Journal of the Scholarship of Teaching and Learning, Vol. 12, No.2, June 2012, pp. 109 – 120.

Co-teaching a dual content-area methods class: Considering context for evaluating collaborative intensity

Mindy Kalchman[1] and Richard H. Kozoll[2]

Abstract: Mathematics and science are often combined in early childhood education programs into a single methods course. This can lead to an integrated view of the two, thus neglecting their conceptual, procedural, and epistemological differences. To promote their foundational integrities, we, one mathematics and one science educator, collaborated on teaching an amalgamated course. Our impetus was the need to develop mutual ability to instruct the course independently. In this paper, we reflect on and discuss the context of our collaboration, from which emerged a conceptualization of co-teaching that emphasizes the importance of context for motivating and understanding its nature.

Keywords: reflective practice, co-teaching, collaboration, higher education, teacher education.

There are many reasons college level co-teaching has been implemented. Broadly, it has been used to improve student outcomes (Dugan & Letterman, 2008), promote professional development between and among faculty (Duchardt, Marlow, Inman, Christensen, & Reves, 1999), and model mentorship and collaboration in the classroom (Kluth & Straut, 2003). Within our field of teacher education, co-teaching has addressed circumstances of interdisciplinary programmatic collaboration for courses such as early childhood special education (Hestenes et al., 2009), and it has been recommended for integrated methods classes that prepare preservice elementary teachers for the challenges of being effective generalists in the classroom (Zhou, Kim, & Kerekes, 2011).

Regardless of the impetus, the broader body of literature on co-teaching suggests its potential to enhance the teaching and learning experience for everyone involved (Brody, 1994; Crow & Smith, 2005). Expanding available literature that helps stakeholders establish expectations and prepare for the experience can encourage college faculty to engage in collaborative activity and administrators to support it. For example, Perry and Stewart (2005) have offered a continuum depicting degrees of collaborative engagement between and among faculty across co-teaching scenarios. However, modeling a general degree of intensity throughout a co-teaching commitment is challenging because it is the particular context of a collaboration that determines the intensity of its participants' involvement. Here, we define collaborative intensity as the intellectual energy, diligence, and time participants invest in the process, and by context we refer to the relevant set of circumstances associated with the collaboration.

In this reflective essay, we share our experiences with co-teaching a combined mathematics and science methods course for early childhood preservice teachers. To capture this undertaking, we took detailed anecdotal records of our preparations for, and teaching of, the

[1] Department of Teacher Education, DePaul University, 2320 N Kenmore Ave., Chicago IL, 60614, mkalchma@depaul.edu.
[2] Department of Teacher Education, DePaul University, 2320 N Kenmore Ave., Chicago IL, 60614, rkozoll@depaul.edu.

course. We used these records to reflect on and characterize the varying nature of our collaborative efforts throughout the process. Thus, by sharing our story we aim to contribute to the available scholarship related to co-teaching and the importance of considering context when preparing for and implementing it. We begin by introducing our context and then go on to describe general phases of collaboration we identified throughout. We consistently reflect on the levels of collaborative intensity as they relate to the aforementioned phases, and finally we conclude with what we learned from the process.

I. Context.

Historically, mathematics and science, as content area disciplines, are often paired because of their inherent relationship (American Association for the Advancement of Science, 1993). For example, some of the mathematical strands discussed in the *Principals and Standards for School Mathematics* (National Council of Teachers of Mathematics [NCTM], 2000), such as measurement and communication, correspond to scientific process skills that are addressed in the *National Science Education Standards* (National Research Council [NRC], 1996). More recent reform documents such as the *Common Core State Standards Mathematics* (CCSSM) (National Governors Association [NGA], 2010) and *A Framework for K-12 Science Education: Practices Crosscutting Concepts and Core Ideas* (NRC, 2012) maintain the connections in their recommendations and statements.

The mathematics/science connection is also reflected within some early childhood teacher education programs where there is a single course addressing methods of mathematics and science instruction, with many of the available text book options for these courses also addressing both content areas (e.g., Charlesworth & Lind, 2007; Davis & Keller, 2009; Prairie, 2005). In our own teacher education program, we have such a combined early childhood mathematics and science methods course, and traditionally, a single faculty member with expertise in one or the other discipline is assigned to teach it.

Prior to our collaboration we had each been assigned to teach the combined course individually without what we felt to be adequate knowledge of science education in one case and mathematics education in the other. Thus, supported by Boyer's (1990) assertion that "[t]hose who teach must, above all, be well informed, and steeped in the knowledge of their field" (p. 23), we proposed to our administration that we co-teach the course in order to improve our understanding of the content and pedagogy in our respective deficit subject-areas and thus be better prepared to teach the course as individuals. We explained that an inherent relationship between mathematics and science does not necessarily mean a mathematics educator will be proficient in science education, and vice versa. We further clarified that our goal was to emerge from our collaboration more confident and capable of teaching the course as individuals rather than for each of us to teach half the course as it related to our fields of study. That is, we wanted to learn about teaching and learning in the discipline not our own so that we could take on the course independently from a more informed, skilled perspective.

Our collaboration plan involved all aspects of the course ranging from developing the syllabus, selecting course readings, determining and grading assignments, to instructing the course. Although our request was approved, resources were not available to extend the opportunity beyond a single quarter. Thus, it was important that we learn as much as possible about teaching and learning in one another's discipline within this limited time frame.

II. Phases of Collaboration.

A. Stage 1: Course Conceptualization.

The combined early childhood mathematics and science methods course at our institution is taught at both the graduate and undergraduate levels. At the graduate level the course meets for three hours weekly throughout an 11-week quarter. In addition to weekly class meetings, the course requires 15 field experience hours in an early childhood setting equally divided between mathematics and science teaching. Likewise, the undergraduate version of the course has weekly three-hour sessions and requires 20 field experience hours. Both course descriptions emphasize an exploration of theoretical principles, materials, methods, and activities for teaching mathematics and science in preschool and primary grades.

In the past, the course has been structured according to the scope and sequence outlined in a relevant textbook. Course material has been either primarily integrated or else weighted in terms of instructors privileging one subject area over the other. Thus, our first collaborative task was to review relevant literature and then consider whether or not we wanted to use an integrated focus for the course, or if we wanted to separate out the subjects now that we had content-area and pedagogical experts for each. One widespread argument we found for integrating mathematics and science focused upon the relevance of learning mathematics within the context of science in order to avoid students accumulating isolated facts and procedures (Meier, Nicol, & Cobbs, 1998). Another compelling position related to specifically integrating methods classes in order to better prepare preservice elementary teachers for their future "generalist" positions in the classroom, where they will be responsible for covering the curriculum for myriad subject areas (Zhou, Kim, & Kerekes, 2011). A more pragmatic thesis was that integrating the two subjects is a more efficient and effective use of instructional time (Stinson, Harkness, Meyer, & Stallworth, 2009).

However, there were also significant arguments opposing the integration of mathematics and science in the classroom. For example, an integrated view of mathematics and science does not acknowledge their conceptual, procedural, and epistemological differences as subject areas (Lederman & Niess, 1997), and thus may not prepare preservice teachers for the specific content-area demands of instruction. Preservice teachers already receive limited exposure to what they are expected to teach and how they are supposed to teach it (Ball, Sleep, Boerst & Bass, 2009). At our institution, liberal studies and early childhood certification requirements include candidates taking two scientific inquiry courses and the course *Quantitative Reasoning and Technological Literacy*, which satisfies the only mathematics-related requirement. Furthermore, those who take dual-content methods courses and are not afforded the time for an entire course of study in either area, do not have the opportunity to develop adequate content knowledge and related instructional skills within each discipline. Such epistemologically differentiated understandings are necessary for pre-service teachers so they may offer their future students the requisite subject-specific foundational knowledge that leads to meaningful applications (Lederman & Niess, 1997).

Potentially, one way to potentially differentiate mathematics and science within the constraints of a single methods course is to organize content around "big ideas" (Bransford, Brown, & Cocking, 1999). Indeed, organizing one's thinking around big, or unifying ideas as opposed to emphasizing isolated facts or prescribed information is a hallmark of how experts operate in their respective fields. Integrating mathematics and science methods conflicts with this notion because the broader themes across the content areas are in fact different. For example, number sense is a "big idea" discussed extensively as a unifying theme throughout the *Principles and Standards for School Mathematics* (NCTM, 2000) and the new CCSSM (NGA, 2010). Yet, it is not found in the *National Science Education Standards* (NRC, 1996), or in *A Framework for K-12 Science Education: Practices Crosscutting Concepts and Core Ideas* (NRC, 2012). Thus, an integrated approach to a mathematics and science methods course may further limit early childhood and elementary teachers' opportunities to develop mathematical and scientific content knowledge that is so critical to effective pedagogy. (Appleton & Kindt, 1999; Ball, Sleep, Boerst & Bass, 2009; Harlen & Holroyd, 1997; Lederman & Niess, 1997).

Thus, the ultimate conceptualization of the course centered upon what we each considered to be the central, or unifying, "big ideas" underpinning teaching and learning in each of mathematics and science (Bransford, Brown, & Cocking, 1999). However, because of the limitations of time within an 11-week quarter and our commitment to differentiating the epistemological underpinnings of mathematics and science, we agreed to focus on one central unifying conceptual theme for each discipline. For mathematics this theme was number sense and for science it was inquiry. We individually selected one theme before discussing how we would elaborate on it within the four class sessions specifically allotted to each content area. That is, we planned to have a general introductory class session during which we would review the syllabus, course requirements, and other relevant logistics. This would be followed by four class sessions related to mathematics education, one class session to transition to science education, four class sessions dedicated to science education, and finally a concluding class session.

We characterized the collaborative intensity of this course conceptualization stage as moderate. This is because we selected each theme individually and were each accountable for sharing and justifying our choices. However, the initial discussions about the approach to take in the course required us to review literature on the impact of learning both content and pedagogy from an integrated versus differentiated perspective. These literature reviews and consideration of their findings were moderately intense because although we could do much of the reading individually, we did need to come together to share our thoughts and to deliberate and discuss them.

B. Stage 2: Initial Co-Planning.

Next, we began planning the class and developing a syllabus, reading agenda, and course of study. We began addressing our reading agenda by reviewing available and recommended textbooks. In reviewing them, one possible option included the use of both a mathematics and science methods text relevant for prospective early childhood educators. However, the books we considered for this option were costly and covered too many topics in too little depth relative to our time frame. Another option was to choose a textbook that combines the pedagogies of early childhood mathematics and science. Upon review, we felt these sorts of texts undermined our intentions of clearly defining the central themes we had identified in our initial conceptualization of the course. Thus we decided not to use an existing textbook, but rather to compile a selection of seminal and relevant readings that would offer teacher candidates concrete instructional ideas with strong theoretical bases while encompassing the aforementioned "big ideas."

Finally, we had to develop and agree upon course assignments that would provide us with insight into students' conceptualization and application of each content area's "big idea" and their pedagogical implications. This entailed reflecting on those mathematics and science education assignments we already used in our respective single-subject methods coursework and on their appropriateness for a dual-content course. This review led to the reformulation of certain assignments aimed at students communicating their theoretical and pedagogical content knowledge. Ultimately, revised assignments included reading response papers and lesson plans. We also designed a new assignment for which we asked students to identify and analyze the mathematical and scientific connections young children make both in and out of school.

The collaboration involved in this co-planning was highly intensive because of the dual nature of the course content. That is, while planning the course we were also beginning to develop pedagogical and content knowledge of one another's discipline. For example, the science educator not only had to plan for an early childhood methods course around inquiry but also needed to learn about and plan around number sense in mathematics. The same held true for the mathematics educator. Further, deciding on our reading agenda not only involved reviewing the texts and deciding on a compilation of readings but also reading and discussing one another's selections for their readability, content, length, and relevance to course goals. Likewise, determining course assignments involved a similar review and discussion of one another's individual syllabi.

C. Stage 3: Individual Instruction.

Subsequent to the co-planning stage, the mathematics educator solely instructed the undergraduate version of the course during the fall quarter because our collaboration had only been approved for the winter quarter graduate sections. Although she taught the course individually, we maintained a moderate level of collaboration. We continued to meet weekly to organize the content and instruction of each individual class session and to discuss the implications and applications of the week's reading. These meetings were significantly shorter than those for the initial co-planning stage and our time together varied depending on the content area focus of the upcoming class.

To illustrate, for an upcoming class session devoted to mathematics teaching, the mathematics educator shared the activity that she would typically do for that week's instructional focus, such as playing board games for developing number sense. We discussed the activity relative to the weekly readings and the "big idea" represented therein. This allowed the science educator to offer ideas for engaging learners as well as to ask questions pertaining to instruction. Likewise, when meeting to prepare for a class such as one devoted to teaching physical science through inquiry-based practices, the science educator shared the activity he would typically implement in his own science methods courses, which is having students complete a circuit involving batteries, bulbs, and wires to provide an experiential context for discussing inquiry and physical science content. Drawing from what the mathematics educator learned from the week's readings, she participated in this activity in preparation for implementing it in the forthcoming class and discussed its significance as a "big idea" in science education. Furthermore, she had the opportunity to offer feedback on its conceptual and procedural accessibility to new learners.

D. Stage 4: Co-Planning Revisions.

After the mathematics educator taught the course and students completed their course evaluations we went into a period of highly intense collaboration in order to revise the course and prepare to co-teach it the following quarter. This stage was condensed relative to the initial co-planning because of the limited amount of time between academic quarters. It was highly intensive because we had to return to the broader conceptualization of the course, and examine readings, assignments, and class session content in the context of the learning goals we established during our initial co-planning and the students' feedback. Further, we had to consider the knowledge we had each developed in one another's discipline in order to ensure the revised course plan effectively facilitated our inevitable return to instructing the course as individuals.

As mentioned above, during the initial co-planning of the course we spent significant time selecting seminal and appropriate readings that were comprehensive enough to communicate those "big ideas" essential to early childhood mathematics and science. Students' feedback about the readings through associated assignments and in-class discussions, as well as the mathematics educator's experiences with grading students' work and facilitating discussions, necessitated revisions with respect to course readings. For example, the seventh week of the course introduced inquiry learning and the emergence of alternative conceptions in science education. We intended the readings for that week to address alternative conceptions through inquiry learning. However, it turned out that although the description of alternative conceptions was clear their relationship to inquiry learning was not. To illustrate, in the primary article we assigned, Sewell (2002) situated her discussion of alternative conceptions within constructivist theory rather than through its explicit application of scientific inquiry. Thus, this iteration of the course did not adequately provide the students with an opportunity to fully appreciate the significance of inquiry learning as best practice for addressing alternative conceptions. Consequently, we decided to restructure the reading list to include additional articles (Blake, 2009; Palmeri, Cole, DeLisle, Erickson, & Janes, 2008) specific to the role of inquiry learning in science education.

E. Stage 5: Co-Teaching.

The next phase of collaboration took place the following quarter when we co-taught the course. Although we met briefly each week before class to do routine preparations such as review the day's agenda, discuss student progress, and prepare materials, we characterized these collaborative efforts as minimal compared to the preceding planning stages. Furthermore, while we met periodically throughout the quarter to grade student work, the time spent on determining course assessments in the two earlier planning stages was thorough enough to expedite this.

With respect to the actual instruction, because half the course was dedicated to early childhood mathematics instruction and the other half to science, each of us acted as lead teacher for certain portions of those class sessions devoted to our respective areas of expertise. The lead teacher was in charge of such things as introducing activities and facilitating discussions about the week's readings, yet we each actively participated in these experiences and discourse. This format allowed us to rely upon one another's respective content area expertise and to act as not only instructors but also as students noting the features, nuances, and patterns experts readily recognize in their disciplines (deGroot, 1965).

For instance, during one class session the science educator introduced the role of sustained inquiry experiences where students investigate questions over time and within differing contexts. Here the mathematics educator noted the role of posing investigative questions that students could answer through their own observations and evidence without necessarily asking explanatory questions pertaining to why something happened. When exploring the properties of magnets, learners observed that magnets attracted only certain materials and compared and contrasted those observations with predicted outcomes and prior experiences with magnets. Students then generalized their observations to communicate that for instance, magnets do not attract all metal objects as may have been originally supposed. Accordingly, the goal of the activity was not to understand *why* magnets attract certain materials, simply that they do. In mathematics education, learners are also expected to solve problems and answer questions using processes such as inquiry, observation, and exploration. However, working toward understanding and communicating why procedures and algorithms work is also critical. Teachers and students strive to respond clearly to questions pertaining to the conceptual bases for learned procedures so that students better understand the history, application, and utility of doing mathematics. Thus, our individual observational roles centered on comparing and contrasting the principles and practices of our respective disciplines with our developing understanding of how to teach in the other's content area.

When it came to the more general, content neutral aspects of each class session such as discussing field experiences and assignments, there was more seamless leadership between us. Our intent was to establish ourselves as the co-instructors of the overall course as opposed to individual content area instructors responsible for only half the course material. This encouraged each of us to reflect upon both the mathematics and science components of the course for general revisions in preparation for future individual instruction.

F. Stage 6: Reflection.

In the final stage of our process we returned to a high level of collaborative intensity as we reflected upon and prepared to teach the course independently in the following academic year. Generally we revisited our overall co-teaching process beginning with the course conceptualization through co-teaching. We also reviewed students' course evaluations for suggestions or predominant themes that would offer additional areas for revision. Evaluations communicated that for the most part students were pleased with the structure and conceptualization course, but some still "[wished] there were more time to spend on each subject."

We considered this reflection stage to be highly intensive because of its focus on what we learned conceptually and instructionally about the "big idea" in one another's discipline. To ensure that each of us was adequately prepared to independently teach the course in the fall, we first took the opportunity to work through any apprehensions we still had about teaching in one another's content areas. For example, when the mathematics educator reflected upon the underlying theme of inquiry across the science education portion of the course, she first considered how it was experientially illustrated in a physical science activity involving circuitry. Specifically, she had to think about how she would recreate the activity while facilitating a discussion about the role of inquiry as a "big idea" in early childhood science education. As part of this reflection, she engaged the science educator in the aforementioned activity and discussion, all the while soliciting feedback. A comparable process was used for number sense in mathematics.

We also felt it was necessary to revisit select pieces of students' work in order to ensure we could confidently and competently assess it independently in both subject areas. For instance, in reviewing one student's mathematics lesson plan we were able to discuss and assess the implications of her procedural over conceptual emphasis and establish how to communicate that with concrete examples and suggestions for change. Likewise, when reviewing a student's science lesson plan, we identified the organizing framework as one of validation and not inquiry-based science. That is, the pre-service teacher had students confirming what they had already been told would happen as opposed to allowing them to fully explore the outcome and the science therein. This process not only allowed us to develop proficiency with assessment in one another's discipline but also helped formulate changes and revisions to course material.

III. Summary Discussion.

Our collaboration consisted of six discrete phases and three levels of intensity – minimal, moderate, and high. We began with conceptualizing the overall course with a moderate amount of collaborative effort. Then we progressed to our initial co-planning stage, which we characterized as highly intensive. In the next stage the mathematics educator individually taught the course with moderate collaborative input from the science educator. Next we returned to a high level of collaboration as we co-planned revisions in preparation for co-teaching. Then we co-taught the course at a low level of collaborative intensity before finishing with a high level of collaboration as we reflected on our experiences and prepared to teach the course as individuals. See Figure 1 for a representation of the six phases and their respective levels of intensity.

The genesis of this process emerged from our initial purpose: We each needed to learn how to teach early childhood methods in one another's content area in order to ultimately teach the course independently. Having completed our initiative, we both feel sufficiently prepared to teach the course in its entirety. We attribute this preparation to significant learning opportunities the context of our collaboration afforded us. First, becoming familiar with and eventually conceptualizing the course around "big ideas" had a tremendous impact on our learning. When the science educator structured the course on his own and prior to any collaboration with the mathematics educator he organized the mathematics portion of the course according to individual topic areas found in a textbook. He can now see that in doing so, he did not establish number sense as an infrastructure of early childhood mathematics and how it would connect individual topics such as measurement, geometry, number and operations (NCTM, 2000). Likewise, the mathematics educator expected to organize the science education aspect of the course around the different science content areas: Life; Physical; and Earth and Space Science. This contrasts with emphasizing the teaching of science through inquiry and using that as a common thread that underlies the instruction of any scientific area of study.

Our co-teaching goal was to develop confidence and expertise in each other's disciplines. Our aim for this paper was to inform others' plans for co-teaching by sharing our experiences, communicating the details of our practice and the varying intensity of it, and modeling the reflection process. We found, for instance, that our actual co-teaching phase was the least intense period of our collaboration. This is in contrast to Perry and Stewart's (2005) continuum, along which co-teaching involves highly collaborative work. Furthermore, it is likely that our work together would have looked very different if we were to co-teach this course indefinitely because the need to become competent in one another's disciplines would not have been necessary to the same extent. Thus, characterizations of co-teaching must account for particular contexts motivating the partnership and inspire the sort of reflective practices that Boyer (1990) referred to as a scholarship of teaching.

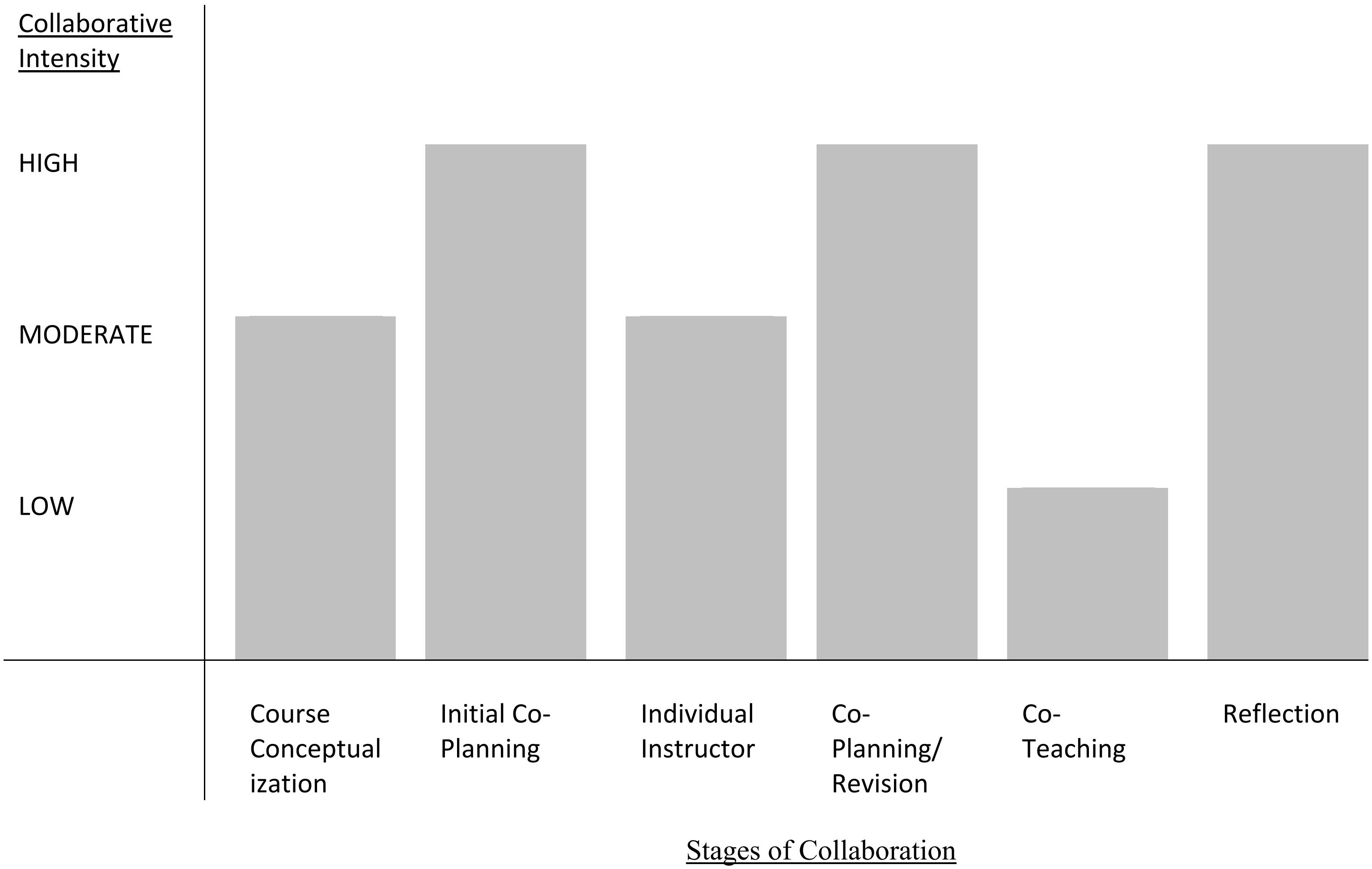

***Figure 1*. Stages of Collaboration and Their Respective Degrees of Intensity.**

Acknowledgments

The authors thank the Quality of Instruction Council at DePaul University for their support of this project.

References

American Association for the Advancement of Science (1993). *Benchmarks for Science Literacy*. New York, NY: Oxford University Press.

Appleton, K., & Kindt, I. (1999). Why teach primary science? Influences on beginning teachers' practices. *International Journal of Science Education*, *21*(1), 155-168.

Ball, D.L., Sleep, L., Boerst, T.A. & Bass, H. (2009). Combining the development of practice and the practice of development in teacher education. *Elementary School Journal, 109*(5), 458-474.

Blake, S. (2009). Engage, investigate, and report: Enhancing the curriculum with scientific inquiry. *Young Children, 64*(6), 49-53.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school*. Washington D.C.: National Academy Press.

Boyer, E. L. (1990). *Scholarship reconsidered: Priorities of the professoriate*. San Francisco: Jossey-Bass.

Brody, C. (1994). Using co-teaching to promote reflective practice. *Journal of Staff Development, 15*(3), 32-36.

Charlesworth, R. & Lind, K. K. (2007). *Math & science for young children, Fifth Ed*. Clifton Park, NY: Thomas Delmar Learning.

Crow, J. & Smith, L. (2005). Co-teaching in higher education: Reflective conversation on shared experience as continued professional development for lecturers and health and social care students. *Reflective Practice, 6*(4), 491-506.

Davis, G. A. & Keller, J. D. (2009). *Exploring science and mathematics in a child's world*. Upper Saddle River, NJ: Pearson Education Inc.

deGroot, A. (1965). *Thought and choice in chess*. The Hague, the Netherlands: Mouton.

Duchardt, B., Marlow, L., Inman, D., Christensen, P., & Reeves, M. (1999). Collaboration and co-teaching: General and special education. *The Clearing House, 72*(3), 186-190.

Dugan, K., & Letterman, M. (2008). Student appraisals of collaborative teaching. *College Teaching*, *56*(1), 11-15.

Ebby, C. (2000). Learning to teach mathematics differently: The interaction between coursework and fieldwork for pre-service teachers. *Journal of Mathematics Teacher Education*, *3*(1), 69-97.

Harlen, W., & Holroyd, C. (1997). Primary teacher understanding of concepts of science: Impact on confidence and teaching. *International Journal of Science Education*, *19*(1), 93-105.

Hestenes, L., Laparo, K., Scott-Little, C., Chakravarthi, S., Lower, J., Cranor, A., et al. (2009). Team teaching in an early childhood interdisciplinary program: A decade of lessons learned. *Journal of Early Childhood Teacher Education, 30*(2), 172-183.

Kluth, P., & Straut, D. (2003). Do as we say and as we do: Co-teaching in the university classroom. *The Journal of Teacher Education*, *54*(3), 228-240.

Lederman, N. G., & Niess, M. L. (1997). Integrated, interdisciplinary, or thematic instruction? Is this a question or is it questionable semantics? *School Science and Mathematics*, 97(2), 57-58. Mathematics. (2009). *Young Children*, *64*(3), 10-44.

Meier, S. L., Nicol, M., & Cobbs, G. (1998). Potential benefits and barriers to integration. *School Science and Mathematics*, 98(8), 438-447.

Merseth, K., (1993). How Old Is the Shepherd? An Essay About Mathematics Education. *Phi Delta Kappan*, *74*, 548-554.

National Council of Teachers of Mathematics. (2000). *Principles and Standards of School Mathematics.* Reston, VA: Author.

National Governors Association: Center for Best Practices, Council of Chief of State School Officers. (2010). *Common Core State Standards Mathematics*. Washington D.C.: Author.

National Research Council. (1999). *National science education standards: Observe, interact, change, learn*. Washington, D.C.: National Academies Press.

National Research Council. (2012). *A framework for K-12 science education: Practices crosscutting concepts and core ideas*. Washington, DC.: National Academies Press.

Palmeri, A., Cole, A., Delisle, S., Erickson, S., & Janes, J. (2008). What's the matter with teaching about matter? *Science and Children, 46*(4), 20-23.

Perry, B., & Stewart, T. (2005). Insights into effective partnership in interdisciplinary team teaching. *System*, *33*, 563-573.

Prairie, A. P. (2005). *Inquiry into math, science, and technology for teaching young children*. Clifton Park, NY: Thomas Delmar Learning.

Science. (2009). *Young Children*, *64*(6), 10-69.

Sewell, A. (2002). Constructivism and student misconceptions. *Australian Science Teachers Journal, 48*(4), 24-28.

Stinson, K., Harkness, S. S., Meyer, H., & Stallworth, J. (2009). Mathematics and science integration: Models and Characterizations. *School Science and Mathematics*, 109(3), 153-161.

Zhou, G., Kim, J., & Kerekes, J. (2011). Collaborative teaching of an integrated methods course. *International Journal of Elementary Education, 3*(2).