph and equation.

Using a T-chart and grappling with the ideas of recursive vs. closed was another important area of learning for many participants, especially those with a limited mathematics background. Some had not had in-depth experience working with T-charts, seeing the recursive relationship, and then moving toward the closed formula with the same T-chart. Participants gained clarity about the meaning of recursive and closed definitions when working with linear functions.

Pedagogy

Participants also learned a considerable amount of what Shulman calls "pedagogical content knowledge." Or perhaps we might even invent a new phrase "content-focused pedagogical knowledge" – that is, the pedagogical approaches to teaching the specific content of linear functions. Through multiple opportunities to see videos of mathematics classrooms and solve mathematics problems, teachers were introduced to many new ideas about teaching styles and practices – all in the context of linear functions. Watching and discussing the video gave teachers several new ideas about teaching mathematics to their students. The two ideas that we heard from almost all

[5] Inverness Research surveyed participants at two pilot sites, representing about two-thirds of all participants in the pilot.

facilitators and participants include listening more often and more carefully to students, and reconsidering the role of the teacher. Surprisingly perhaps, it was nonetheless a new realization for many participants that one important role of the teacher is to listen and to focus on the mathematical thinking of their students. Of the teachers surveyed, 72% responded that the use of video as a tool for examining classroom practice increased their understanding of how students think about and learn mathematics.

The video is a tool that gives participants the rare opportunity to see other teachers teach mathematics. They see that some teachers teach differently than they do. This contrast can be obvious even when seeing a short video clip. For example, in the video, the teacher is asking the students questions, listening to their responses, and really working to understand what the student is thinking and how the student is solving the problem. In some cases it seems like the student doesn't understand the problem. However, watching the teacher carefully listen and ask clarifying questions, the viewer realizes that the student does understand but maybe is approaching the problem in a different way. This was a powerful and compelling experience for many of the participants in the sessions.

> *I think [the teachers] are going to look at student work differently, and I think they are going to listen differently to what students say.*
>
> *[Teachers learned] to really look at student thinking, to listen to their questions, to listen to the comments they are making, their explanations… to try to gain understanding of what their misconceptions are, or what their understanding is.*

Teachers are able to see and discuss real images of classrooms. In some cases what the teacher in the video was doing was quite different than what the participants do in their own classrooms. This can change teachers' ideas and beliefs about what is possible with their students. In the words of one teacher participant:

> *[The VCMPD sessions] motivated me to facilitate class discussions…. I learned to believe my students more. If it happens in one's classroom, perhaps it will be the same in my class.*

The practice of constructively listening, trying to discern student thinking, and valuing alternative problem solving approaches is directly related to teachers reconsidering their role in the classroom. (And, we note it is only possible to see this when one knows the problem very well and has time to really dissect classroom interactions – both of which the sessions promoted.) The standard role of the mathematics teacher is one of introducing content, demonstrating how to solve problems, and then assisting students as they attempt more problems. It is a marked shift to have the role of the teacher to develop mathematical conceptual understanding and empower students to trust their own thinking to problem solve. As such, the teacher is viewed as an expert guide and a support, not as lecturer in the front of the room who holds the only correct approach

and solution. In this way teachers are learning to be more respectful and mindful of their interactions with students and the students' development of their own mathematical thinking.

> *By the end, instead of positioning themselves in front of the students and saying, 'do this,' they were positioning themselves next to and in some cases maybe behind the student, thinking 'where is this kid going with this?'*

This vision of teaching and learning has been promoted for decades. But it is easy to say and hard to do. The VCMPD case studies allow for teachers to interact with teaching and learning on a level that is much more concrete and detailed. The ability to examine practice carefully and independently is unique to video and particularly digital video and technology. The video influences the participants' ideas about what is possible in their own classrooms in ways that other "records of classroom practice" (e.g., student work) do not. To be clear, it is not just the video itself that was powerful, but also that the technology has the ability to track what is happening in the classroom through multiple viewings, having the subtitles, and reading the transcripts. This functionality enables the participants to question and rethink what students are saying and delve more deeply into what is happening in the classroom. What makes the video so compelling is that it makes use of digital video and technology to explore the content and dynamics in the video. The ability to go back to a particular moment in the video and see it again allows participants to gain a deeper understanding of the students' thinking and problem solving approaches.

Self-knowledge

In subtle but powerful ways the VCMPD workshops helped teachers develop more knowledge about themselves – both as math learners and as math teachers. Facilitators said that the sessions helped teachers observe and label their own thinking process. These experiences enabled teachers to step outside themselves and to observe their own thinking and solutions. By identifying and labeling their own approaches to solving the problems and seeing other participants' approaches, they learned multiple approaches to solving the problems and the relationships between them. Over time, they were more careful about accurately displaying and describing their representations.

Solving the mathematics problems during the VCMPD sessions and then openly discussing multiple approaches to the solution provided teachers with firsthand experience about the value and importance of being open to and honoring others' different problem solving approaches.

> *Most people noted that the most valuable part was working and discussing the problems with their group. They learned the most by hearing and seeing other people's solutions.*

This led them to the idea of working with their students in the same way.

> *Many liked the reality of seeing the classroom and realized there was a different level of engagement than in their own classes.*

As teachers labeled their approaches and compared them to others, they began to consider their own thinking versus students' thinking. They saw that in some ways the students thought the same way they did, but in other ways the students thought differently. This opened the door to question the common stance that there is only one way to accurately solve a problem. Now, teachers more firmly believed in the idea of multiple approaches to solve a problem and saw the value and learning potential in them.

Benefits to Facilitators

We did not study explicitly the benefits to facilitators who participated in the supported pilot. However, we did hear from some facilitators that they personally benefited from their use of the VCMPD materials. Although these benefits varied according to the facilitators, they fall into three general categories: learning more mathematics, deepening pedagogical content knowledge, and becoming a better professional development provider. The curricula is demanding for both teachers and facilitators, and thus stretched facilitators in interesting ways:

> *The program provided me with a lot of new tools as a professional developer. It provided me with an excellent way to look at and discuss classroom video. It encouraged me to look for evidence when having discussions around classrooms and student work. It encouraged me to be more open about letting the discussion go where it needed to go while still keeping a handle on it. So I do feel that using these materials made me a better professional developer.*

> *The mathematics of indexing was new to me. I was familiar with the idea, but I haven't really dealt with it in this kind of context before. I see some powerful advantages to using the idea of indexing as a tool for dealing with certain types of problems.*

> *I learned the importance of naming student ideas – not with the student's name – but with a name that describes the student's approach.*

In some ways, the benefits to facilitators appear to closely mirror the benefits to the participants that we described earlier in this report. Based on our observations and interviews, we can surmise that use of the VCMPD materials has the potential to be a significant learning experience for facilitators. The experiences of facilitators in this project seemed similar to those of facilitators of other professional development curricula we have studied (e. g., Developing Mathematical Ideas and the Exploratorium's Institute for Inquiry). In these cases we have noted that in the same way that teachers can learn from the curriculum they use in their classrooms, similarly facilitators learn valuable things from using an innovative and demanding professional

development curriculum. Hence, we believe that the benefits of this curricula will be symmetrical, helping facilitators extend their learning at the same time they are using the materials to extend the teacher participants' knowledge.

V. RECOMMENDATIONS

In this section we offer a few recommendations. Actually, we present these more as "things to think about" than as hard and fast recommendations. They also serve to summarize some of the findings made in the earlier section.

Training

- Consider designing and offering a facilitator training that includes a complete walk through of at least one session, along with a meta-level discussion about what needs to be highlighted and why it is important.
- Present an overview and rationale for the design and purpose of the VCMPD materials so facilitators have a gestalt to guide them.
- Provide specific modeling and directions on "mining the video."

Facilitator Guide

- Design the facilitator guide to have less narrative and more bullets.
- Separate direction (details of what to do in preparation for and during each session) from wisdom (insight and guidance about what to be mindful of during each session).
- Include a piece that describes the elements of a successful session (e.g., watch the video at least twice during the session).
- Provide a rich array of prompts, questions and activities that can help facilitators "mine the video."
- Provide a clear overview and rationale for the design and purpose of the VCMPD materials so facilitators have a gestalt to guide them.
- Provide clear framing and transitions from one component to the next, explaining how and why each piece fits together. Frame the applied practice more in terms of big mathematical and pedagogical ideas and less in terms of specific linear algebra problems.
- Provide guidance for shortening or otherwise "adapting" the curriculum to one's own setting and constraints.

Technology

- Streamline the materials onto one CD.
- Resolve Mac system issues.
- Postpone work for the online component for the time being.
- Make some files available in an editable version (vs. PDF).

Components of the Materials

- Continue to work on transitions and setting up the next component of the session, for example, from doing the math to setting up watching the video, from watching the video to setting up a conversation about the video.
- Broaden the number and type of prompts for the video discussions so that facilitators can engineer a variety of purposeful discussions.
- Provide a development sequence for the Linking to Practice section.

VI. SUMMARY

The pilot of VCMPD Module 1 is the first field test of the materials. It is an opportunity to compare the vision and intention of the materials to the reality of usage in schools and districts. What we have learned is that the pilot has been successful in that it has demonstrated the value of the VCMPD materials and the challenges to using them. First and foremost, we have learned that the VCMPD materials are usable by trained facilitators across the country in a variety of settings. Facilitators and participants judge them to be of high quality and of value. The sessions provide participants with the unique opportunity to see images of real mathematics classrooms and grapple with issues of mathematics teaching and learning. These accomplishments are significant and necessary for newly developed materials to succeed.

It is important to point out that the pilot highlighted the benefits and opportunities for teachers that would be difficult to obtain through other types of professional development. The use of digital video and technology offers participants a chance to reflect upon and deeply discuss mathematics content classroom practice based on the common experience of seeing a real example of mathematics teaching and learning. Outside of a group visit to a real classroom, this would be impossible.

The VCMPD materials are valuable not only for facilitators and teachers, but also for what they offer the field in terms of learning how to create meaningful professional development experiences using videos of classroom practice. In this sense, we see this project as a very important experiment – one that could yield many lessons learned about an exciting new approach to professional development. The approach explored by this project seeks to create a professional culture for teachers in which they reflect upon mathematical ideas and students' thinking and learning of mathematics – all through the primary examination of classroom practice. The work to date that has gone into the creation of a complete module including the technology development and the selection and analysis of the classroom videos is remarkable. We see the success of the pilot test as affirming the validity of both concept and design; but we also see the difficulties and challenges that emerged as equally important. The design challenges found in helping facilitators "mine the videos" in particular are critical to the success of this new approach. We encourage the project to continue a research stance toward this whole endeavor and we encourage the project to produce and disseminate the "lessons

learned" from this design experiment. The production of knowledge, at this point in the development stage, is at least as important as the production of actual modules.