The Scalability and Sustainability of Professional Development: Challenges in Preparing Mathematics PD Facilitators

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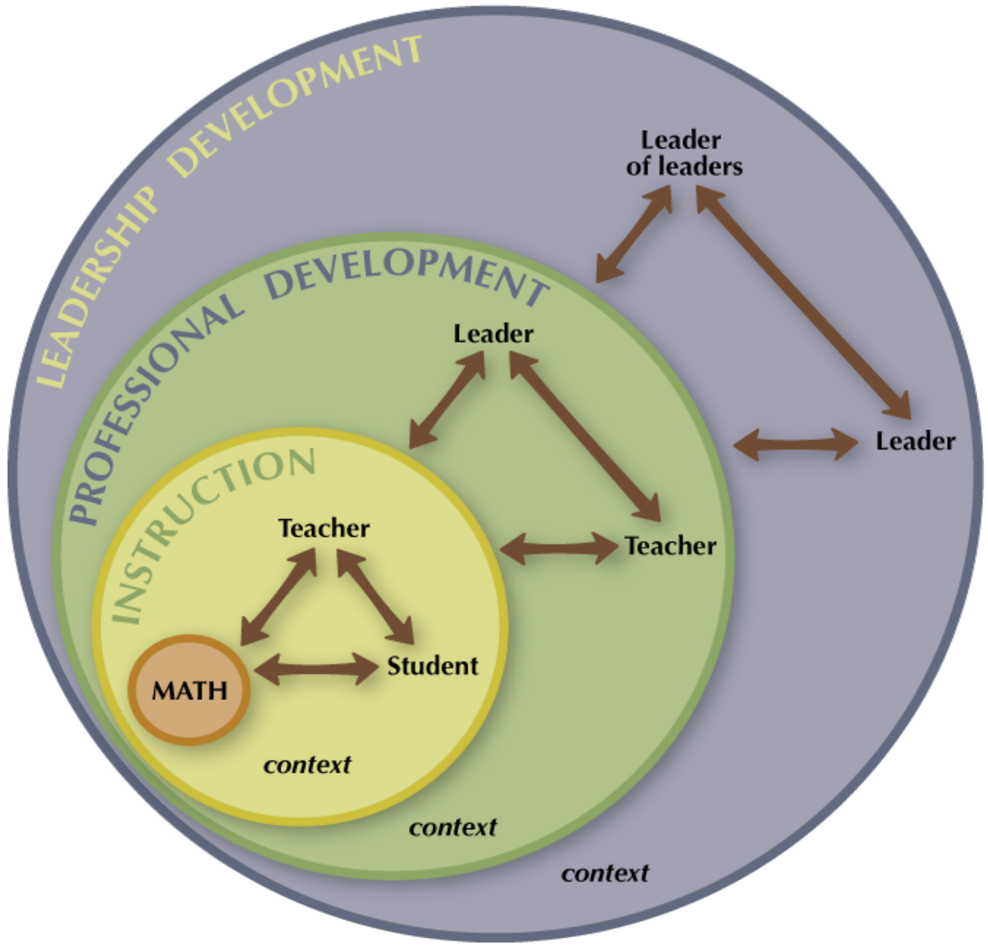
Vision of High Quality PD

- Improving teaching and learning requires participation in high quality professional development (PD) (Darling Hammond et al., 2009; Loucks-Horsley et al., 2003).
- General principles provide a *vision* of high quality PD.
- What leaders need to know and be able to do in order to construct high quality PD is under defined (Even, 2008)


LEADERSHIP DEVELOPMENT
PROFESSIONAL DEVELOPMENT
INSTRUCTION
Leader of leaders
Leader
Leader
Teacher
Teacher
Student
MATH
context
context
context

Session Overview

- Short introduction of each project
  - LTG: Learning to Teach Geometry
  - RMLL: Researching Mathematics Leader Learning
  - iPSC: Implementing the Problem Solving Cycle
- Challenges of Scaling and Sustainability
  - Conceptualizing the role of the leader
  - Supporting that role
  - Determining outcomes

Researching Mathematics Leader Learning (RMLL)*

Project Staff

- Judy Mumme & Cathy Carroll - WestEd
- Rebekah Elliott, Kristin Lesseig &
  Matthew Campbell - Oregon State University
- Elham Kazemi & Megan Kelley-Petersen - University of Washington

rmll
researching mathematics leader learning

*(ESI- 0554186)

Focus & Rationale for RMLL

- Focus
  - RMLL's work is to better understand and develop ways for leaders to facilitate the mathematical learning of teachers in PD.
- Rationale
  - Teachers need to develop a specialized knowledge of mathematics content that will enable them to engage students in the kind of discourse around rich mathematical tasks that will deepen students' mathematical understandings.

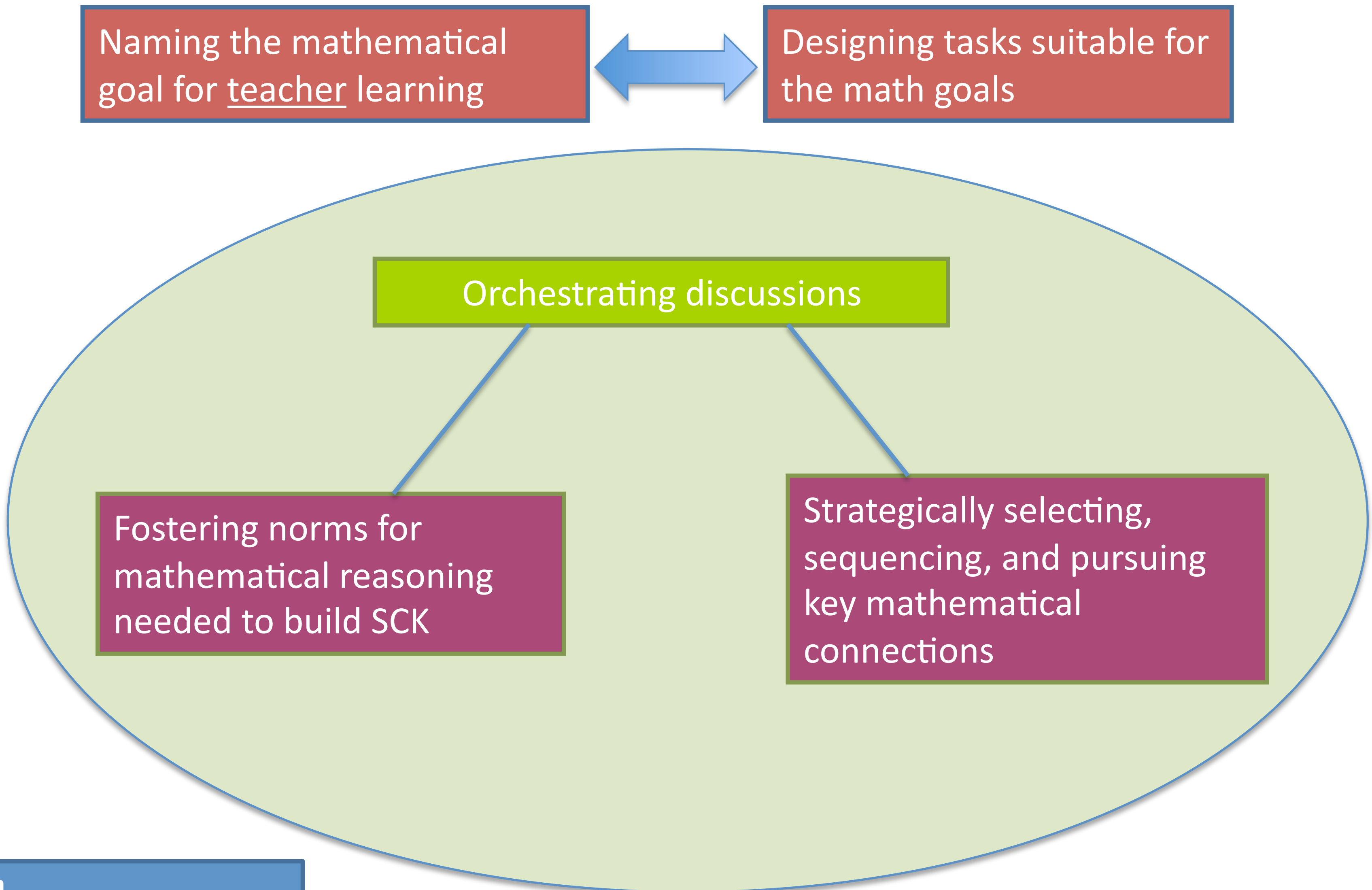
Who?

Leaders

Facilitate mathematics professional development

- In schools & districts
- Other contexts (e.g., cross district, regional education centers, professional development groups)

Revised Framework for Doing Math in PD



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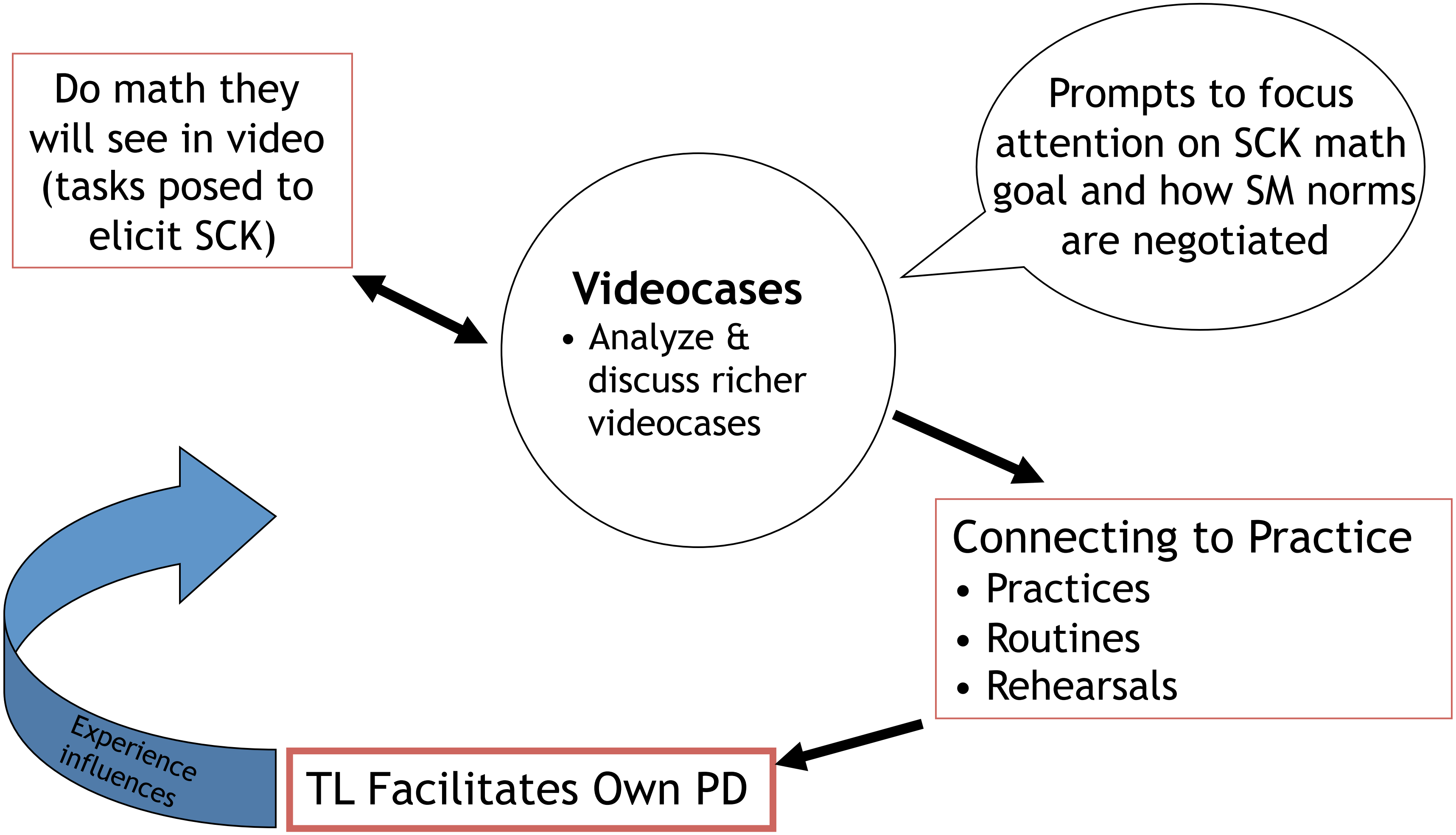
Seminar Experiences for Leaders



Participants

Phase 1 Cohort:

- Seminars: 6 full day seminars
- Leaders: 36 TLs in 2 sites
  - Site 1: K-8 (1 district)
  - Site 2: K-12 (multiple districts)

Phase 2 Cohort:

- Seminars: 9 full day seminars
- Leaders: 45 TLs in 1 site
  - K-12 (multiple districts)

Research Design

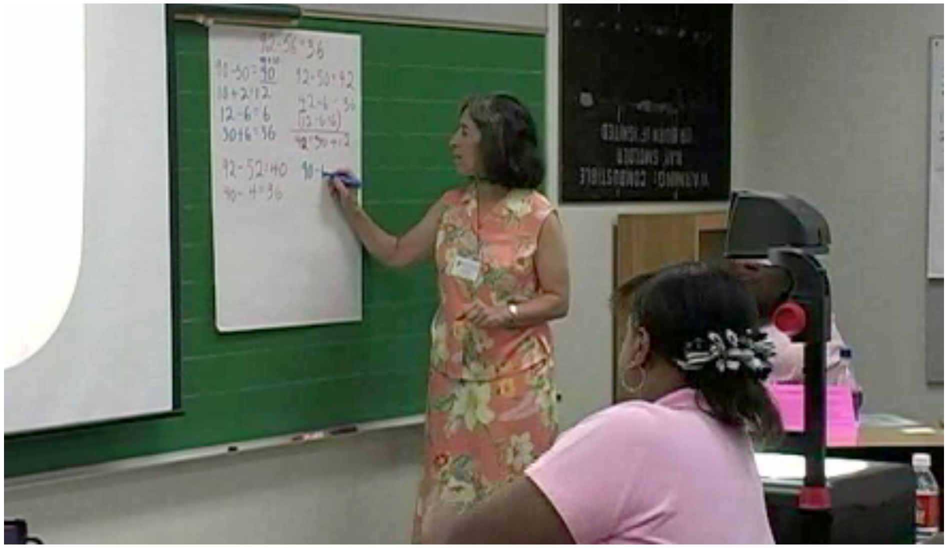
Studying leaders' understandings and practices associated with developing mathematically rich learning environments for teachers

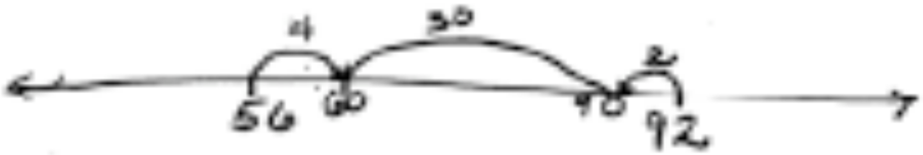
- Two Phase Study (repeat cycle in yr 3-5)
  - Design, Enact, Analyze, Re-Design, Enact, Analyze
  - Qualitative Analyses
    - Pre/Post Questionnaire (qualitative/quantitative)
      - Selected response, Likert scale, task constructed response, scenario responses
    - Video Analysis of leader development seminars
    - Pre/Post Leader Interviews (sample of leaders)
    - Case Studies of leader PD facilitation- video analysis/interviews
  - Quantitative Analyses
    - Pre/Post Questionnaire
    - Learning Mathematics for Teaching (LMT) measures
  - Comparison Site

Videocase: Janice’s method

$$92 - 56 = 90 - 60 + 2 + 4$$

And so ninety is two away from ninety-two. So I needed to recover that two. And fifty-six is four away from sixty, so I needed to recover my four. And I added the two plus four equals six, and I knew I had to put the thirty and six together. And it just made it easier for me to subtract it out, using the landmark numbers.





Findings Phase I

Leaders responded favorably to frameworks

Tempered by tensions of working with adult learners -- can press kids but not adults & issues of status.

Leaders take-up *in* facilitation mixed

Tempered by specificity of purpose and relevance to all teachers.

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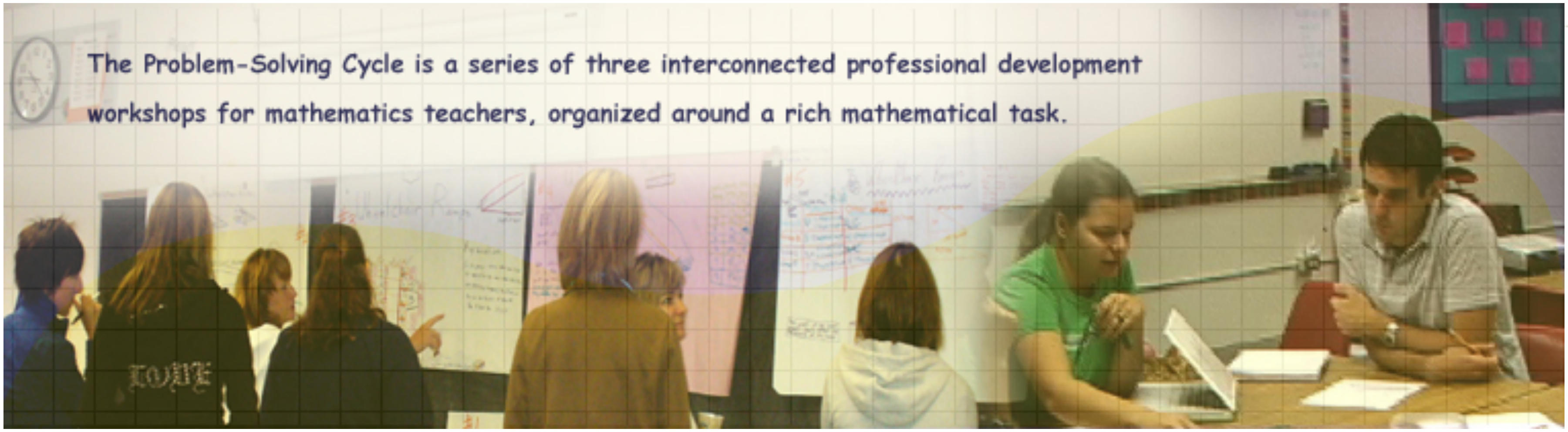
researching mathematics leader learning

Elliott, R. L., Kazemi, E., Lessieg, K., Mumme, J., Carroll, C., & Kelley-Petersen, M. (2009). Conceptualizing the work of leading mathematical tasks in professional development. *Journal of Teacher Education, 60*(4), 364-379.

PSC Problem Solving Cycle



Preparing Instructional Leaders to Facilitate the Problem-Solving Cycle Model of Mathematics Professional Development (iPSC)

University of Colorado at Boulder School of Education

University of Colorado Denver Downtown Campus

Stanford University School of Education

Professional Development and Research Team

- Hilda Borko
- Jennifer Jacobs
- Karen Koellner
- Ed Wiley

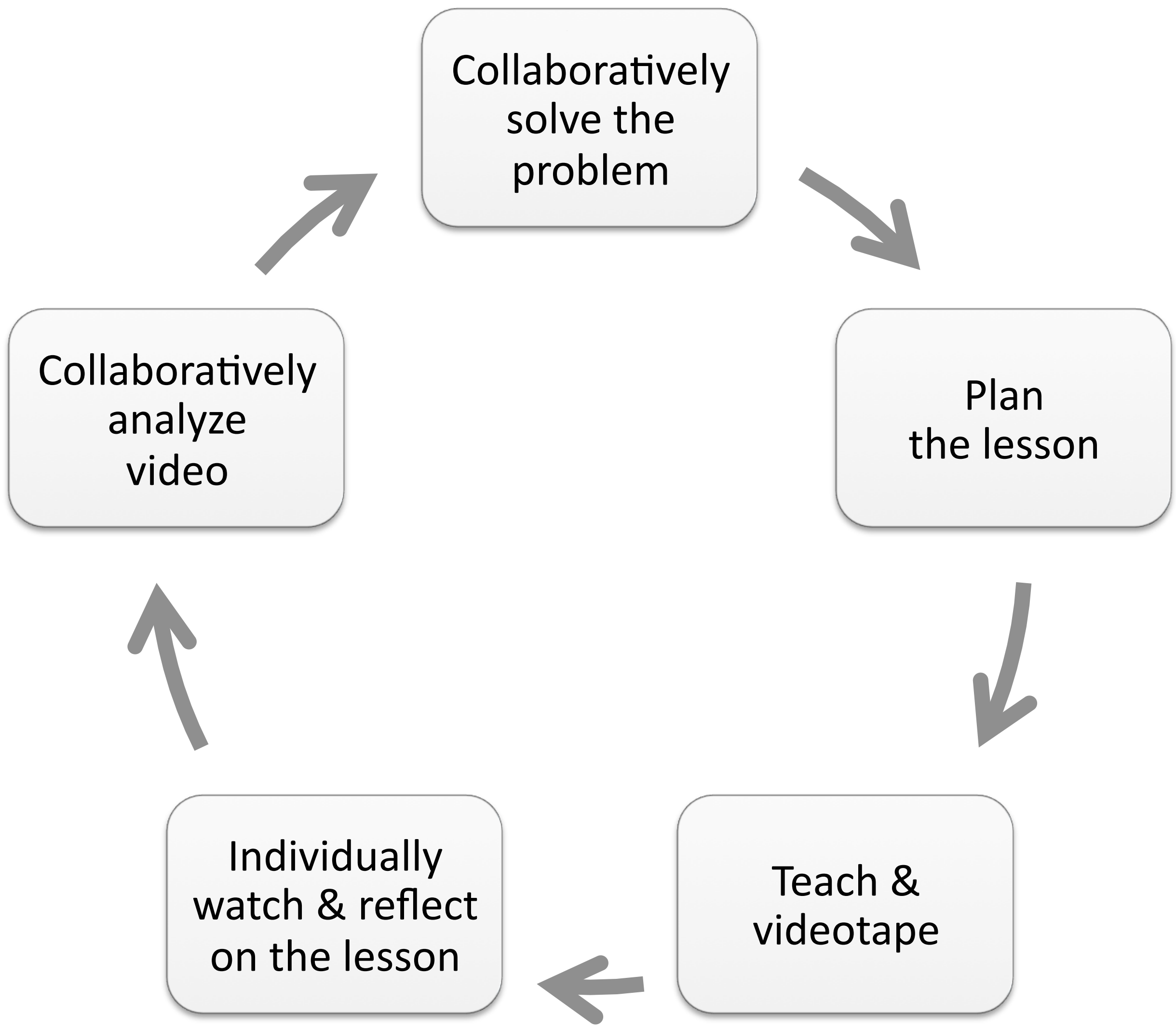
- Erin Baldinger
- Melissa Colsman
- Rachael Risley
- Sarah Roberts
- Sarah Kate Selling
- Adam Van Iwaarden

Phase 1: Developing the PSC

Series of interconnected workshops focused on Knowledge of Mathematics for Teaching:

- Specialized knowledge of mathematics (SCK)
- Students' mathematical reasoning (KCS)
- Instructional practices to support student learning (KCT)

Problem Solving Cycle



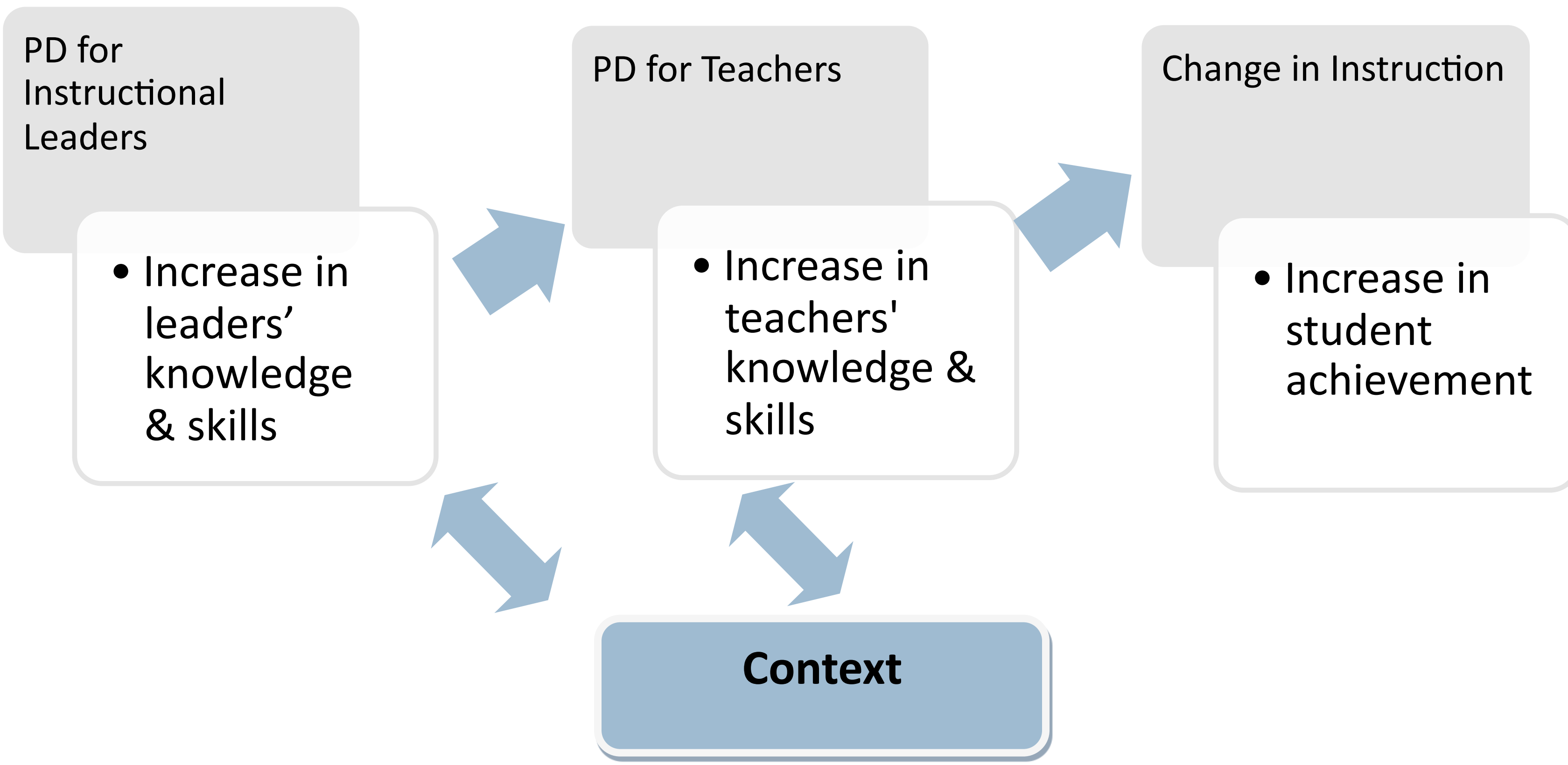
Key PSC Practices

- Multiple iterations that build on one another
- Adaptive (design decisions that take the local context into account)
- Mathematics problem addresses multiple concepts and skills, accessible to all students
- Common teaching experience (same problem, adapted to specific learners)
- Video from teachers' lessons to situate workshops
- IL-prepared questions to guide viewing and discussions
- Explicit attention to developing community

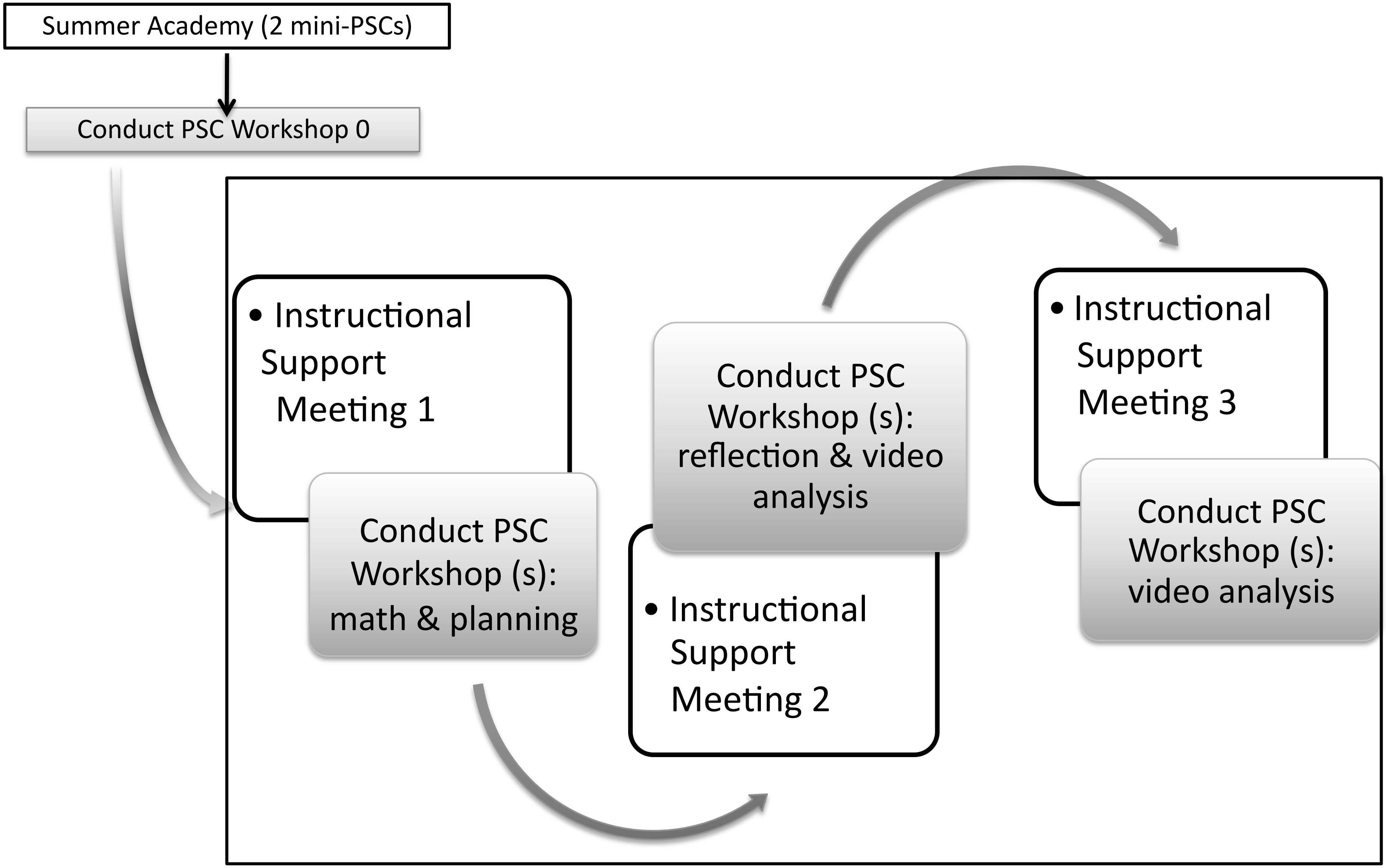
Phase 2: iPSC Efficacy Study: Key Research Questions

- **EFFECTIVENESS**: Is the Problem-Solving Cycle model of PD effective in improving student learning and achievement?
- **SCALABILITY**: Can it be adapted to different contexts?
- **SUSTAINABILITY**: Can it be successfully enacted by different instructional leaders?

Scalable & Sustainable PD: Theory of Action



Structure of Support for ILs



Analytic Framework: Workshop Videos

- Workshop culture
- Workshop design & structure
- Depth of Content
  - Mathematics (SCK)
  - Instructional practices (KCT)
  - Student thinking (KCS)

Key Sources

- *Professional Development Observation Protocol (Horizons, Inc)*
- *Facilitator's Guide (video); Stein et al. (discussion facilitation practices) Hill, Ball et al. (mathematical knowledge for teaching and mathematical quality of instruction)*

Culture of Workshop: Workshop 3

	Cr	Cn	J	Kr	K & J	M	R
Climate of respect for experiences, ideas and contributions	4.5	4	3.5	5	5	5	3.5
Collaborative working relationship between IL and participants	2.5	44	4	5	5	5	4
Collegial working relationships among participants	4.5	4.5	4	5	5	5	2.5
Active participation encouraged and valued	4	4	3	5	5	5	3.5

Specialized Content Knowledge: Workshop 1

	Cr	Cn	J	Kr	K & J	M	R
Leaders anticipate teachers' solution strategies and solutions	4	4	3.5	4	3.5	4.5	3.5
Engage mathematics in ways to help them develop SCK – e.g., generate and analyze ways to solve task	4	3.5	3.5	4.5	4.5	4.5	3
Discussion of various solution strategies	3.5	3.5	4	4	4.5	4.5	3
Discussion of relationships among solution strategies	2	2.5	2.5	3	3	2.5	2
Discussion of affordances and constraints of various solution strategies	1.5	1.5	1.5	2.5	2.5	2.5	3
Discussion of reasoning used to arrive at correct and incorrect solutions	1.5	2.5	2.5	3.5	4	3.5	2.5

Specialized Content Knowledge: Workshop 1

	Cr	Cn	J	Kr	K & J	M	R
Leaders anticipate teachers' solution strategies and solutions	4	4	3.5	4	3.5	4.5	3.5
Engage mathematics in ways to help them develop SCK – e.g., generate and analyze ways to solve task	4	3.5	3.5	4.5	4.5	4.5	3
Discussion of various solution strategies	3.5	3.5	4	4	4.5	4.5	3
Discussion of relationships among solution strategies	2	2.5	2.5	3	3	2.5	2
Discussion of affordances and constraints of various solution strategies	1.5	1.5	1.5	2.5	2.5	2.5	3
Discussion of reasoning used to arrive at correct and incorrect solutions	1.5	2.5	2.5	3.5	4	3.5	2.5

KCT and KCS (Video): Workshops 2 & 3

	Cr	Cn	J	Kr	K & J	M	R
Video clips accessible and relevant to the teachers (workshop 2)	--	5	4.5	4.5	5	5	3.5
Video clips appropriate with respect to level of trust within community (workshop 2 – leaders' classes)	--	4.5	4.5	3.5	4.5	5	4.5
Video clips appropriate with respect to level of trust within community (workshop 3 – initial selection by Ts)	4.5	4.5	3	5	5	4.5	3.5
Questions that encourage teachers to think deeply about instructional practices (workshop 2)	--	3	2.5	3.5	4	4	2
Questions that encourage teachers to think deeply about students' math ideas & reasoning (workshop 3)	2	4.5	--	4.5	--	5	--

KCT and KCS (Video): Workshops 2 & 3

	Cr	Cn	J	Kr	K & J	M	R
Video clips accessible and relevant to the teachers (workshop 2)	--	5	4.5	4.5	5	5	3.5
Video clips appropriate with respect to level of trust within community (workshop 2 – leaders' classes)	--	4.5	4.5	3.5	4.5	5	4.5
Video clips appropriate with respect to level of trust within community (workshop 3 – initial selection by Ts)	4.5	4.5	3	5	5	4.5	3.5
Questions that encourage teachers to think deeply about instructional practices (workshop 2)	--	3	2.5	3.5	4	4	2
Questions that encourage teachers to think deeply about students' math ideas & reasoning (workshop 3)	2	4.5	--	4.5	--	5	--

Emerging Insights

- **Integrity of implementation**
  - Importance of mutual adaptation with local contexts
  - 3-workshop cycle not a core principle
  - 1 workshop not enough time to explore problem, adapt task, and plan lesson
  - Need to work closely with district and school administration in early stages
- **Knowledge of mathematics and pedagogy needed for facilitation**
  - Mathematics Knowledge for Teaching Teachers is not the same as Mathematics Knowledge for Teaching
  - Teacher Analysis Tasks versus Student Math Problems
  - Need for greater emphasis on relationships, affordances & constraints
  - Need for greater emphasis on leading video-analysis discussions

Problem Solving Cycle

iPSC: Implementing the Problem-Solving Cycle

http://psc.stanford.edu/

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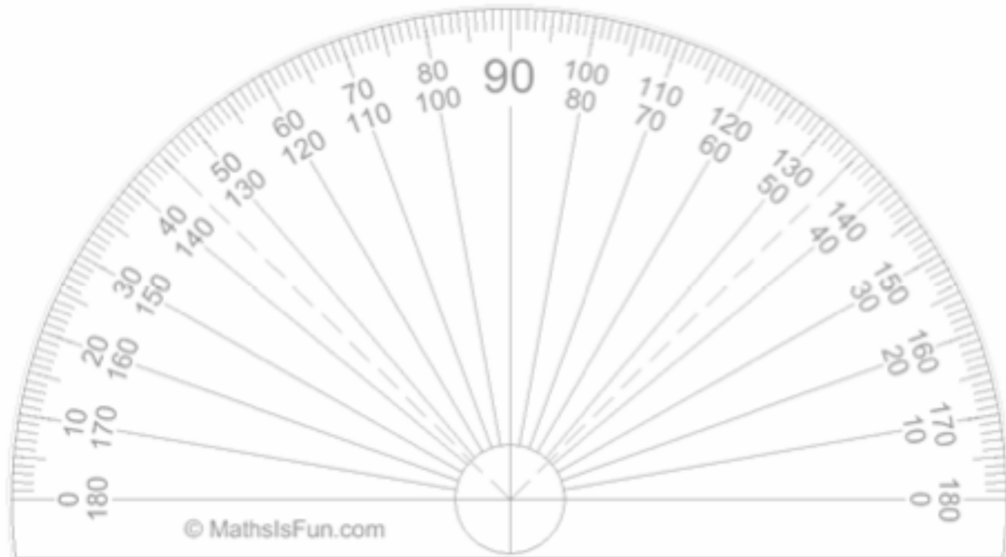


Learning and Teaching Geometry

Learning and Teaching Geometry Project Overview

- In year four of a 5-year National Science Foundation project
- Developing videocase-based, PD materials
  - **1 Foundation Module (10, sequenced 3-hour sessions)**
  - 4 Extension Modules (2-3, 3-hour sessions each)

- Staff: Nanette Seago (PI), Mark Driscoll (Co-PI), Jennifer Jacobs, Johannah Nikula, Patrick Callahan, Hilda Borko
- Advisory Board:Harold Asturias, Tom Banchoff, Phil Daro, Megan Franke, Karen Koellner, Glenda Lappan, Hung-Hsi Wu
- Evaluation Team: [Horizon Research, Inc.] Dan Heck, Kristen Malzahn, Courtney Nelson

LTG Materials

- Built around authentic video clips from grades 6-8 classrooms
- Focus on similarity and its mathematical use in teaching (Specialized Content Knowledge)
- Modular in design--coherent, sequenced set of videocase professional development sessions
- Highly-specified facilitator support materials:
  - Explicitly communicates the underlying core principles
  - Clearly laid out rationale for principles
  - Detailed sample agendas with predictable structure and mathematics/ SCK notes embedded
  - Designed with an eye toward making the goals, design and values explicit

Use of VideoCases in LTG

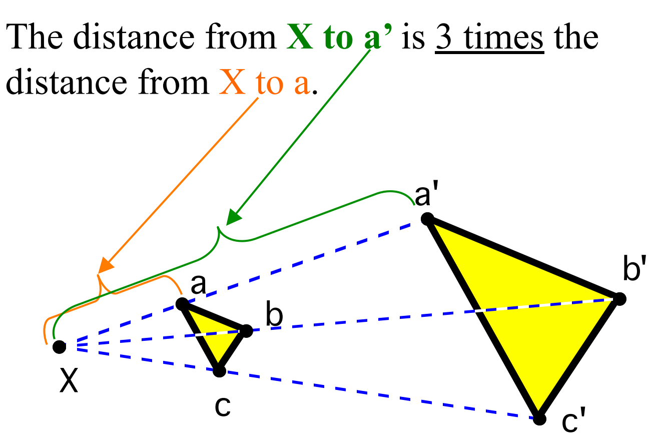
- Not intended as models
- Used to analyze the dynamic nature of classroom interactions
- Used to generate discussion, conjectures and evidence
- Intended to respect teachers, students and teaching
- Use of lesson graphs as resources to situate the short video clips within the context of a whole lesson

LTG Materials are based upon a transformational definition of similarity

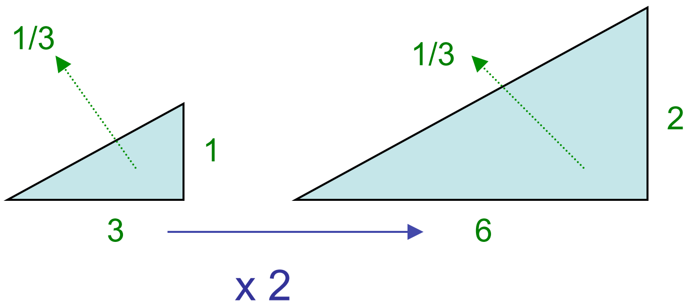
Two figures are similar if one is congruent to a dilation of the other.

– "congruent" ~ "equivalent *(can be matched)* by a combination of translations, rotations, and/or reflections."

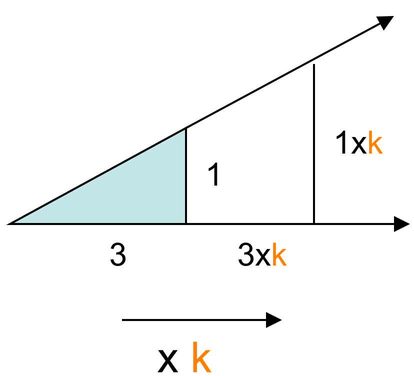
– "dilation" ~ "enlargement or reduction" or "stretching or shrinking" or "each point is moved to a point the same direction from a fixed point, and each point and its image form a fixed ratio of distances from the fixed point"



Focus on distinguishing static and dynamic conceptions of similarity



Attention is on the relationship between adjacent sides and/or corresponding sides within and across two static figures



Attention is on the dynamic relationship between the original figure and a class of continuous similar figures

Common Core Standards

The new Common Core Standards for 8th Grade Mathematics support a dynamic, transformational approach to understanding congruence and similarity:

1. Verify experimentally the properties of rotations, reflections, and translations:

2. Understand that a two-dimensional figure is **congruent** to another if the second can be obtained from the first by a sequence of rotations, reflections, and translations; given two congruent figures, describe a sequence that exhibits the congruence between them.
3. Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates.
4. Understand that a two-dimensional figure is **similar** to another if the second can be obtained from the first by a sequence of rotations, reflections, translations, and dilations; given two similar two-dimensional figures, describe a sequence that exhibits the similarity between them.

Foundation Module Goals

- Help teachers develop a deep, flexible understanding of similarity
- Promote a dynamic, transformational view of similarity, and geometry in general.
- Provide insight into students developing conceptions of similarity
- Equip teachers with *specialized content knowledge* in the area of similarity

Specialized Content Knowledge (SCK)

“The mathematical knowledge and skill unique to teaching- not typically needed for purposes other than teaching.

This work involves an uncanny kind of unpacking of mathematics that is not needed--or even desirable--in settings other than teaching. Many of the everyday tasks of teaching are distinctive to this special work.”

For example:

- Evaluating the plausibility of students’ claims (often quickly)
- Giving or evaluating mathematical explanations
- Choosing and developing useable definitions
- Recognizing what is involved in using a particular representation
- Linking representations to underlying ideas and to other representations

(Ball, Thames, & Phelps, 2008)

A sequence of learning experiences

LTG Foundation Module Map

Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10
A dynamic, transformational view of congruence	*A dynamic, transformational view of similarity*	*Relationship between dilation and similarity*	*Preservation of angles through dilation*	*Preservation of angles & proportional lengths through dilation*	*Ratios within & across similar figures*	*Ratios within & across similar figures, part 2*	*Connections between similarity and slope & linearity*	*Area of similar figures*	*Closure and re-capping of big ideas*

Defining Congruence and Similarity	Relationships and Attributes of Similar Figures	Connections	Closure
Sessions 1–3	Sessions 4–7	Sessions 8–9	Session 10

Design Research Component

1. Developed Foundation Module
2. Pilot conducted by LTG staff
3. Facilitator Institute
4. Field testing
   - Collecting data on teachers' learning & their students' learning
   - Collecting data on facilitators implementation & adaptations of Foundation module

Challenge 1:
The Role of Teacher Leaders

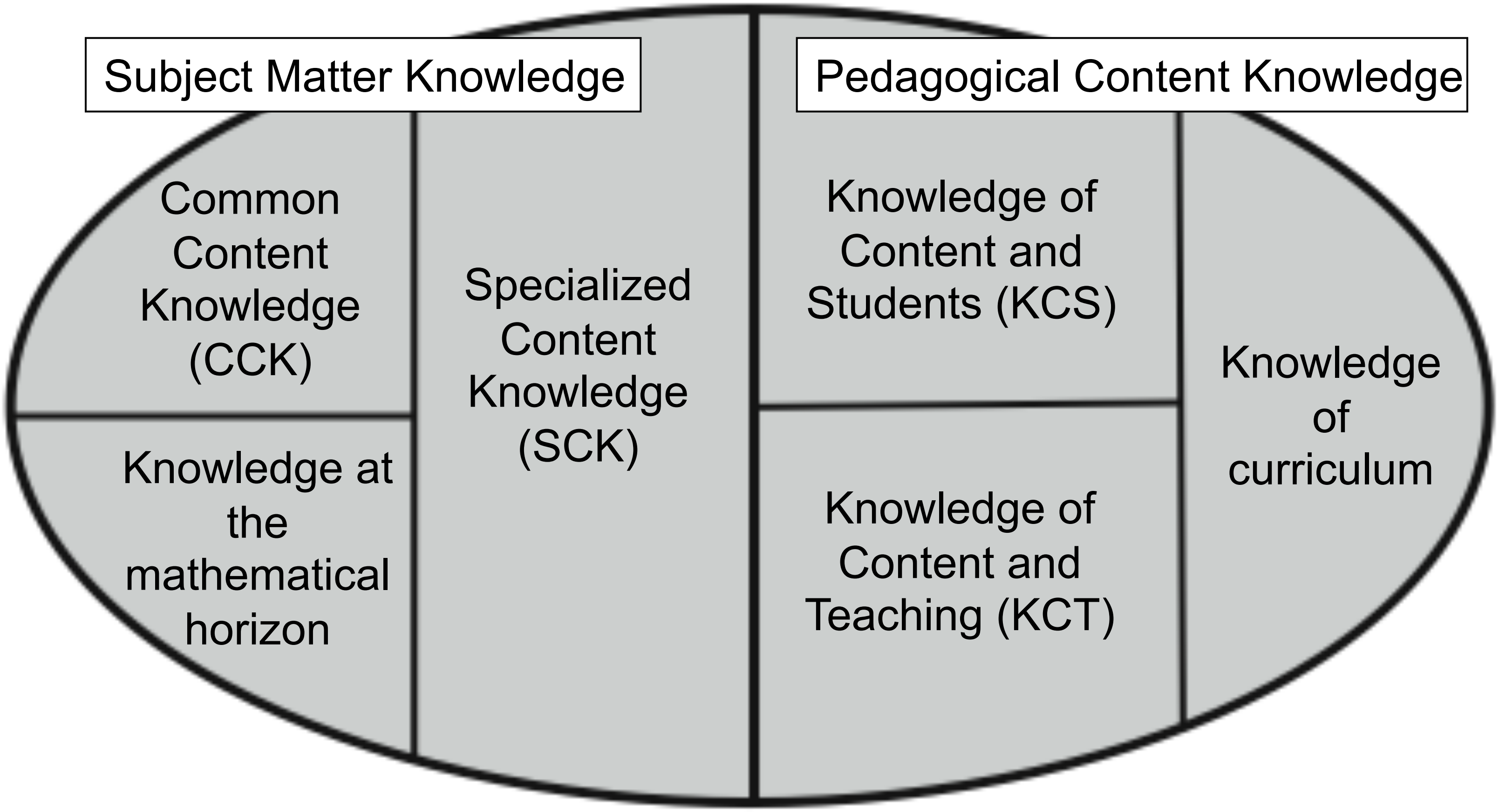
Possible role

Help teachers

develop and use

mathematical knowledge for teaching

Mathematical knowledge for teaching



Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? Journal for Teacher Education, 59(5), 389-407.

Knowledge use in the classroom

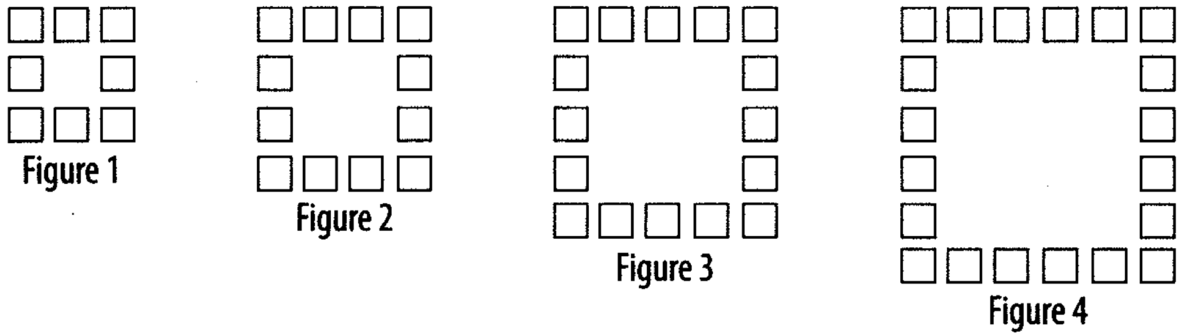


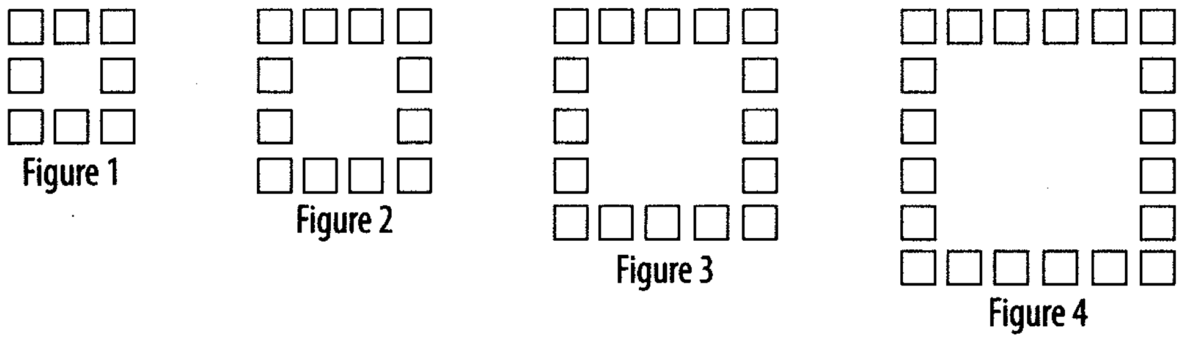
Figure 1 Figure 2 Figure 3 Figure 4

To change from 1 figure to the next, the number of square tiles is increased by 1 on each of the 4 sides of the figure. How many square tiles are needed to build Figure 10? Write an expression for the 100th case. Can you write a formula for the n^{th} case? Explain your thinking. (DMI, Patterns, Functions, & Change)

Teachers will need to plan, enact, and reflect on what they accomplished with students:

- how to launch the task
- what strategies students will use
- what mathematics to focus on and why
- how to structure the class: lecture, small group, whole group discussion

Goals for teachers in PD



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What mathematical ideas do leaders need to work on with teachers to prepare them for effective use of this task?

Why would those be good mathematical goals for teachers?

What do teachers need to learn about using this task with students? e.g., How might they need to be prepared for interpreting student thinking?

Examples of challenges in developing an understanding of leader role

What goals do leaders have for different PD components?

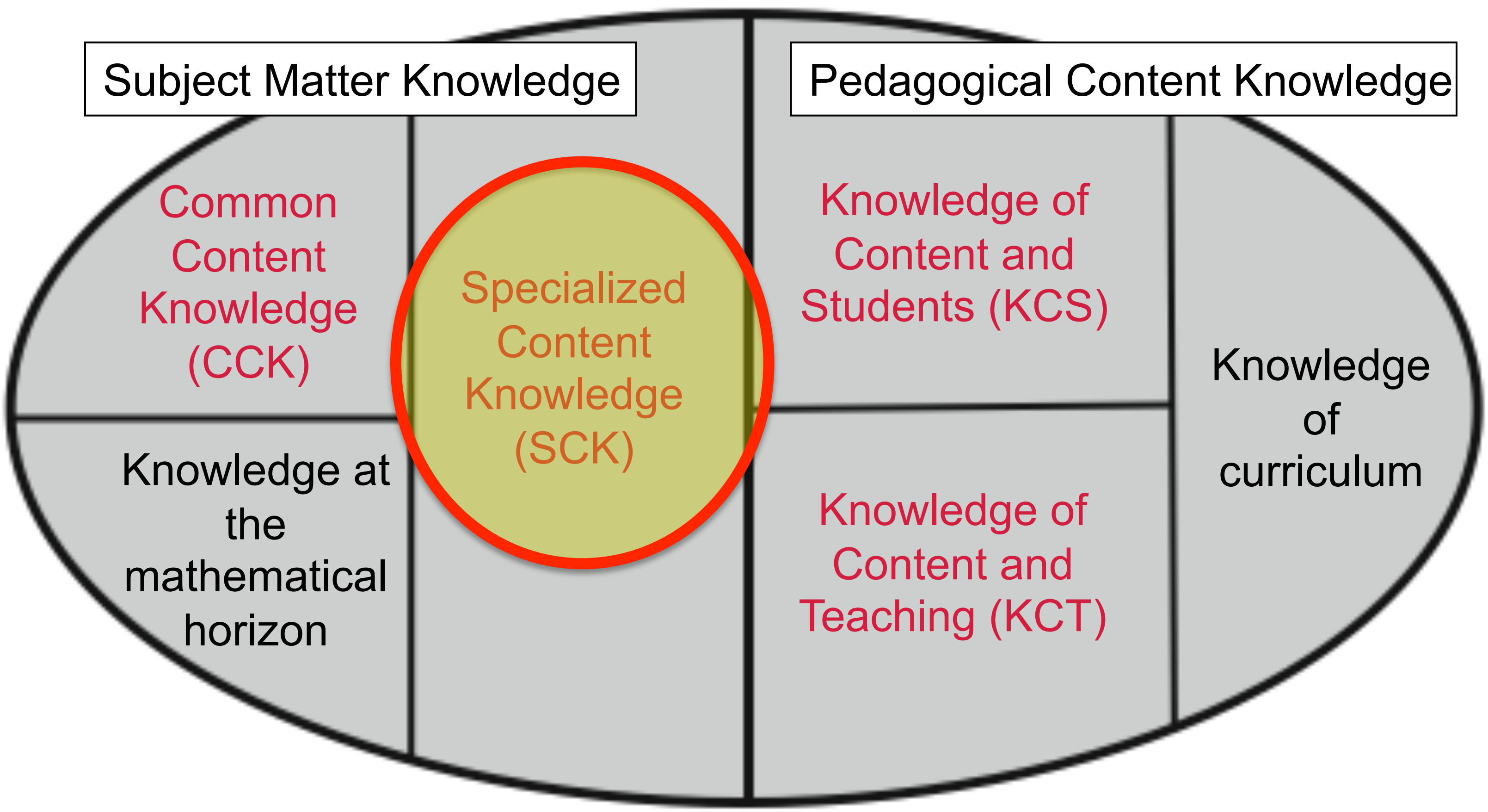
How do leaders orient teachers to make sense of students' mathematical thinking?

How should leaders interpret teachers' math explanations and be able to respond when they facilitate PD?

How do leaders engage teachers in examining and preparing for classroom enactment?

What mathematics do we work on with teachers? And why?

Mathematical knowledge for teaching



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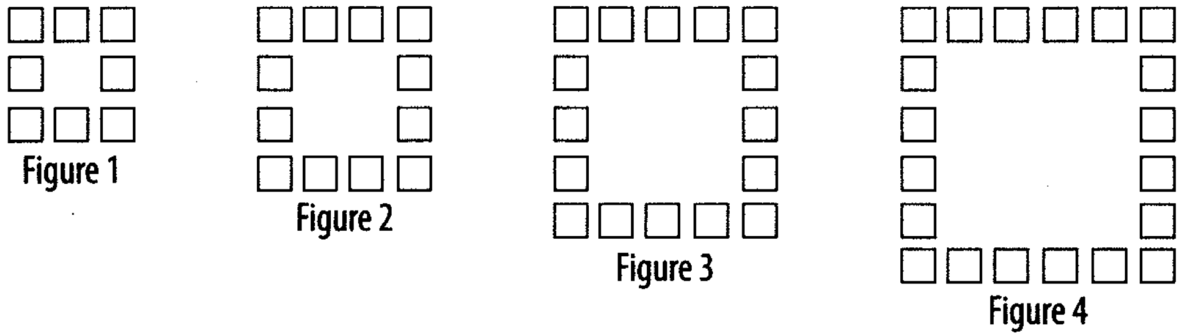
Examples of tasks of teaching requiring specialized knowledge of mathematics

- Unpacking and decomposing mathematical ideas
- Using mathematical language and notation
- Generating examples
- Choosing and using representations
- Analyzing errors
- Interpreting and evaluating explanations

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? Journal for Teacher Education, 59(5), 389-407.

Task as it could be used with teachers



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Working on math with teachers

"I'm done"

"I'll just let __ do it"

"I wouldn't use this problem with my students"

"I remember from high school that you just …."

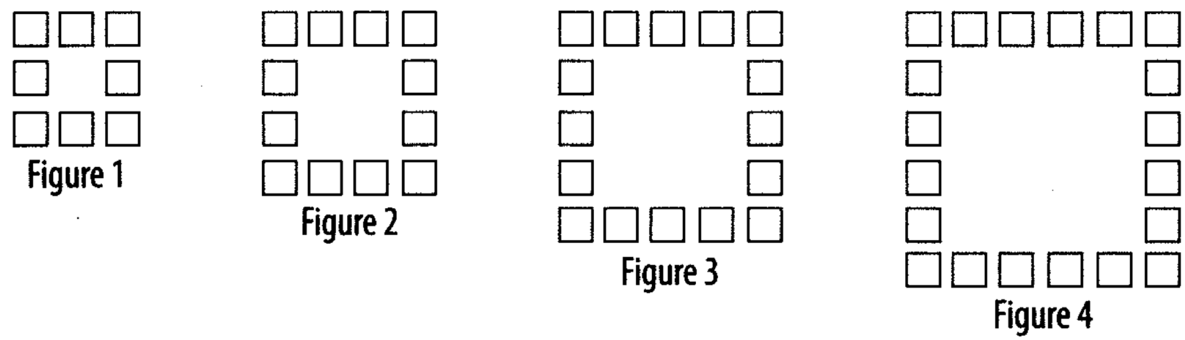
"This is too hard/simple for my students."

"Why are we doing this?"

SCK Task design may not have direct translation to classroom

- Leaders may not be modeling how to use the task with students.
- Ts will not ask students to do the same thing they did in professional development.
- This is a not a “make it and take it” experience.

Task re-framed for teachers in PD



How do the following symbolic expressions correspond to the way the geometric model can be decomposed?

$4(n+2) - 4$
$(2n + 1)2 + 2$
$(n+2)^2 - n^2$
$4n + 4$
$2(2n +2)$

How can leaders use this new task and facilitate conversations about teachers' work on this task to develop SCK?

Linking math task to teaching enactment

A 7th grade teacher has used the original border task in the classroom and she is finding that the students could generate a rule for the predicting the nth case as $4n + 4$, but the students are having a hard time “seeing” the $4n + 4$. (DMI case, Patterns, Functions, Change)

If the teacher has knowledge of the range of ways this model can be decompose, she needs to develop ways of drawing on that knowledge in making decisions about which decompositions she might steer the students towards.

Are all decompositions equally helpful for students who are stuck seeing the “$4n + 4$?”

Mathematical Knowledge for Teaching Teachers (MKT-T)

- Being clear about what kind of teacher knowledge is being developed and what kind of tasks are needed to meet those goals
- When doing math with teachers, unpacking the mathematics sufficiently and convincingly helping teachers see what there is to learn and do
- Making visible the connections between PD tasks and the kinds of mathematical thinking, judgment, reasoning one has to do in teaching
- Knowing how to motivate teachers to engage productively together
- Preparing leaders to make wise use of professional development resources instead of inventing their own PD sessions

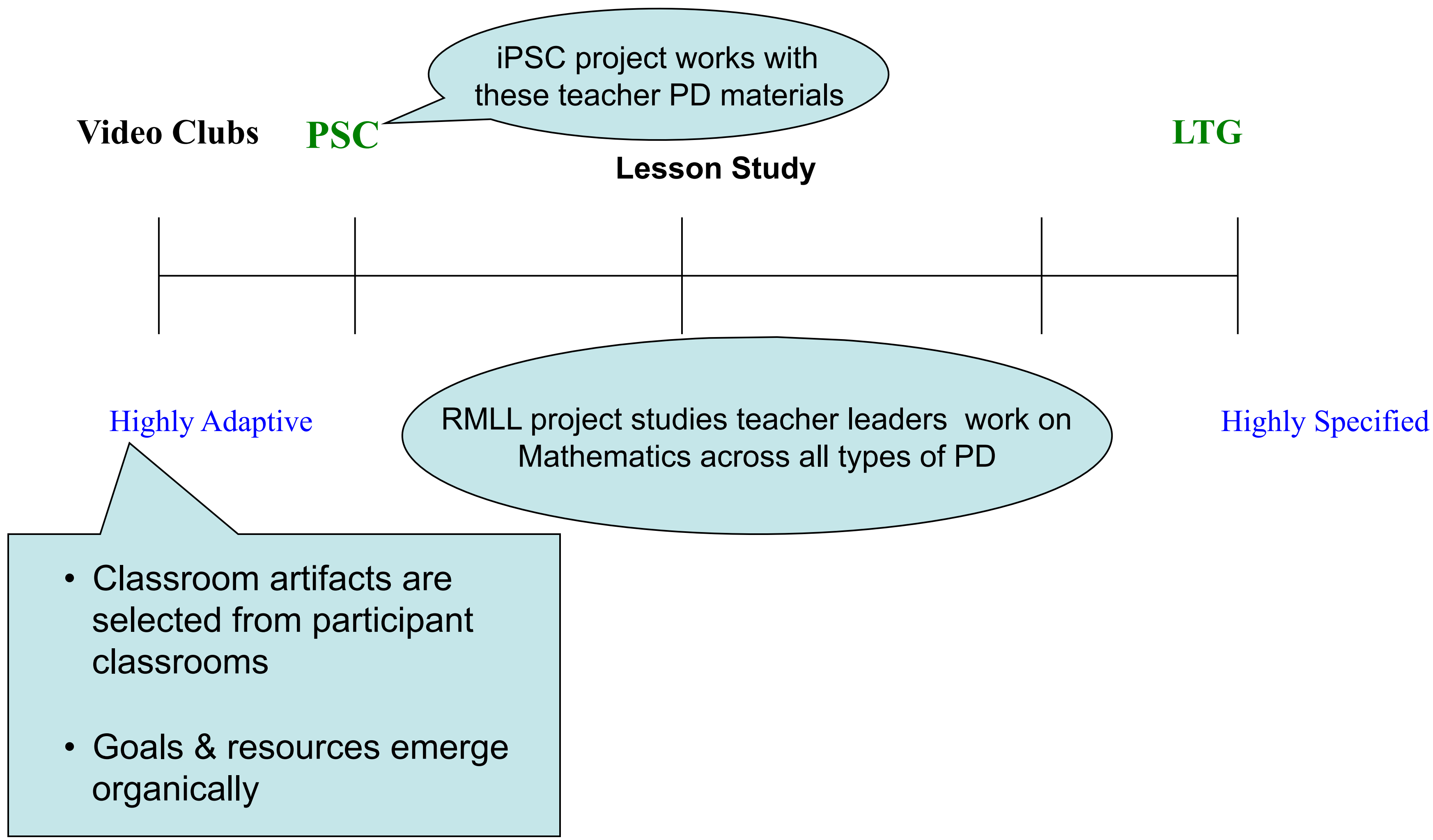
Challenge 2: How do we prepare teacher leaders for their role in the PD?

It depends upon the context

- Three categories of common situations:
  - Researching/designing leader learning opportunities (RMLL in one focal area)
  - Working with/Developing leaders around a particular PD context (iPSC)
  - Designing/creating PD materials for leaders to use with teachers (LTG)

Practice-based PD materials are not all the same:

They can vary from highly adaptive to highly specified in nature



What characteristics make LTG considered highly specified?

- Materials are designed around pre-determined goals, videos and tasks
- Goals and principles are explicit
- Resources and supports for leaders are produced purposely to support facilitation with integrity

Challenges Faced by the LTG project

- How do you design materials that support the learning of SCK?
- How do you create facilitator support materials so that the materials are used with integrity?
- How much do you specify? Leave open?
- How do you support mathematics, pedagogy, video use?

What we have learned so far in the LTG project about leaders

- Leaders do not have time to sift through a ton of support documents, therefore we embedded critical supports within the two documents that they do use: session agendas and power point slides.

- Creating predictable structures that emerge repeatedly across the sessions helps support leaders to use the materials with flexibility while keeping sight of the goals and principles.

In Small Groups, discuss:

- Where might your work fall along the adaptive-specified scale?
- Which of the three categories best fits your context:
  - Researching/designing leader learning opportunities
  - Working with/Developing leaders around a PD context
  - Designing/creating PD materials for leaders to use with teachers
- What are your challenges in preparing teacher leaders? What have you learned?

Challenge #3: Measuring the Impact of Large-Scale PD

DR K-12 PI Meeting
December 3, 2010

Measuring Impact at 3 Levels

- The 3 levels of impact
  - Student
  - Teacher
  - Leader
- Complications at all 3 levels
  - Complications differ at the different levels
  - We're farther along in our thinking and development at some levels than others
- Highlight some issues our projects are addressing

Measuring Impact on Students

- Sources of evidence
  - Close (embedded assessments)
  - Proximal (end-of-unit assessments tied to PD focus)
  - Distal (large-scale assessments aligned with curriculum frameworks)
  - Remote (national assessments; TIMSS)
- Issues of existence and access
- Examples from our projects
  - Focus on math achievement
  - iPSC: state assessment (partially aligned); no resources to develop proximal or close
  - LTG: content assessment: transformational geometry (proximal)

Measuring Impact on Teachers: Teacher Knowledge

- Domains of knowledge
  - Specialized content knowledge
  - Knowledge of content and students
  - Knowledge of content and teaching
- Options and trade-offs
  - Use an existing measure as is (e.g., MKT)
  - Adapt existing measure to project focus
  - Develop measure specific to project
- Examples from our projects
  - iPSC: MKT Middle School Number Concepts and Operations (distal)
  - LTG: SCK transformational geometry: embedded assessment, proximal assessment

Measuring Impact on Teachers: Instructional Practices

- What are we measuring: What is effective teaching?
- Existing measures
  - MQI: mathematics quality of instruction
  - CLASS: classroom assessment scoring system
  - Are there others?
- State of the field: Several agencies funding developing measures of quality instruction
  - GATES
  - WT Grant/Spencer
- Examples from our projects
  - iPSC: modified version of MQI

Measuring Impact on Leaders

The literature offers only limited empirical information about the practice of mathematics teacher educators working with practicing teachers. … current empirical work tends to focus on the learning of (prospective and practicing) teachers who participated in professional education activities, and not on the nature of the practice of offering professional education. (Even, 2008)

Measuring the Impact on Leaders: Leader Knowledge

- Just beginning to conceptualize the construct of MKT-T

- Is there any work on measuring MKT-T or other domains of leader knowledge?

Measuring the Impact on Leaders: PD Practices

- What are we assessing: what are effective leader practices?
- Existing measures
  - PDOP (Horizons, Inc.): ratings of features of PD
  - Are there instruments for *coding* leader practices?
- Examples from our projects:
  - iPSC:
    - Modified PDOP based on core practices of the PSC
    - Not yet capturing some key aspects of PSC facilitation
  - RMLL
    - Developing a coding scheme using StudioCode