Adapting a Model of Preservice Teacher Professional Development for Use in Other Contexts: Lessons Learned and Recommendations

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Abstract

We discuss how an innovative field experience model initially developed at Indiana University - Bloomington (IUB) is adapted for use at two other institutions. The teacher preparation programs at the two adapting universities not only differ from IUB, but also from each other with respect to course structure and student population. We begin with describing the original model, referred to as Iterative Model Building (IMB), and how it is designed to incorporate on a variety of research-based teacher education methods (e.g., teaching experiment interviews and Lesson Study) for the purpose of supporting preservice teachers with constructing models of children's thinking, using this information to inform lesson planning, and then participating in a modified form of lesson study for the purpose of reflecting on changes to the lesson taught and future lessons that will be taught in the field experience. The goal of these combined innovations is to initiate the development of preservice teachers' knowledge and skill for focusing on children's scientific and mathematical thinking. We then share how we utilize formative assessment interviews and model building with graduate level in-service teachers at one institution and how the component of lesson study is adapted for use with undergraduate preservice teachers at another institution. Finally, we provide recommendations for adapting the IMB approach further at other institutions.

Introduction

There is a clear consensus that teachers must learn to question, listen to, and respond to what and how students are thinking (Jacobs, Lamb, & Philipp, 2010; NRC, 2007; Russ & Luna, 2013). With this information teachers can decide appropriate steps for instruction that will build on students' current understandings and address misunderstandings. At Indiana University – Bloomington (IUB) we received funding to rethink our approach to the early field experience that our elementary education majors take in order to emphasize this need for developing our preservice teachers' knowledge and abilities to ask children productive questions (Harlen, 2015), interpret their understanding, and respond with appropriate instructional methods to develop students' conceptual understanding about the topics being discussed (Carter, Park Rogers, Amador, Akerson, & Pongsanon, 2016). Our field experience model titled, Iterative Model Building (IMB), is taken in a block with the elementary mathematics methods and science methods courses, and as such half of the field experience time (~5-6 weeks) is devoted to each subject area. Over the course of the semester, the preservice teachers attend local schools for one afternoon a week. In teams of four to six, the preservice teachers engage with elementary students through interviews and the teaching of lessons, and then experience various modes of reflection to begin developing an orientation towards teaching mathematics and science that is grounded in the notion that student thinking should drive instruction (National Research Council, 2007). Thus, the IMB approach consists of four components that include weekly formative assessment interviews with children, discussions regarding models of the children's thinking from the weekly interviews, lesson planning and teaching, and small group lesson reflections similar in nature to Lesson Study (Nargund-Joshi, Park Rogers, Wiebke, & Akerson., 2012; Carter et al., 2016). The intent of our approach is to teach preservice teachers to not only attend to student thinking, but to learn how to take this information and use it when designing lessons so they will make informed decisions about appropriate instructional strategies.

In this article we describe not only the original IMB approach, but also demonstrate the flexibility in the use of its components with descriptions of how Authors 2 and 3 (Ingrid and Julie) have adapted aspects of the IMB to incorporate into their science and mathematics teacher education courses at different institutions. Although this journal focuses on innovations for science teacher education, at the elementary level many teacher educators are asked to either teach both mathematics and science methods, or work collaboratively with colleagues in mathematics education, as students are often enrolled in both content area methods courses during the same semester. Therefore, we believe sharing our stories of how this shared science and mathematics field experience model was initially developed and employed at IUB, but has been modified for use at two other institutions, has the potential for demonstrating how the components of the model can be used in other contexts.

To begin, we believe it is important to disclose that Ingrid and Julie, who made the adaptations we are sharing, attended or worked at IUB and held positions on the IMB Project for several years during the funded phases of research and development. When they left IUB for academic positions, they took with them the premise of the IMB approach as foundational to developing quality mathematics and science teachers. However, the structure of their current teacher education programs are not the same as at IUB, and thus they adapted the IMB approach to fit their institutional structure while trying to staying true to what they believed were core aspects of the approach for quality teacher development.

We begin with sharing an overview of the components of the IMB approach followed by descriptions from Ingrid and Julie about the context and course structure where they implement components of IMB. In addition, we share examples of how their students discuss K-12 students' mathematical and scientific ideas and relate this to instructional decision-making. Through sharing our stories of adaptation of the IMB approach, we aim to inspire other teacher educators to consider how they may incorporate aspects of this approach into their professional development model for preparing or advancing teachers' knowledge for teaching in STEM related disciplines.

Overview of IMB Approach – Indiana University (IUB)

As previously mentioned, IMB includes four components: (i) developing preservice teachers' questioning abilities to analyze students' thinking through the use of formative assessment interviews (FAIs); (ii) constructing models of students' thinking about concepts that are asked about in the interviews (i.e., Model Building); (iii) developing and teaching lessons that take into consideration the evolving models of children's thinking about the concepts being taught (i.e., Act of Teaching); (iv) learning to revise lessons using evidence gathered about children's thinking from the lesson taught (i.e., Lesson Study). Although these components may not appear to be innovative to those in the field of teacher preparation, the unique feature of the IMB model is the iterative process, and weekly combination of all four components, within an early field experience for elementary education majors that we believe demonstrate innovative practice in preparing science and mathematics elementary teachers. In addition, the field experience at IUB applies this four-step iterative process in the first 5-6 weeks with respect to teaching mathematics concepts, then continues for an additional 5-6 weeks on science concepts. In the next few paragraphs, each of the IMB components are described in more detail. We have grouped components according to those that Ingrid and Julie have adopted for use at their institutions.

Formative Assessment Interviews and Model Building

Formative assessment interviews (FAIs) are modified 'clinical interviews' that are aimed at understanding students' conceptualizations of scientific phenomenon or mathematics problems (Steffe & Thompson, 2000). From these video-recorded interviews, the preservice teachers identify short snippets that illustrate elementary students explaining their thinking about what a concepts is, how it works, and how they solved for it. These explanations are then used to try to develop a predictive model to help the teachers consider how the students might respond to a related phenomenon, problem, or task (Norton, McCloskey, & Hudson, 2012). The Model Building sessions require the preservice teachers to consider what is known about the students' thinking on the concept or problem, based on the specific evidence given in the snippet of video, and identify what other information would be helpful to know. See Akerson, Carter, Park Rogers, & Pongsanon (2018) for further details on the purpose, structure and ability of preservice teachers to participate in a task where they are asked to make evidence-based predictions regarding students future responses to relate content (i.e., anticipate the student thinking).

With respect to the IMB approach, a secondary purpose of the FAI and Model Building sessions is to develop preservice teachers' knowledge and abilities to think about how to improve their questioning of students' thinking within the context of their teaching. This relates to being able to develop their professional noticing skills; a core aspect identified in the research literature (Jacobs, et al., 2010; van Es & Sherin, 2008) and critical to fostering the expert knowledge teachers possess (Shulman, 1987). See ‘Resources’ for examples of the post FAI Reflection Form (Document A) and Model Building Form (Document B) preservice teachers complete at IUB as part of their field experience requirements.

Act of Teaching and Lesson Study

Each week the teams develop a lesson plan using the information gathered from the FAIs, Model Building sessions, and as time goes on, their experience of teaching previous lessons to the students in their field classroom. With respect to the mathematics portion of the field experience, the mathematics lessons are developed in conjunction with the field experience supervisor from week to week. However, given the additional time that science has, because the science teaching in the field does not start until halfway through the semester, a first draft of all five science lessons are completed as part of the science methods course. Once the switch is made to science in the field, the preservice teachers then revise the drafted lessons from week to week using the information gathered through the IMB approach and with the guidance of the field instructor.

During the teaching of the lesson, two to three members of each team lead the instruction and the other two to three members of the team move around the room amongst the elementary students observing and gathering information about what the students are saying and doing related to the lesson objectives. After the teaching experience, all members come together and follow the IMB’s modified lesson study approach that is adapted from the Japanese Lesson Study model (Lewis & Tsuchida, 1998)[1]. Using the Lesson Study Form developed for use in the IMB, the different members of the teaching team reflect on what the children understood about the concepts taught in the lesson and propose revisions for that lesson based on the children’s understandings and misunderstandings. Possible strategies related to these understandings are also discussed with respect to the next lesson to be taught in the series of lessons. Supporting them in this reflective process is the evidence some members of the team recorded using the Lesson Observation Form (see ‘Resources’, Document C), as well as what those who taught the lesson assessed while teaching. The Lesson Study Form (see ‘Resources’, Document D) guides this evidence-based, collaborative, and reflective process.

Stories of Adaptation

In the following sections we describe how Ingrid and Julie have adapted components of the IMB approach for use in their teacher education programs. To keep with the flow of how we described the IMB approach above, we begin with Julie’s story as she adapted the FAI and Model Building components for use at her institution. Following her story is Ingrid’s, and her adaptation of the teaching and Lesson Study components of the IMB approach. While neither of these stories demonstrates an adaptation of the complete IMB approach, demonstrating that type of transfer is not our intent with this article. Rather, we want to share how aspects of the IMB approach could be adapted together for use in other institutional structures. Table 1 provides a side-by-side comparison of how the IMB components were adapted for use at our different institutions to meet the needs of our students in our different contexts.

Table 1 (Click on image to enlarge)

Comparison of IMB components across Institutions

Components	Indiana University – Bloomington (IUB)	University of Idaho (UI)	Metropolitan State University of Denver (MSU Denver)
Context and Frequency	• *5-6 preservice teachers placed in one classroom* • *working through all components weekly as a team for* • *iterative process occurs for 5-6 weeks for math and another 5-6 weeks for science*	• *graduate students work individually with a single student* • *process occurs twice in a semester* • *graduate students complete a case study paper about the student's knowledge drawing on information gathered from the process.*	• *one preservice teacher placed in a classroom* • *preservice teachers paired to work through components* • *process occurs once over the course of the semester.*
Formative Assessment Interviews (FAIs)	Preservice teachers conduct FAIs with a pair of students in order to uncover students' thinking about a concept. **FAI Reflection Form** is used.	Graduate students conduct a FAI with a K-12 student to uncover student's thinking about a concept. **FAI Reflection Form** is used.	
Model Building	Preservice teachers build models of students' thinking based on the FAI. **Model Building Form** is used.	Graduate students build a model of a student's thinking based on the FAI. **Model Building Form** is used.	
Act of Teaching	Two preservice teachers plan and teach the lesson while four preservice teachers observe the lesson. **Lesson Observation Form** is used.		One preservice teacher plans and teaches the lesson while one preservice teacher observes the lesson. **Lesson Observation Form** is used.
Lesson Study	All six preservice teachers debrief the lesson with the cooperating teacher and discuss plans for the following week's lesson based on the discussion of students' thinking. **Lesson Study Form** is used.		Two preservice teachers (teaching the lesson and observing the lesson) debrief the lesson and discuss revisions to the lesson based on the discussion of students' thinking. **Lesson Study Form** is used.

Julie's Story of Adaptation at the University of Idaho (UI)

In the final two years of the five year IMB, Julie was a postdoctoral researcher and IMB manager for IMB. In this capacity, she taught the field experience course and coordinated with other instructors of the course. At the same time, she worked with participants after they had completed the field experience and moved to their student teaching or actual teaching placements. Julie was also involved with writing a manual to support others to implement the IMB field experience process.

At her current institution, Julie has incorporated FAIs and Model Building into a graduate course on K-12 mathematics education. The university is a medium-size doctoral granting institution in the upper Northwest of the United States. The course, for which the IMB approach has been adapted, engages masters and doctoral students in exploring: a) connections between research literature and practice (Lambdin & Lester, 2010; Lobato & Lester, 2010), b) the cognitive demand of tasks (Stein, Smith Henningsen, & Silver, 2009), and c) professional noticing (Jacobs et al., 2010; Sherin, Jacobs, & Philipp, 2011). The fully online course lasts sixteen weeks and students engage in weekly modules around these three core foci. Students in the course are primarily practicing teachers from across the state in which the university resides.

The IMB process of engaging teachers in FAIs and Model Building is followed in this course; however, the process spans over a longer period with a whole semester devoted solely to mathematics. Each person designs two FAIs on a specific mathematical topic and completes a Model Building session for each interview. This process is slightly different than the IMB approach because there are fewer students in the graduate class, and since many are practicing K-12 classroom teachers, they have access to students with whom they can easily conduct the FAIs. Despite the teacher population and logistical differences between IUB and UI, Julie used the supporting documents and implemented them in a manner very similar to how they were initially designed and employed for the IMB approach at IUB. For example, at UI each graduate student/teacher selects appropriate mathematics content for the interview based on the standards and learning objectives that are age appropriate for the K-12 student they will interview. They then plan a goal for the interview, along with five problematic questions to be asked during the interview and related follow-up questions. Based on the second focus of the graduate course, they are encouraged to consider the cognitive demand of the tasks they include in their questions. The interview is audio recorded and the graduate students are asked to reflect on the questions outlined on the FAI Reflection Form (see 'Resources', Document A). Referring specifically to the second question on the reflection form, one graduate student responded, "During my post-FAI analysis of the student work and audio, my noticing, once again, improved as I began to consider the relationship between the student's misconceptions and teaching strategies." Comments like this were commonly found across the FAI reflection forms, indicating the value of this interview experience in preparing teachers mathematical knowledge of content and students' understanding of the content (Ball, Thames, & Phelps, 2008).

Following the first FAI, the graduate students are tasked to create a model of the student's thinking that again mirrors the model-building process of the IMB approach (see 'Resources,' Document B). To do this, they are asked to listen to their audio recording and select a clip that highlights what the student says or does as evidence of how the student thinks about particular ideas. They transcribe the segment of audio and conduct an analysis on what the student knows, does not know, and what further information would be helpful. As an example, the following task was given during one FAI conducted by a graduate student — . Going through the Model Building process, the graduate student who gave this question in their FAI highlighted the following portion of their transcript, and provided the accompanying image of the student's work in solving this question.

> Student: I did that because the equal sign is right there. And so because these numbers are supposed to be at the beginning but they switched them around to the end and then you would add them together to get nine and then you would do plus two and then you write your answer (write 11 underneath the box).

> Teacher: How could we check that this (points to the left side of the equation) equals this (points to the right side of the equation? Is there a way we could check that?
>
> Student: Umm… what do you mean?
>
> Teacher: So, I saw that you added these numbers together and placed the nine here. Could we check or is there a way to check that these two things added together equals these numbers added together?

> Student: I guess you could just add them together.
>
> Teacher: Do they come out equal?

> Student: No because this is eleven (points to left side of equation). And then this goes three, four, five, six, seven, eight, nine. Oh! So it goes eleven like that and then eleven, twelve, thirteen, like that and then that will equal nine.

> Teacher: So I saw a light bulb go off. Is that going to change he number you put in there (points to the box)?
>
> Student: So if was eleven, wait, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, twenty, twenty-one, twenty-two and that equals twenty-two. And that is your real answer.

$$17 + 5 = \boxed{22} + 4 = 26.$$

Building on this evidence, the graduate student wrote the following model of the student's thinking with this problem. This model is the graduate student's attempt at explaining the student's thinking with the evidence provided from the task.

> Given a numeric equation with values on each side of the equation but a missing value on one side (e.g. 17+5=___+4), the student added the numbers on one side of the equation and placed that sum into the blank space. The student then continued executing computations by placing another equal sign and adding the newly determined answer with the existing value on that side of the equation. This same action happened in two different tasks with the missing value on the left and right side of the equation. Thus, the student does not conceptually understand the meaning of the equal sign and/or the concept of equality. She does not understand that the equal sign describes the relationship between two expressions and that the correct answer should create two equal expressions. Instead, the student views the equal sign as an indicator to perform computations to find answers.

This model describes what the student knows and understands with respect to different sides of an equation.

Following this first round of FAIs and Model Building, the graduate students then repeat this entire process again, with the same student. However, before the second round, the graduate students have an opportunity to first share their models and thinking in online discussion boards and receive written instructor feedback. Their peers are also required to comment and engage in dialogue with them through the virtual discussions. With the second FAI, the intent is for the mathematical content to align with the content of the first interview, but focus on revealing deeper understandings of this content from the same student. For example, if the first FAI asked questions that broadly addressed fractional understanding at grade three, and the graduate student recognized some misconceptions related to part-whole relationships and understanding, then the second FAI may be designed to focus entirely on part-whole relationships. The purpose of the second FAI is to dive deeper into a child's thinking about the concept to obtain a greater understanding of how the child conceptualizes part and whole.

As the graduate students conducted the series of two FAIs and two Model Building exercises, they focused on the same K-12 student to provide an in-depth understanding of that student's knowledge. As a result, they were then asked to deeply study what they had learned about that student's mathematical thinking and focus on that student as a case study. This is a component that is not included in the original IMB process. Julie elected to add this component of a case study to provide her graduate students the opportunity to revisit both cycles of the FAIs and Model Building processes and formulate some ideas around supporting the student based on evidence from interactions across the two cycles. As a part of the case study, they write a formal paper about the student that includes an analysis of the students' thinking and makes recommendations for supporting the students' understanding in the classroom context—these components stem from the research literature on professional noticing and the importance of attending to thinking, interpreting thinking, and making instructional decisions of how to respond (Jacobs et al., 2010). In the final component of the case study paper, the graduate student situates the student's understanding within the broader mathematics education literature. Therefore, Julie has adapted the FAI and Model Building process of the IMB to engage graduate students in the act of professional noticing through a specific focus on one child as a case study (Jacobs et al., 2010). The following comment from one of the case study reports illustrates the value of this adapted experience for one student, but the same sentiment was echoed by others.

> The student thinking uncovered during the formative assessment interviews and the learning from this course on noticing, cognitive demand, and teacher knowledge combined together to profoundly influence on my views of mathematics instruction. Slowing down to thoughtfully probe a struggling student's thinking revealed so much more than my prior noticing ability would have allowed.

Ingrid's Story of Adaptation at Metropolitan State University of Denver (MSU Denver)

Ingrid joined the IMB as a graduate teaching and research assistant in the second year of implementation. In her first year with the IMB, she instructed a section of the field experience with preservice elementary teachers. Later on in her doctoral program, she taught the affiliated science methods course that is taken in the cluster with the field experience, but was no longer an instructor of the field experience. During this time however, she remained on the IMB as a research assistant. Therefore, throughout her time on the IMB project, Ingrid worked on many facets of the IMB and was integral in developing procedures and protocols for teaching the IMB approach.

At her current institution, Ingrid has adapted the Act of Teaching and Lesson Study components of the IMB, infusing it into her undergraduate elementary science and health methods course. Her institution is a large urban commuter campus with a large majority of students being undergraduates. The student body is diverse and most are from the expansive metropolitan area. For their field experience, which combines science, health, and mathematics, each preservice teacher is placed in an elementary classroom for 45 hours per semester. In most cases, this is usually the fourth field experience these preservice teachers have participated in for their program. The science and health methods course meets face-to-face for 15 weeks of classes and incorporates a teaching rehearsal experience in the methods course to provide the preservice teachers with the opportunity to practice a lesson they have planned and the Lesson Study component of the IMB approach before completing the teaching experience in the field with children.

The preservice teachers at MSU Denver are placed in separate classrooms for their field experience, thus they plan different lessons and teach the lessons independently. Despite this independent teaching experience, Ingrid has tried to maintain the collaborative integrity of the Lesson Study component of the IMB by pairing preservice teachers that are placed at the same school or nearby schools. The purpose of this pairing is so they can serve as peer observers for each other and participate in a shared Lesson Study experience. Unfortunately, this request cannot always be made, and in some instances the preservice teachers work with the mentor classroom teacher through the Act of Teaching and Lesson Study components.

Before the preservice teachers begin their teaching cycle in the field however, Ingrid has her preservice teachers participate in a type of *teaching rehearsal* (Lampert et al., 2013). The preservice teachers are placed into teams of four or five and together they develop a learning plan (similar to a lesson) but with a focus on just the first three Es of a Learning Cycle (Engage, Explore, and Explain) and the learning objective. Preservice teachers usually focus on science, but in some cases they elect to teach a health or engineering lesson. Two groups are then brought together to serve as the different members of the teaching cycle. When one team is teaching, one member of the other team serves as the peer observer completing the Lesson Observation Form (see ‘Resources’, Document C) and all remaining members of the other group are acting as elementary students for the teaching of the lesson. The group then switches and they repeat the experience for another lesson. Following each rehearsal the two groups then walk through the Lesson Study Form and complete it for each rehearsed lesson. Ingrid believes taking her students through this rehearsal of planning a lesson, teaching it, and practicing with the forms helps the preservice teachers to be more successful in all aspects of the Act of Teaching and Lesson Study when they conduct it in their smaller pairings and in the context of their field experience classrooms.

Due to the complex structure of field placement at Ingrid's institution, with it being a commuter-based university serving a large urban/suburban area, Ingrid has made more adaptations to the IMB approach and documents than Julie, some of which are described above. Additional adaptations however, include Ingrid providing feedback on the each preservice teacher's lesson and then having preservice teachers revise the lesson using this feedback, and having the preservice teacher partners participating in a Pre-Observation Conference. The purpose of this conference is help the preservice teachers who are partnered for the Act of Teaching and Lesson Study (or the preservice teacher and the mentor teacher) to understand the learning objectives of the lesson and the intentions of the preservice teacher for structuring the lesson in the manner they did. In addition, there is a section called "look-fors" that directs the preservice teachers to anticipate what the children should be able to do by the end of the lesson (with respect to the learning objective) and what evidence will be gathered to determine this goal was met. This is intended to support the preservice teachers to focus on students' thinking in the Act of Teaching and Lesson Study processes in the field. The pair completes one Pre-Observation Conference Form (see 'Resources', Document E) together for each partner's lesson. To complete the Act of Teaching and Lesson Study cycle, each preservice teacher is required to submit a packet to document the experience that includes: the Pre-Observation Conference Form, the Lesson Observation Form completed by their partner, their collaborative Lesson Study Form, a revised lesson that incorporates the color-coded revisions suggested in the Lesson Study, and a personal reflection paper about what they took away from the experience.

Lastly, Ingrid's Act of Teaching/Lesson Study cycle concludes with a debriefing about the experience with all students in the class. She focuses much of the conversation on asking the preservice teachers to share what they reflected on in their individual papers about the experience and she guides the discussion with questions such as,

- What did you think about the peer observation process?
- How did participating in lesson study support your growth as a teacher?
  What parts of the lesson study process were particularly helpful for you?
- What would you do differently if you could do this again?
- How did lesson study support you in focusing on students' thinking?
- What have you learned from the lesson study process that you will take with you in your future classroom?

From this class discussion she is able to glean how they view the whole process as supporting the preservice teachers' understanding of how to focus their attention on children's scientific thinking and use this information to inform their future instruction.

Reflecting on Our Stories of Adaptation: Lessons Learned

At Julie's institution (University of Idaho [UI]), implementation using FAIs and Model Building have shown to be beneficial for the graduate students, as most of them are practicing classroom teachers. One accommodation from the IMB model is the time span for the FAIs and Model Building. In the modified version, two cycles are spread over six weeks, as opposed to having a new cycle each week. Additionally, one graduate student interviews one student in K-12, as opposed to working in pairs. This has afforded opportunities for greater flexibility with scheduling and diving in deeper around a specific mathematical topic. However, the graduate student has only one student with whom they work and do not develop a broader understanding of various students, which may lessen their opportunity for understanding the thinking of multiple students. Additionally, at UI, every graduate student selects the grade level and the student with whom they will work. The FAIs and Model Building then focus on their selected student and topic, which restricts collaboration across the graduate students and learning from one another; whereas with the original IMB model, the same mathematics topic (e.g., number sense) is covered by each team. This modification affords teams experiencing the full IMB model the opportunity to learn from each other within their team, but also across the teams to learn about content progressions. Therefore, a possible limitation of the modification at UI is that every graduate student has a different topic and they are unable to share and discuss students' thinking and ideas about a similar mathematical domain. Determining ways to work around this limitation depends on the intentions of the course instructor/teacher educator for using FAIs and Model Building. For Julie, her focus is on developing individual teachers' professional noticing, thus the limitations in collaborating with others does not prevent her from meeting her intentions.

Another accommodation from the IMB model is that Julie is unable to attend the FAI recordings in person unlike the field instructors at IUB who are present weekly. The online nature of Julie's course provided the graduate students with flexibility in accessing students and scheduling the recordings at times throughout the school day that worked for them and the students. However, being disconnected to the context limited Julie's abilities, she believes, in providing more targeted or individualized feedback regarding specific student's thinking. The inclusion of the case study however, is how Julie works around the limited contextual understanding she feels she has and it affords her the opportunity to dig more into an understanding of the 'whole' child that her graduate students' are presenting to her. The case study, while it includes evidence from the FAI and Model Building cycles, is only a portion of what is required for the case study paper. Therefore, we suggest the FAI and Model Building be done not in isolation but merged with other tasks that can help foster deeper professional noticing, such as Julie has done with her Case Study assignment.

With respect to Ingrid's story of adaptation at MSU Denver, the implementation of the IMB's modified lesson study has been positively received. As previously described, two accommodations made by Ingrid were the implementation of a modified teaching rehearsal experience and the development of the Pre-Observation Conference Form (see 'Resources', Document E). Considering her field placement arrangements, she learned she needed to include both of these modifications to give the preservice teachers practice with both the Act of Teaching and Lesson Study components before doing it in the field. Also, because the preservice teachers are not placed in the same classroom (unlike IUB) they need the opportunity to first review each other's lesson (i.e., Pre-Observation Conference) so they had some idea of what to expect when observing each other teach.

Overall, the preservice teachers at Ingrid's institution mentioned they enjoy the "lower stakes" atmosphere of being observed by a peer (when possible) rather than a university supervisor and the opportunity to discuss possible revisions to the lesson with a peer considering their different participatory perspectives. This arrangement can create a challenge however, as not all preservice teachers may provide the same level of constructive criticism for revising the lesson. Ingrid has attempted to address this challenge by first providing the teaching rehearsal experience in class so students can gain experience in her methods course on how to complete the forms and provide constructive feedback on a lesson.

Recommendations

There is consensus across both science and mathematics teacher education that for effective teaching to occur teachers must learn to recognize and build on students' ideas and experiences (Bransford, Brown, &Cocking, 1999; Kang & Anderson, 2015, NRC, 2007; van Es & Sherin, 2008). Considering this goal, preparation programs often design opportunities for prospective teachers to question and analyze students' thinking, and when possible do so within the context of teaching science. However, few programs offer a systematic and iterative experience such as the IMB approach, and this is due in part to the structural variation in teacher education programs and the varied constraints of these different models. As Zeichner and Conklin (2005) explain,

there will always be a wide range of quality in any model of teacher education….The state policy context, type of institution, and institutional history and culture in which the program is located; the goals and capabilities of the teacher education faculty, and many other factors will affect the character and quality of programs (p. 700).

Therefore, our intent with this article is to show the potential for taking well-recognized practices for teacher education, such as those used in the IMB approach, and demonstrate how they can be combined for use in other science and mathematics teacher education models. In particular, we wanted to highlight the adaptations made by Ingrid and Julie because their institutions and learner populations are very different from those where the IMB approach was initially developed, and this sort of variation in context is rarely described in the research (Zeichner & Conklin, 2005). Despite the vast program differences at our three institutions, Ingrid and Julie were able to adapt key aspects of the IMB approach to fit the context and needs of their learners.

More specifically, although we recognize that individually the four aspects of the IMB approach are not innovative, it is the potential for combining features of the IMB, as Authors 2 and 3 have shared, that we believe demonstrates the innovation and potential of the IMB approach for impacting science and mathematics teacher learning. As such, we offer the following recommendations from lessons we have learned through our adaptive processes, with the hope of inspiring others to consider how they may combine features of the IMB for use at their institutions.

1. *Understand your own orientation toward teacher preparation.* Begin with selecting aspects of the IMB approach that most align with your own beliefs as to core practices for developing teachers' cognition about learning to attend to students' thinking to inform practice. Ingrid and Julie made their selections based on what they viewed as critical practices given the professional development needs of their student teachers (i.e., their population of teacher), as well as the purpose of their course.
2. *Don't lose sight of the goal!* Make modifications to the sample documents provided (see Resources) or provide additional support documents (e.g., the Pre-Observation Conference form designed by Ingrid) to guide preservice or inservice teachers' cognition of how to uncover K-12 students' ideas and reflect on their ideas in order to identify rich and appropriate learning tasks.
3. *Choose the strategies that best fit your context.* If some components of the IMB approach will not fit into your current program or university structure, select the one that will fit and be most appropriate for your own students and situation. The goal is to help preservice and inservice teachers understand their students' thinking, and whatever strategies can best work for you and your students given your context are the ones to include.
4. *Remember that improvement is an iterative process.* Continue to adapt and refine the approach as needed for your context. Once you have selected the aspect or aspects of IMB that you think will be most impactful, continue to reflect on and obtain feedback about the process from the students with whom you work, and then make modifications to support your goals.
5. *Collaboration is valuable and can take many forms.* At the core of the IMB approach is the belief that collaboration leads to better understandings about learning to teach science and mathematics. Whether collaborating to plan, teach, and reflect on lessons taught, or the sharing of models of students' thinking and engaging through discussion boards online, the notion of collaboration is still at the core of each of our pedagogical approaches to working with teachers. We recognize the structure of various institutions teacher education programs/courses may make it difficult to afford students the opportunity to collaborate in the same physical space (classroom, or school), as did Julie; however, it is worth exploring what technologies your institution may offer to arrange other means of collaborating in synchronous and asynchronous spaces.

[1] For further details comparing these two models of Lesson Study see Carter et al. (2016).

Supplemental Files

IMB-Supplementary-Materials.pdf

References

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