Co-teaching in Physical Sciences at the University Level:

Positive Impacts of Combining Two Areas of Expertise

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Proceedings Abstract

Co-teaching by a professor of physical science and a professor of information science in the university context of teaching control variable experiment concepts and information and technology literacy skills to future teachers of science was initially investigated. Quantitative and qualitative findings were used to inform modifications to future instruction and to create an Institute of Museum and Library Services research project proposal. As a result, a 2015 Laura Bush 21st Century Librarian Program Grant ($496,277) was funded to support fifty students enrolled in four, three-credit hour courses required for a new information, technology, and scientific literacy certificate program. The presentation highlights justification for educational change at the university level; the innovative work that was done across two university programs to create and approve new interdisciplinary course titles, purposes, and learning outcomes; and the design of assignments and learning activities that build co-teaching dispositions and skills. Elements of co-teaching in contrast to solo teaching are emphasized. For later classes, strategies and techniques were developed that resulted in improved student abilities to identify and articulate authentic research topics when making use of primary and secondary sources of authority that inform topics, problems, central questions, hypothesis statements, and experimental variables. A new theory of co-teaching, the *intensity of effort theory* of co-teaching, is proposed to explain what happens when two educators work together to build maximum intellectual strength in themselves that can be measured by their students' achievement of identified learning outcomes.

Co-teaching in Physical Sciences at the University Level: Positive Impacts of Combining Two Areas of Expertise

Co-teaching is growing as a strategy for educational change. According to Ledin and Conderman (2015), co-teaching provides equitable learning opportunities and increases collaboration between instructional leaders in regular and special education. Co-teaching using integrative curriculum and hands-on lessons including math, science, language arts, religion, art, physical education, music, sociology, and geography has been explored for effectiveness (Lee, 2007). In teacher education programs, co-teaching is used as a strategy to enhance student teaching experiences (Bacharach, Heck, and Dahlberg, 2013). Co-teaching in academic institutions (ACRL, 2016), and PreK-12 schools (Dow, 2013) ideally serves to embed library, information, and technology literacy instruction in content area learning.

Shared in this paper, and our 2017ASTE conference presentation, are philosophical and practical explanations for co-teaching using cross-disciplinary curriculum and learning outcomes with two university professors teaching entire courses together. We believe our experiences are demonstrating the need for co-teaching as a strategy for delivery of instruction that increases an "individual's knowledge, attitudes, and skills to identify questions and problems in life situations, to explain the natural and designed world, and to draw evidence based conclusions about STEM related-issues" (Bybee, 2013, p. 65). An overview follows of the in-progress STEM-ALL project at Emporia State University (ESU) in Emporia, KS, USA, including justification for this educational change, how we teamed up, our discoveries about the benefits of co-teaching over solo-teaching, and our instructional modifications in later courses.

Justification for Educational Change

The National Research Council (NRC, 2012a) in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* emphasizes that through education, teachers must improve the United States global economic competitiveness, create a better workforce, and find solutions for solving problems related to the environment, energy, and health. In addition, the NRC (2012b) in *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century* asserts a strong argument that a key set of information fluency skills is required to foster the necessary deep learning, higher order thinking, and college and career readiness if students are to reach their full potential. Recently, the Every Student Succeeds Act (ESSA) of 2015 (20 USC 6301), Public Law 114–95, articulates new roles and purposes for education including a mandate for states to have flexibility in developing accountability systems, deciding how tests should be weighted, determining measures of student and school performance, and in evaluating teachers. ESSA includes new provisions that authorize states and districts to use grant funds to support instructional services provided by school library programs; address access to effective school library programs as part of professional development; and describe how effective school library programs will provide students an opportunity to develop digital literacy skills and improve academic achievement. These national mandates and changes in the federal law ensure that school libraries and school librarians are included in state and local education plans.

Two University Programs Come Together

In response to national calls for educational improvement, a professor of physical sciences and a professor of library and information science at ESU "teamed up . . . to create a campus-wide partnership . . . to prepare future classroom teachers and school librarians as co-teachers" (Dow, 2014, p. 15). Together we created the STEM-ALL program: Science, Technology, Engineering, and Mathematics: Information, Technology, and Scientific Literacy for All. To avoid common sense understandings of STEM education, we adopted Bybee's (2013) definition of "STEM literacy" (p. 65) and his position on developing cross-disciplinary instruction. We obtained funding from the Institute of Museum and Library Services that provides scholarships to 50 students for tuition, books, and travel expenses for two face-to-face Saturday class sessions on the Emporia, KS campus. Face-to-face class sessions provide content and instructional details. In addition to time with the Professors and fellow students, guest presenters share their expertise and first-hand knowledge of relevant STEM topics. Throughout the semester, professors and students use Canvas, a platform for technology-based instruction.

We started by creating new course syllabi for four, distinctive for-credit courses. The new syllabi were approved through the University course approval process in three degree programs. To determine course learning outcomes, we did an exhaustive review of standards documents looking for relationships and convergences in mathematics, science, and English language arts. We discovered a common thread running through all content area standards that clearly conveys information and technology skills competencies. It was at strategic point where content and information and technology come together in content standards that we located our new courses to teach an agreed upon course content and a skill set. Consequently, each of the four courses require university students – science, technology, engineering, mathematics, and school librarians – to attend courses together and to learn and demonstrate the same advanced knowledge and skills that they can later modify for grades 4-12 instruction.

Elements of Effective Co-teaching

Our experiences indicate that effective co-teaching "involves sharing planning, organization, delivery and assessment of instruction; sharing the physical and/or virtual space of instruction; and combining two or more areas of academic expertise in learning outcomes and assignment activities" (Dow and Thompson, 2017, in-press). Combining two areas of academic expertise as we have done enables students to learn science and mathematics principles while at the same time becoming information and technology literate.

Through acquiring advanced skills for access, retrieval, evaluation, and use of published sources (ARCL, 2016; KSDE, 2016), educators gain substantive, reliable knowledge about big relevant problems in the world such as prevention and treatment of illness and disease, maintaining clean food and water, sufficient energy, and global environmental change. We observed during the first two years of the project that substantive reading results in improved articulation of topics and problems; improved development of hypothesis and research questions; and improved identification of variables and overall design of investigations. Based on the ACRL (2016) framework, students have new, worthwhile understandings of information value, information as exploration, information research and inquiry, information authority, information formats, and information as conversation.

Strategies and Techniques in Later Classes

For later classes, strategies and techniques were developed that resulted from our summative and formative assessment and analysis of a control variable experiment unit comprised of seven assignments (Thompson and Dow, 2017, in-progress). Our new strategies and techniques have improved student abilities to identify and articulate authentic research topics when making use of primary and secondary sources of authority that inform topics, problems, central questions, hypothesis statements, and experimental variables. Our instructional modifications were informed by our observations of student's limitations and out understandings of the gaps in learning that we needed to fill.

New structure for scenario writing. We developed a four-part structure for writing topic/problem scenarios from which central research questions can be identified, claims and hypotheses stated, and control variable experiments can be designed. We call this model the *observe, know, question, claim* model. (This model is available in presentation PP.)

More instruction for locating and reading multiple sources of authority. Through using the *observe, know, question, claim* model together with professor-written examples of scenarios, we offered our students more specific guidance for exercising curiosity and increasing what they know from reading multiple sources of authority. We articulated specific ways to become immersed in reading appropriate publications to increase students' depth of knowledge of real problems that they observe. We also emphasized proper use of control variable experiment vocabulary when conducting advanced database searches. This modification improved retrieval and use of relevant sources and resulted in higher quality scenario writing.

Provided professor-written topic/problem scenarios. We provided later students more time to examine and discuss good scenario examples. When students were given time to listen and then study our example scenarios, they learned more quickly to use the *observe, know, question, claim* model we recommend for topic selection and writing problem statements. Students were encouraged to become more knowledgeable of a selected topic by going beyond the textbook to other current publications with the guidance of the librarian.

New research process model. We created a new illustration showing eight steps of experimental research. Our model targets co-teaching content and librarian experts. It divides the research process into two phases: Phase One, Preparation, Literature Context; and Phase Two, Experimental, Data Context. During topic selection and problem statement writing, the researcher is asked to actively access, retrieve, evaluate, and use existing research publications with assistance from a professional librarian before moving on to the text steps in the experimental process. (This model is available in presentation PP.)

Summary

Our co-teaching in ESU's STEM-ALL project is in-progress and has produced new language for describing the philosophy (how to think) and science (how to practice and observe) of co-teaching in the current ESSA age of school librarians as teaching partners with content teachers. Our new theory, "the *intensity of effort theory of co-teaching*, can be widely used to explain what happens when two or more educators work together to build maximum intellectual strength in themselves that can be measured by their students' achievement of identified learning outcomes. Educators together 1) lift and support substantive aspects of the weight of the curriculum and instruction; 2) contribute multiple repetitions explaining what students should know, do, and learn; and 3) exert significant efforts during the planning, implementation, and evaluation of ongoing instruction" (Dow and Thompson, 2017, in-press). Courses include multiple assignments built on standards-based competencies. Course titles provide a four-part outline that can be considered as school building level educators develop integrative curriculum. Learning outcomes identify criteria that should be observed and used in teacher evaluation as well as in assessment of student learning. We are involved in creating a STEM-literate society.

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