Werklund School of Education

Supporting mathematics teachers' professional growth

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Research and professional learning experiences with teachers of mathematics in Calgary, Alberta

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Research foci

- My research interests focus on mathematics teachers' thinking, learning, change, and mathematics knowledge for teaching; mathematical problem-solving knowledge for teaching; inquiry-based mathematics pedagogy; and the use of narratives as inquiry tools in mathematics teacher education and research.

- This includes understanding elementary and secondary school mathematics teachers' practical knowledge and classroom actions from their perspectives, self-directed approaches to their learning, and transformation of their teaching to create innovative learning environments and effectively engage their students in meaningful learning of mathematics.

- My research shows how understanding the mathematics teacher in these ways is important to address the complexities and support autonomy in their learning.

Journey with mathematics teacher knowledge development

- Workshops in Calgary schools/symposiums in Alberta
- High School Project
- Private School Project
- Elementary School project

Workshops in Calgary schools/symposiums in Alberta

- Invitations from schools for their PD day or our provincial mathematics teachers' council symposiums or ministry funded consortium.

- Invited to do "how to ____"; e.g., How to teach through constructivism. How to teach problem solving. How to teach with manipulatives. How to use the new mathematics textbook.

High School Project

Graduate student, Rosie:

"as a constructivist, inquiry-oriented, high school mathematics teacher and as a leader of PD sessions and consultant for high school mathematics teachers."

High school mathematics teachers' learning from exploratory learning activities

A PD workshop day sponsored by the School Division.

Opened to any high school mathematics teacher in the Division.

Was advertised through the Divisional email system as a high school mathematics workshop.

High School Project

Goal was for teachers to understand what these tasks look like and how to use them in their teaching and to influence them to include such tasks in their teaching.

She created/adapted 7 exploratory tasks based on her experience with them in her teaching

Tasks can be used to explore new or existing mathemati- cal concepts to either construct better under- standing of a concept or to build knowledge of a new concept. They provide different examples of exploratory tasks.

Structure of workshop

- Introduction to the task
- Teachers worked on the task [with guidance]
- Sharing and whole-group discussion
- Completed a personal reflection sheet
- Sharing and whole-group discussion

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- Task 1: Addition/Subtraction number pattern Proofs
- Task 2: Pascal's Triangle
- Task 3: Inverse Functions
- Task 4: Root 2 board
- Task 5: Polynomial Function Investigation
- Task 6: Quick Draw
- Task 7: Female History Stories and Activities

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- Goal of task 1:

  To allow the teachers to explore patterns by adding and subtracting a multi-digit number with the number formed by reversing the order of its digits, making conjectures and using deductive and Inductive reasoning is used to prove the conjectures.

- “What do you notice?” “Do you have any conjectures?”

- “If the two digits in the number sum to 10 or greater, than the resultant sum will always be larger than one hundred.”
- “The resultant sum is always a multiple of 11.”

- Rose asked them to prove it deductively or inductively. They were able to do it with her guidance.

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Findings

- They showed understanding that an “exploratory leaning activity” is about students’ discovery and construction of knowledge and is inquiry-based or of an investigative nature. They saw benefits of such tasks for students in terms of motivation and depth in learning mathematics.

- The tasks most meaningful and memorable for them were those that challenged their content knowledge for teaching and connected to them through emotions [positive or negative].

- One teacher tried the Pascal triangle task and one the number pattern task.
- Some did not connect with most of the tasks in terms of recalling them or using them.

Their thinking was reinforced regarding:

- these are good activities to have in your toolkit to use occasionally when there is time
- it requires too much time or work to find/create such tasks and to use them
- there isn’t one source that provides all of the exploratory learning activities applicable to the curriculum.

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- Experience with the activities did not help them to make sense of what teaching should look like to support this type of tasks.

Private School Project

- A grade 2 to12 school that is noted for innovations in language literacy learning and special needs, but had placed little emphasis on mathematics learning and had a culture oriented towards traditional teaching.

- Visit to school

- It provided a unique opportunity for teachers to work across grade levels, it was interested in becoming more innovative in mathematics learning

- Research grant – change the math culture of the school

- School provided support for teachers

- A course-based master's program, designed for them and held at their school.
  - Year 1 consisted of 4 mathematics education courses [equivalent of a graduate diploma] and
  - year 2 required courses for the M.Ed.

- Initially a core group of 14 teachers volunteered; 10 completed the 4 courses and 8 the M.Ed.

The core group of 10 teachers who completed the math education courses covered grades 4 to 12 but were mainly secondary level teachers.

“This focus was intended as a strategy to infuse recent research into this social system, anticipating that members of the core group would eventually offer conceptual and pragmatic leadership to their colleagues.”

- Group work; lesson study; examples were connected to the curriculum

- “Our expectation was that members of the core group would eventually offer conceptual and pragmatic leadership to their colleagues.”

- After 2 years, the hoped-for leadership and consequent impact on mathematics teaching was not realized.

- All of the teachers learned a lot and wanted to make changes to their teaching. But it was a challenge.
- The teachers interpreted and enacted the content of the master's program in different ways.

Conclusions

- LC do not evolve naturally from a group of teachers' common experiences with new/different ways of engaging students in learning mathematics
- Common learning experiences do not result in similar knowledge development to impact practice
- Teachers whose teaching could easily facilitate some new ideas are likely to enhance their practice; others who want to adopt new ideas are likely to struggle and need ongoing support.
- Talking about what you learned as if you know it without understanding how to implement it in the classroom provides a barrier to learning and growth.

Elementary School project

In October 2003, Alberta's Commission on Learning released a comprehensive vision for the future of primary and secondary education in Alberta entitled, *Every Child Learns. Every Child Succeeds.*

The Commission developed a list of ninety-five recommendations to achieve its vision. Recommendation number thirteen of the report, "Require[s] every school to operate as a professional learning community dedicated to continuous improvement in students' achievement.“

In the spring of 2004 the Government of Alberta accepted this recommendation, thereby mandating every public school in the province to become a professional learning community

Edgemont Elementary School experience/project

- Alberta Initiative for School Improvement [AISI]
- Teacher Professional Growth Plan [TPGP]

Alberta Initiative for School Improvement [AISI]

- Goal: to improve student learning and performance by fostering initiatives that reflect the unique needs and circumstances of each school authority.

- Funding provided to school authorities for specific local initiatives that focused on improving student learning.

- Partnership among teachers, superintendents, trustees, business officials, universities, parents, and government

AISI projects as PLC

- Collaborated on planning, analyzing and evaluating instruction
- Shared knowledge, expertise, and resources
- Reflected on past and new experiences
- Discussed and debriefed implementation of new instructional strategies
- Analyzed and discussed student work

What the teachers valued

Teachers identified the most important factors in the success of their projects as:

- Regularly scheduled group meetings embedded in the school timetable,
- Directly related to teachers' students and their learning
- Topics and content generated by the teachers
- Collaborative sharing times and meetings with peers to review practice and research, to plan and to analyze their practice and their students' performance

Concerns of teachers

- **Colleagues resisting need for change**

It takes time and the persistence to move some colleagues from asking for and following specific direction to taking ownership and joint responsibility for project goals, and to developing and practising instructional strategies to meet those goals.

Concerns of teachers

- **Staff changes**

Could bring with it changes in focus and/or values that makes it difficult to keep the original vision. New team members part way through a project may be resistant to change and take away the developed strengths and contributing roles of departing team members.

- **Timetable limitations**

The importance of ongoing, job-embedded PD for teachers, where they meet and share and work collaboratively, requires significant time that teachers want – but not at the cost of over-reliance on substitutes.

Mathematics projects

- To explore, develop and apply more effective teaching practices to enhance student learning and to improve student achievement.

- To change teaching practices through instructional strategies different from those previously used by teacher participants and their students.

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Mathematics pedagogy

- Using games and manipulatives
- Using pictorial, symbolic and verbal representations
- Using contextual problems

Using children literature

Teacher Professional Growth Plan

- In Alberta, every teacher employed by a school system must develop and implement an annual plan for professional growth that outlines the professional development activities the teacher intends to undertake in that year.
- Developing the plan is a professional function through which teachers demonstrate their commitment to lifelong professional learning while fulfilling their regulatory requirement pertaining to continuing education.
- A key component of the plan states: “a teacher’s annual growth plan shall reflect goals and objectives based on an assessment of learning needs by the individual teacher.”

Edgemont School

- Study groups [spin-off from AISI]
- Mathematics study groups [Edgemont School]
- Share experiences
- Mathematics consultant
- Enters me!

Self-directed learning

- A process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing strategies, and evaluating learning outcomes (Knowles, 1975).
- The learner has more autonomy in the way that she or he learns.

Factors of the self-directedness that supported the teachers' learning

1. An emergent process of inquiry
2. A common pedagogical problem
3. Relevant practical knowledge (PK)
4. Self-based and meaning-based questions/prompts
5. Personalized models/guidelines
6. Accessible mathematics topic

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An emergent process of inquiry

- The learning inquiry cycle the teachers' engaged in emerged from decisions they had to make to achieve their goal.

- Each step emerged when needed and was discussed and defined only in relation to that need.

- This emergent approach allowed them to contextualize and personalize each step so they all could make sense of it in a similar and relevant way that supported their learning collectively and individually

A common pedagogical problem

- Started with a broad goal of learning more about inquiry-based teaching and adopting it in their practice.
- Realized need for a specific topic to focus their inquiry.
- Identified a topic of common interest that they could relate to their individual teaching,
- Explored the mathematical processes emphasized throughout the curriculum [communication, connections, estimation and mental mathematics, problem solving, reasoning, and visualization]

- Concluded that *communication* in an inquiry-teaching context was the key process that they would like to explore as a starting point.

- Their initial common pedagogical problem to inquire became how to transform their teaching to use communication that allowed students to think and be actively engaged in their learning in an inquiry-learning context.

Relevant practical knowledge (PK)

- When faced with a situation of learning more about something or planning to enact something the teachers would choose to start with their PK or practical situations where they could connect to PK examples

Self-based and meaning-based questioning

- **Self-based questioning** involves posing questions that enable one to think about and talk about oneself. It is triggered by curiosity or puzzlement about one's own or others' thinking or actions.

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- **Meaning-based questioning** involves asking questions that require a search for meaning, that is, to understand or make sense of something that leads to action. It is triggered by curiosity or puzzlement about something one is interested in and desires to know more about.

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Personalized models/guidelines

- Constructing and using personalized models/guidelines were central to the teachers' self-directed inquiry process and learning from it.

- Instead of studying and adopting available theoretical models/guidelines, they developed their own based on their own inquiry.

- Sustained the LC.

Guideline for observing videos.

Themes to guide and record their observations:

- learning goal of lesson
- students' role
- teacher's role
- questions posed by the teacher to encourage and extend students' thinking
- learning environment
- nature of tasks
- key inquiry features of lesson

Guideline for questions/prompts and good problem

- Based on the video studies, they developed guidelines for questions/prompts and good problems.

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Examples of questions/prompts

Questions/prompts
What do you notice?
What else do you notice that is different?
Who can explain how [or why] this makes sense?
What do you think the answer [or pattern or outcome] could be?
How do you know?
How do you know it will [will not] work?
Where [or when] would you use this ___?
Suppose I want to___, how can I start?
Who can describe it so that I can do it?
Present your idea.
Explain the problem to your partner [or the class].
What do you know about ____ (e.g. this topic)?
Can you make a general statement about ____?

Guideline for observing research lessons

- to guide the initial observations to make it easier for them to compare and discuss their findings.

Model of IB teaching

- Central to their work was the development of a model of inquiry-based teaching.

Designed and tested in 3 inquiry cycles

- **The jigsaw-inquiry teaching model**

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Components of the Jigsaw Teaching Model

(i) Identify ***learning goals*** that include conceptual understanding

(ii) Expose students' ***prerequisite knowledge/conceptions*** for the concept being taught in an inquiry way

(iii) Have students make ***predictions*** about possible outcomes related to the concept

(iv) Allow students to engage in ***free exploration*** of the concept

(v) Engage students in ***focused exploration***

(vi) Have students work on ***application*** of concept

(vii) Engage students in ***comparison, evaluation*** **and** ***reflection*** of their learning

(viii) Suggest ***extension*** of concept to other situations or related concepts

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- By creating and testing the model, the teachers understood how it worked, what it meant, why it worked in a particular way, and how they could adopt it in their teaching.

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Accessible mathematics topic

- In order to create their inquiry-based teaching model, the teachers started with mathematics topics that they thought they all could make sense of with adequate depth and relate to individually in the context of their teaching.

- Having a commonly accessible topic allowed them to focus on the features of the inquiry-based teaching model and see the relationship between the topic and inquiry-based teaching and learning.

- Their first research lesson was to *explore and classify 3-D objects according to their properties*.