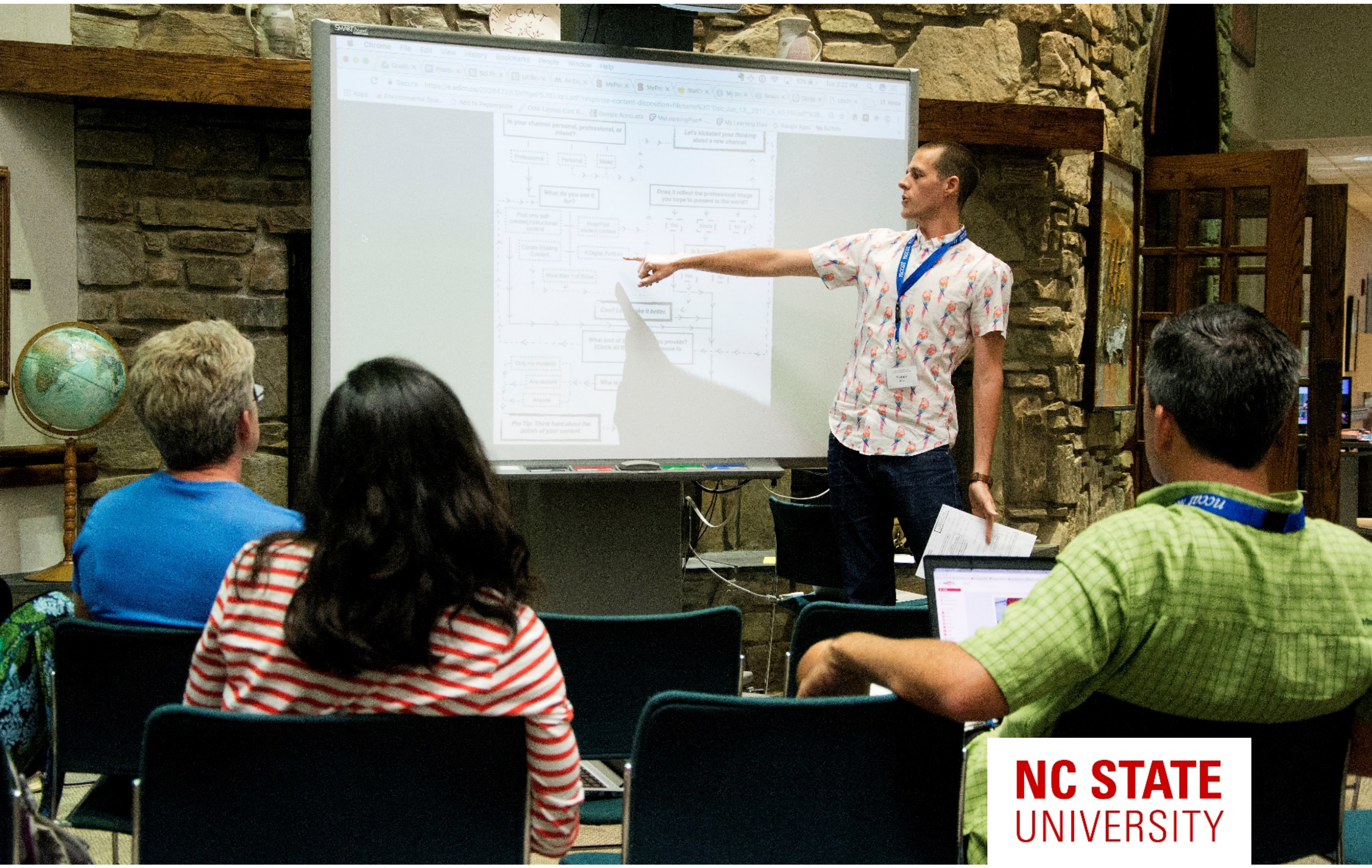
KENAN FELLOWS PROGRAM
FOR TEACHER LEADERSHIP

ISSN 2474-7432



NC STATE
UNIVERSITY

# Journal of Interdisciplinary Teacher Leadership

VOLUME 2, NO. 2, SUMMER 2017

# Table of Contents

## ARTICLES



## LITERATURE REVIEW



## ACKNOWLEDGEMENTS

# Developing Advocacy in Teacher Leadership

**Jane C. Manner and Louis L. Warren**
East Carolina University, North Carolina

**Abstract:** *The term teacher leadership is one that can refer to a differing set of skills and understandings, depending on the context in which it is employed. Providing leadership in a classroom, for example, can be quite different from providing leadership to the profession. Many states, including North Carolina, have developed leadership standards for practicing teachers. These standards emphasize classroom leadership, but also address leadership of the profession, with an emphasis on advocacy. This study evolved from the consistent observations of graduate faculty that the latter form of leadership appeared poorly understood and enacted by teachers. Although teachers seemed clear that leading classrooms and leading schools were essential aspects of their practice, they did not often seem to consider leadership of the profession or advocacy as an element within the purview of their responsibilities. These limiting perceptions on the part of contemporary educators are likely to propagate a narrow and incomplete view of teacher leadership. This study addressed the question of whether or not particular course instructional strategies could influence teachers' views of themselves as advocates and leaders of the profession, and found highly significant results.*

*Keywords: teacher leadership, advocacy, teacher evaluation*

Developing a shared definition for teacher leadership is an important task, particularly since the concept has been receiving increasing global attention.

The Glossary of Education Reform (2014) notes that the term is evolving with a broadening set of roles being ascribed to teachers. While the concept of teacher leadership is often cited in educational circles, its meaning can span a wide range of understandings (Warren & Sugar, 2005). The literature relates the term to various activities and dispositions that occur in a number of contexts.

Some of them are extensively implemented while others seem nearly overlooked, by teachers themselves, and other stakeholders in education. This appears to be because teacher leadership, as described in contemporary times, occurs in a wide range of contexts, and as such, represents an equally expansive scope of behaviors, some of which figure prominently in teachers' perceptions of leadership, while others appear rarely acknowledged and practiced.

Smylie, Conley & Marks (2002) note that teacher leadership has become an established feature of educational reform in the United States only in the last several decades. Prior to this period, most concepts of leadership that related to school improvement depended on what could be provided by principals and superintendents. These were the agents of the traditional Educational Leadership cadre.

More recently, however, states and organizations have clarified structures to describe teacher leadership that express the broadening view of it in standards that identify both the behaviors and contexts in which such leadership is intended to exist. For example, the state of North Carolina includes leadership as a standard in its rubric for the evaluation of teachers, but the contextual aspect of those standards reveals that the skills and dispositions required to exercise it are typically context-specific and significantly different from one another.

## ADDRESSING TEACHER ADVOCACY

Demonstrating leadership in a classroom or school, for example, usually heads the list of standards, but can be very different from the standard that addresses advocating for and participating in the development of educational policy at the state or national level. Yet both of these aspects of leadership are part of the leadership rubric. The same can be said for other examples, such as the work of the Teacher Leadership Exploratory Consortium (2011) where demonstrating leadership in the classroom and school figure prominently, along with advocacy for policy.

Since there is considerable variability in the roles and responsibilities of this expanded view of teacher leadership, it is important to be specific regarding which context and behaviors are being addressed.

## SELF-ASSESSMENT IN TEACHER ADVOCACY

It is our experience as graduate university faculty that practicing teachers are typically well versed in the definition of teacher leadership that relates to their students, classrooms, schools, and districts.

We teach a course in which in-service teachers are asked to rate themselves on all standards of the North Carolina Teacher Evaluation System, one of which is teacher leadership. In consistent majorities, teachers rank themselves as conversant and proficient with the more commonly held views of teacher leadership within the classroom, school and district.

However, just as consistently, a majority will ascribe lower rankings to their achievement in the area of advocacy for the profession and for educational policy. An examination of the data derived from these self-assessments and rankings supports an additional conclusion. Not only are teachers giving themselves lower marks when it comes to the advocacy aspect of teacher leadership, but their expressed examples of what they think advocacy entails indicate a lack of understanding of what it really means, even when the standard against which they are judging themselves spells it out clearly.

In the example of the North Carolina Teacher Evaluation Process, standards are accompanied by clear descriptors of what behaviors relate to varying levels of accomplishment with respect to those standards.  As it happens, teacher leadership is the first of the standards, but it is further broken down into five sub-standards.  As is typical, teachers leading in their classrooms represents the first substandard, followed by teachers leading in their schools as the second.  On each of the sub-standards, a rubric provides descriptions of developing, proficient, accomplished, or distinguished achievement levels for the sub-standards.

The third leadership substandard relates to teachers leading their profession.  Among other evidences, the rubric clearly cites advocacy for decision-making structures in education and government that take advantage of the expertise of teachers. This indicator is frequently ignored.

While we had observed this phenomenon informally over the course of several semesters, we examined the data more critically in a recent administration of the self-assessment in effort to quantify the condition we were seeing. The results of this analysis appear below, in Table 1. In this table, the self-assessment ratings of eighteen teachers regarding their achievement on standard 1c of the rubric for leading the teaching profession are juxtaposed with the examples they gave to justify the rating.

Although the rubric for this substandard clearly identifies advocacy for decision-making structures in education and government, such advocacy is rarely acknowledged as part of their behavioral repertoires in the teachers' self-assessments This occurs even when teachers consider themselves distinguished with respect to the sub-standard.

As Table 2 shows, even those who consider themselves proficient or accomplished with respect to the standard do not describe accompanying evidences that support the rating. When prompted to describe what it is they actually do that earns the ranking they ascribe, descriptions largely include activities unrelated to advocacy in education or government. In only 11% of the self-assessments is actual advocacy included as a salient part of the rationale for the grade assigned.

TABLE 1

*Teacher Self-Assessments on Standard 1c of the Rubric for Evaluating North Carolina Teachers*

| | **Rating** | **Evidences Offered** |
|---|---|---|
| 1 | Distinguished | Work with county officer |
| 2 | Developing | Have my classes observed |
| 3 | Accomplished | Further my education |
| 4 | Accomplished | Serve as mentor |
| 5 | Accomplished | Use ideas from other teachers' classrooms and encourage them to share in professional development sessions |
| 6 | Developing | Attend all TAT trainings to identify strategies for low performers |
| 7 | Proficient | Work on master's degree |
| 8 | Developing | Learn more about school's rules and procedures |
| 9 | Proficient | An indicator, which applies to my teaching, is that teachers advocate for change within their school community by contacting policy makers at the county, state, and national level. |
| 10 | Proficient | Send home a weekly newsletter to parents |
| 11 | Accomplished | Arranged an anti-bullying program |
| 12 | Accomplished | Continue education to graduate. School |
| 13 | Proficient | Implementing what I learn in professional development |
| 14 | Accomplished | Make all personnel feel important, including custodians, etc. |
| 15 | Accomplished | An indicator that applies to me would be my participation in our local NCAE chapter. I believe my participation and involvement with this group advocates for education and government decision-making. My participation with this organization also allows me to help others stay informed and advocate for education as well. |
| 16 | Developing | Accepting of performance feedback. |
| 17 | Accomplished | Work with others for class collaboration |
| 18 | Proficient | Volunteer to help other teachers with projects |

TABLE 2

*Self-Assessments by Ranking and Evidence on Standard 1c*

| Rating | Number | Responses that referenced school or district-based activities | Responses that referenced decision-making structures in education & government |
|---|---|---|---|
| Developing | 4 | 4 | |
| Proficient | 5 | 4 | 1 |
| Accomplished | 8 | 7 | 1 |
| Distinguished | 1 | 1 | |

Our interest in this subject grew as we distilled the finding that advocacy was, in fact, a nearly ignored aspect of teacher leadership among our teachers, despite being part of their own state evaluation system, and represented in the model standards of national groups. For example, the Teacher Leader Model Standards from the teacherleaderstandards.org cite advocacy as Domain VII in clear terms: the teacher leader understands how educational policy is made at the local, state, and national level as well as the roles of school leaders, boards of education, legislators, and other stakeholders in formulating those policies. The teacher leader uses this knowledge to advocate for student needs and practices that support effective teaching and increase student learning. (http://www.teacherleaderstandards.org/index.php)/

More recently, teachers have been invited to move into leadership roles in varying contexts, to the extent that the United States Department of Education and the National Board for Professional Teaching Standards have launched an initiative entitled Teach to Lead that is committed to expanding teacher leadership. Associated remarks by the former U.S. Secretary of Education, Arne Duncan, assert "Teacher leadership means having a voice in the policies and decisions that affect your students, your daily work, and the shape of your profession." (2015).

We wondered if we, as teacher educators, could affect our students' perceptions of their advocacy roles in a way that would cause them to reflect and consider amplifying their views and potential activism in their own profession. As Warren and Sugar (2005) have observed, other professions are largely led by their own practitioners. Why not teachers?

## DEVELOPING THE RESEARCH QUESTION

We wanted to examine how our work might impact teacher perceptions of their role in advocacy, so we modified our course design to include a series of targeted assignments. First, we required students to define an educational issue about which they felt strongly, and over which they would like to exert some influence. Second, we required them to educate themselves beyond their current level of knowledge about that issue through investigating a variety of sources. Students were then asked to create a position paper that described the issue, its importance, and one or more potential solutions, so that the exercise was not one of simply carping about a challenge, but synthesizing possible approaches to working toward improvement.

In order to improve the chances of having their views read and considered, students titrated the position papers to succinct advocacy statements, developed a list of prominent individuals whom they felt could influence policy, and contacted them directly. Our research question became, "Does the described series of course experiences modify teacher perceptions about the importance of this advocacy in their work?"

## METHODOLOGY

In our work as faculty teaching a graduate course entitled Teacher Leadership at a large, state university, we work with students who are, in the main, practicing classroom teachers. In a typical class in any semester, more than ninety percent of our participants fall into this category, with the exception being a small number of graduate students who are seeking a master's degree directly following an earned baccalaureate in Education. While they represent differing levels of classroom experience, they share a common perception about the aspect of teacher leadership dealing with advocacy for the profession.

Our students are, almost without exception, working in North Carolina, so we ask them to judge themselves with respect to each area of the teacher evaluation rubric provided by the state. We typically discover that they either ignore advocacy as a part of teacher leadership, or misunderstand the evidences associated with the standard that describes it. We wanted to emphasize advocacy through targeted exploration and assignments in our courses to see if we could bring it out of the marginalized position it appeared to hold.

## REVISING THE COURSE

A related series of assignments was added to our course, which required each student to examine personal views on what is important in education and to select a cause for which each would be willing to advocate as an informed educator. Once the causes were identified, students educated themselves about the topic through various print, online, and in-person sources.

Finally, each student developed a succinct but comprehensive advocacy statement relating to the topic that contained not just complaint, but also one or more potential solutions. These advocacy statements were distributed as personal messages to influential individuals chosen by the students at the local, state, and national levels.

As part of a mixed-methods design at the conclusion of the course, we asked students to compare their perceptions about the role of advocacy by teachers from the beginning of the course to the final stage, using an ipsative scale. In addition, we invited students to share their reasons for having adjusted or not adjusted their perceptions of the role of advocacy in their professional practices. Using a repeated-measures t-test design, student responses were examined to find out whether or not the course redesign strategies had been effective in modifying teacher views on their role in advocacy.

## DATA ANALYSIS

The subjects in this study were twenty-four graduate students enrolled in a Teacher Leadership course, all of whom were enrolled in an M.A.Ed. program. With the exception of two, all subjects were practicing teachers in public schools. Participation in the survey at the end of the courses was voluntary. The survey was brief, and required students to select a statement that most closely represented their view of advocacy as a professional responsibility at the beginning of the course. The statement choices were:

__I didn't consider it as part of my role as a teacher at all

__I considered it somewhat important to my role as a teacher

__I considered it important to my role as a teacher

__I considered it a highly important part of my role as a teacher

The next question asked subjects to make the same judgment from the perspective of the end of the course, and the same options were provided as responses. Numerical values were assigned to each of the possible answers in both sets, and those values were compared in a repeated-measures t-test analysis to examine the data for possible significant change. Finally, students were asked to describe whether or not creating and communicating their advocacy statements had been responsible for any shift in perception, and why they believed the experience to be important or insignificant.

## RESULTS

Although there were a couple of outliers in the data, most students reported significant and positive changes in their views about advocacy. The outliers commented that their opinions had not changed for one of two reasons. One of these explained that she did not believe advocacy was part of her role now or in the past, because, in her view, politicians do not understand what teachers go through, nor do they care.

Another commented that she already believed that advocacy was a highly important part of her role before she began the course, so there was not any room for improvement. The others were strongly clustered in a positive direction, indicating that over the course of the semester, their views on their role as educational advocates had become more favorable.

In fact, even with the outliers whose scores did not change over time, the t-statistic for the group was highly significant, indicating that the new course strategies had been effective in modifying teacher perceptions regarding the importance of advocacy in their professional roles. Table 3 reports those findings, with results being significant at the .0001 level.

TABLE 3

*Effectiveness of Course Strategies in Modifying Teacher Perceptions of the Importance of Advocacy*

*t Test Results*

| *N* | *Mean* | *Standard Deviation* | *Degrees of Freedom* | *t value* | ***p*** |
|---|---|---|---|---|---|
| 24 | 1.375 | 0.92372 | 23 | 7.2923 | < .0001 |

Overall, students indicated that the advocacy assignment was important in changing their views. The following statements are representative examples of their feedback. Although in one case, the fact that the student's message had not been acknowledged and had not received a response was responsible for being judged as insignificant.

"I was fortunate enough to receive a response from the state superintendent, and this portion of the class reiterated the significance of speaking up and advocating for what you believe in. It was a leading example of how standing up for yourself can be beneficial for you, as well as other professionals."

"Sharing my advocacy statement with a governmental individual and a national corporation really heightened and influenced my views on the importance of teachers as policy advocates. Sending my advocacy statement made me feel empowered; it made me feel that my voice was being heard. Even though I never received anything back from either of the two individuals that I sent it to, it still made me feel that my concerns were being listened to."

"Again it made me feel that change could really happen and it made me want to pursue becoming a better teacher leader and help create a voice for other teachers who haven't had the opportunity I had in explicitly learning about the importance of teacher leadership and advocating for change."

## CONCLUSIONS

Our examination of teacher perceptions regarding advocacy in teacher leadership has been a process of hope and insight. We were pleased to discover support for what we hoped: that our course design and instructional strategies could have a positive impact on this subject that we feel is too often neglected, both by powerful administrations and by teachers themselves. We were also gratified to observe that, for most of our students, several collateral benefits accrued. They identified and examined causes they wished to influence, analyzed potential solutions from a teacher's perspective, and broadened their professional views beyond the scope of a single classroom, school, or district.

Our findings lend credence to a notion that we had titrated from many observations over multiple semesters: teachers do not frequently include or understand the role of advocacy in their professional responsibilities. Our examination of the literature cites many reasons this may be the case, however, if, as a profession, we are serious about all of the elements of teacher leadership that we evaluate, we need to equip our teachers with the knowledge and perceptions that are required to implement them. In our situation, and we believe in most others, advocacy is not a concept that figures prominently in teacher preparation or professional development. We hope that our findings will encourage others to adopt similar strategies in their courses for both teacher candidates and practicing professionals.

## REFERENCES


Acker-Hocevar, M., & Touchton, D. (1999, April). *A model of power as social relationships: Teacher leaders describe the phenomena of effective agency in practice.* Paper presented at the annual meeting of the American Educational Research Association, Montreal, Quebec, Canada.

Ash, R. C., & Persall, J. M. (2000). The principal as chief learning officer: Developing teacher leaders. *NASSP Bulletin*, 84, 15–22.

Barth, R. S. (1999). *The teacher leader*. Providence, RI: The Rhode Island Foundation.

Barth, R. S. (2001). Teacher leader. *Phi Delta Kappan*, 82(6), 443–449.

Carter, M., & Powell, D. (1992). Teacher leaders as staff developers. *Journal of Staff Development*, 13(1), 8–12.

Coyle, M. (1997). Teacher leadership vs. school management: Flatten the hierarchies. *The Clearing House*, 70(5), 236–239.

Darling-Hammond, L. (1988). Policy and professionalism. In A. Lieberman (Ed.), *Building a professional culture in schools* (pp. 55–77). New York, NY: Teachers College Press.

Darling-Hammond, L., Bullmaster, M. L., & Cobb, V. L. (1995). Rethinking teacher leadership through professional development schools. *Elementary School Journal*, 96(1), 87–106.

Day, C., & Harris, A. (2002). Teacher leadership, reflective practice and school improvement. In K. Leithwood & P. Hallinger (Eds.), *Second international handbook of educational leadership and administration* (pp. 957–977). Dordrecht, Netherlands: Kluwer.

Duke, D. L., Showers, B. K., & Imber, M. (1980). Teachers and shared decision making: The costs and benefits of involvement. *Educational Administration Quarterly*, 16(1), 93–106.

Frost, D., & Harris, A. (2003). Teacher leadership: Towards a research agenda. *Cambridge Journal of Education*, 33(3), 479–498.

Fullan, M. G. (1993). *Change forces*. New York, NY: Falmer Press.

Harris, A. (2003). Teacher leadership and school improvement. In A. Harris, C. Day, D. Hopkins, M. Hadfield, A. Hargreaves & C. Chapman (Eds.), *Effective leadership for school improvement* (pp. 72–83). London: Routledge Falmer.

Harris, A., & Muijs, D. (2002). *Teacher leadership: A review of the research*. Retrieved February 10, 2010, from www.ncsl.org.uk/researchpublications

Harris, A., & Muijs, D. (2005). *Improving schools through teacher leadership*. Berkshire, England: Open University Press.

Howey, K. R. (1988). Why teacher leadership? *Journal of Teacher Education*, 39(1), 28–31. doi: 10.1177/002248718803900107

Hoerr, T. R. (1996). Collegiality: A new way to define instructional leadership. *Phi Delta Kappan*, 77(5), 380–381.

Ingersoll, R. M. (1996). Teachers' decision-making power and school conflict. *Sociology of Education*, 69(2), 159–176.

Katzenmeyer, M., & Moller, G. (2001). *Awakening the sleeping giant: Helping teachers develop as leaders* (2nd ed.). Thousand Oaks, CA: Corwin Press.

Keung, C. C. (2009). Revitalizing teacher leadership via bureaucratic-professional practices: A structural equation model. *The Asia-Pacific Education Researcher*, 18(2), 283–295.

LeBlanc, P. R., & Shelton, M. M. (1997). Teacher leadership: The needs of teachers. *Action in Teacher Education*, 19(3), 32–48.

Leithwood, K., & Jantzi, D. (1990, June). *Transformational leadership: How principals can help reform school cultures.* Paper presented at the annual meeting of the Canadian Association for Curriculum Studies, Victoria, B.C.

Lieberman, A., Saxl, E. R., & Miles, M. B. (1988). Teacher leadership: Ideology and practice. In A. Lieberman (Ed.), *Building a professional culture in schools* (pp. 148–166). New York, NY: Teachers College Press.

Little, J. W. (1988). Assessing the prospects for teacher leadership. In A. Lieberman (Ed.), *Building a professional culture in schools* (pp. 78–106). New York, NY: Teachers College Press.

MacBeath, J. (Ed.). (1998). *Effective school leadership: Responding to change.* London: Paul Chapman.

Malen, B., Ogawa, R. T. & Krantz, J. (1990). What do we know about school-based management?

A case study of the literature – a call for research. In W. H. Clune & J. F. Witte (Eds.) *Choice and control in American education, Vol. 2: The practice of choice, decentralization, and school restructuring.* New York, NY: Falmer Press.

Miller, B., Moon, J., & Elko, S. (2000). Teacher leadership in mathematics and science: *Casebook and facilitator's guide.* Portsmouth, NH: Heinemann.

O'Connor, K., & Boles, K. (1992, April). *Assessing the needs of teacher leaders in Massachusetts.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Ovando, M. N. (1996). Teacher leadership: Opportunities and challenges. *Planning and Changing*, 27(1), 30–44.

Pellicer, L. O., & Anderson, L. W. (1995). *A handbook for teacher leaders.* Thousand Oaks, CA: Corwin Press.

Rosenholz, S. (1989). Teachers' workplace: *The social organization of schools.* New York, NY: Teachers College Press.

Smylie, M. A. (1994). Redesigning teachers' work: Connections to the classroom. In L. Darling-Hammond (Ed.), *Review of research in education* (Vol. 20, pp. 129–177). Washington, DC: American Educational Research Association.

Smylie, M. A., & Denny, J. W. (1990). Teacher leadership: Tensions and ambiguities in organizational perspective. *Educational Administration Quarterly*, 26(3), 235–259.

St. John, M. (1999). *The nature of teacher leadership: Lessons learned from the California subject matter projects* [Electronic Version]. Iverness Research Associates. Retrieved from http://lsc-net.terc.edu/do.cfm/paper/8123/show/page-6/use_set-ldrshp.

Stone, M., Horejs, J., & Lomas, A. (1997). Commonalities and differences in teacher leadership at the elementary, middle, and high school levels. *Action in Teacher Education,* 19(3), 49–64.

Warren, L. & Sugar, W. (2005). *Introducing the teacher-leader designer: A guide for success.* Dubuque, IA: Kendall/Hunt Publishing Company.

Wasley, P. A. (1991). *Teachers who lead: The rhetoric of reform and the realities of practice.* New York, NY: Teachers College Press.

Whitaker, T. (1995). Informal teacher leadership: The key to successful change in the middle level. *NASSP Bulletin*, 79(567), 76-81.

York-Barr, J., & Duke, K. (2004). What do we know about teacher leadership? Findings from two decades of scholarship. *Review of Educational Research*, 74(3), 255–316.

Zimpher, N. L., & Sherrill, J. A. (1996). Professors, teachers and leaders in schools, colleges and departments of education. In J. Sikula, T. J. Buttery, & E. Guyton (Eds.), *Handbook research on teacher education* (pp. 279–305). New York, NY: Macmillan.

## ABOUT THE AUTHORS

Jane Carol Manner is an associate professor and Louis L. Warren is a professor in the Department of Elementary and Middle Grades Education at East Carolina University in Greenville, N.C.

# NASA STEM Digital Badges for Educators and Their Students:

## A Pilot Program Bringing STEM into Middle Schools Using NASA Langley Research Center's Centennial Celebration

**Marile Colon Robles, Marjorie Thrash, Candace Walker, and Kimberly M. Brush**

**Abstract:** *A pilot program was developed for middle school (grades 6-8) educators and students to apply NASA real-world problems to classroom concepts through the use of digital badges, as part of NASA Langley Research Center's (LaRC) Centennial Celebration. Three sets of digital badges were developed on three of NASA's main missions: Earth Science, Aeronautics, and Journey to Mars. Each digital badge offers a total of 5 hours of professional development for educators and 2 hours of activities for students. These digital badges have introduced educators to NASA Langley Research Center's missions and 100th anniversary. Online discussion sessions, a requirement for these badges, has attracted educators new to the digital badge concepts. The LaRC Centennial badges provide a forum through which educators can learn about this new format of professional development. Educators report that these badges are worth their time and effort as part of their professional development. LaRC looks forward to building new badges in the future to expand beyond middle school and reach across the K-12 continuum.*

### INTRODUCTION

Digital badges, or micro credentials, are online representations of learning experiences and activities that tell a story about the learner's education and skills (Gamrat et. al, 2014). Digital badges in education have been expanding since the 2013 "Chicago Summer of Learning" where the City of Chicago collaborated with the MacArthur Foundation, allowing K-12 students to engage in summer activities through Open Badges by the Mozilla Foundation (Hurst, 2015).

Digital badges allow users to drive their own learning through various sources, providing a certification of proficiency upon completion (Waters, 2013). Digital badges also allow educators to personalize their professional development and become knowledgeable in topics that they rarely learn in their credentialing programs or through formal learning opportunities (DeNisco, 2016).

NASA Langley Research Center's (LaRC) Office of Education developed a pilot program to use digital badges to correlate NASA real-world projects to STEM classroom content as part of NASA LaRC's Centennial Celebration. The digital badges in this pilot are part of the NASA STEM Educator Professional Development Collaborative (EPDC), a national educator professional development system comprised of and designed to serve STEM Educators at all levels, free of charge through various methods of delivery.

NASA STEM EPDC, led in collaboration with Texas State University, uses Digital Badges at Penn State University as their platform[1].

### STRUCTURE OF THE NASA LANGLEY CENTENNIAL DIGITAL BADGES

A team composed of an in-service middle school science educator, a pre-service teacher, a NASA STEM EPDC educator, and a NASA Langley Research Center Education Specialist worked together to design the digital badges.

NASA-inspired problem-based activities were chosen with strong correlations to middle school (grades 6-8) Next Generation Science Standards on three of NASA's priorities: Earth Science, Aeronautics, and Journey to Mars[2].

Each topic comprises a digital badge for the educator and for the students. The educator and student badges mirror one another with pertinent background information, examples from NASA's workforce, and applications to NASA research.

[1] Features and details of the platform can be found at the following site - http://badges.psu.edu/features/

[2] The digital badges can be accessed at https://nasatxstate-epdc.net/ by searching for "NASA LaRC 100" on the search bar.

The digital badges are visually attractive and engaging with videos and images for each step. Educator badges equate to a total of 5 hours of professional development divided into five one-hour steps. Student badges equate to a total of two hours of activities divided into four 30-minute steps.

All three badges are structured in the following matter for educators and students, respectively:

TABLE 1

*Detailed structure of the educator and student digital badges.*

| Steps | Educator Badge (Five 1-hour steps) | Student Badge (Four 30-minute steps) |
|---|---|---|
| **1** | Educators are introduced to the topic with background information. | Students are introduced to a short video or reading on the topic. |
| **2** | Correlations to the topic are presented to research done at NASA Langley Research Center. | Students see how NASA engineers, researchers, and scientists are working to solve a problem. Students hypothesize or plan their own solutions to the problem. |
| **3** | Educators are asked to review and complete the pre-selected problem-based activity following the recommended implementation steps. | Students perform an investigation and gather their own data based on the badge activity. |
| **4** | Educators participate of an online open discussion and reflection of best practices. | Students evaluate their data and draw conclusions. Students watch a video about a NASA engineer, researcher, or scientist working on the topic. |
| **5** | Educators submit a picture of their students at work or student designs as proof of implementation of the activity. | - |

Each digital badge focuses on different aspects of STEM. For example, the Earth Science badge, titled Earth Right Now: NASA LaRC 100 Educator (or Student), focuses on science investigations on how cloud types affect Earth's Radiation Budget.

This digital badge offers the opportunity for educators to become part of the Global Learning and Observation to Benefit the Environment (GLOBE) community.

Using free GLOBE products, teachers can do observations with students as described in the digital badges. Details of each digital badge can be found on Table 2. Videos of NASA LaRC engineers, researchers, and scientists were produced to show examples of people working on current solutions. The identified researchers, as well as the links to the videos produced for the digital badges are listed in Table 2.

TABLE 2

*Description of STEM focus and main learning outcomes for each topic selected for the digital badges.*

| **Title of Digital Badge** | **Earth Right Now** | **Journey to Mars** | **Aeronautics** |
|---|---|---|---|
| **STEM Focus Area** | Science | Engineering | Math and Science |
| **Main Topic** | How cloud types and cloud heights impact the amount of energy from the Sun, affecting Earth's Energy Budget. | How engineers use Mars' atmosphere to generate drag and slow down a capsule carrying a Mars rover. | How scale models of airplanes are used to test composite materials to design safer and more efficient aircrafts. |
| **Activity Description** | Create an atmosphere using a clear plastic container. Using a thermometer and cotton balls, gather temperature measurements to test differences between thin, high clouds and low, thick clouds on the energy reaching the surface. | Use different recyclable materials to create a design with minimal weight and large surface area to create drag to get the slowest speeds possible. | Graph data of flight time and distance a pre-selected paper airplane design performed using copy paper, cardstock, and newspaper to select which material performed the best. |
| **NASA Workforce Example and Video Link** | Atmospheric Scientist Dr. Yolanda Shea https://youtu.be/F1s5ow--ILs | Aerospace Engineer Alicia Dwyer Cianciolo https://youtu.be/USEnZrbeMYo | Engineering Technician Sam James https://youtu.be/nCtmPjX9a9M |

## INITIAL EVALUATIONS

A group of fifteen volunteers composed of teacher educators, in-service, and informal educators was assembled to evaluate both educator and student digital badges.

Table 3 shows the distribution of the volunteers based on instruction level. Six volunteers reviewed each digital badge. The others each focused on a specific digital badge based on their STEM focus area.

TABLE 3

*Distribution of digital badge evaluators based on instruction level.*

| **Distribution of Badge Evaluators** | | | | | | |
|---|---|---|---|---|---|---|
| **Middle School Science** | **Middle School Math** | **High School Science** | **High School Math** | **STEM Director or Science Specialist** | **Science Teacher Educator** | **Informal Educators** |
| **2** | 1 | 3 | 2 | 4 | 1 | 2 |

Volunteers were asked questions focused on site design, appropriateness of material for targeted grade level, and likelihood of implementation in their own classrooms

Table 4 highlights questions related to content appropriateness for the targeted audience and usability.

## TABLE 4

*Evaluator responses to questions regarding activities in the digital badges.*

| Selection of Questions Submitted to Evaluators | | Earth Right Now | Journey to Mars | Aeronautics |
|---|---|---|---|---|
| 1. Were all of the activities and resources used in this badge appropriate for middle school? | **Yes** | 10/10 | 10/10 | 10/10 |
| | **No** | - | - | - |
| 2. On average, how long did it take to complete each individual step in the TEACHER badge? | **< 1hour** | 1/10 | 4/10 | 1/10 |
| | **1hour** | 9/10 | 5/10 | 9/10 |
| | **> 1hour** | - | 1/10 | - |
| 3. On average, how long did it take to complete each individual step in the STUDENT badge? | **15 mins** | 1/10 | - | - |
| | **30 mins** | 7/10 | 7/10 | 7/10 |
| | **45 mins** | 2/10 | 3/10 | 2/10 |
| | **1 hour** | - | - | 1/10 |
| 4. In a scale of 0-5, where 0 is no implementation and 5 is implementation of all activities, how likely are you to implement these activities in your classroom? | **0** | - | 1/10 | - |
| | **1** | 2/10 | - | - |
| | **2** | - | - | 1/10 |
| | **3** | 1/10 | - | |
| | **4** | 4/10 | 4/10 | 5/10 |
| | **5** | 3/10 | 5/10 | 4/10 |

## REDESIGN OF DIGITAL BADGES

Evaluators all agreed that the activities met the targeted grade levels but shared detailed concerns about the time required to complete specific steps. Most concerns revolved around the Journey to Mars digital badge and the lack of time for students to follow the engineering design process of building, testing, and redesigning their capsules, in addition to making calculations to choose the best design. Adjustments were therefore made, distributing the engineering design process throughout the four steps of the student digital badge.

For example, in step two students learn about the problem, study the constraints and draw a design; in step three they build, test and gather data; and in step four they study the data, redesign their capsule and draw conclusions based on their calculations. Additionally, the activity sheets developed for the activity highlight each portion of the engineering design process across the four steps. Concerns about time to complete the engineering design process are commonly expressed by teachers implementing engineering design challenges in their classrooms. In an effort to identify additional solutions, educators completing the Journey to Mars digital badge are asked to provide feedback about the adjustments they make within the teacher activity sheets.

Other concerns were associated with the Aeronautics digital badge and the time it took to fold paper airplanes. Informal observations collected from educators indicate that the majority of students have never made a paper airplane. A very basic paper airplane model was selected to address these concerns. The student badges were reviewed and restructured, reducing and simplifying the amount of work per step. The main objectives were presented in a cleaner, simplified format, reducing the time to complete the steps.

## PARTICIPATION OF EDUCATORS AND STUDENTS

The NASA Langley Centennial Digital Badges were released November 7, 2016 onto the NASA STEM EPDC Digital Badge website. As of the end of March, 2017 thirty-one educators were working through the digital badges and twelve have earned one or more digital badges. Only a handful of submissions have been registered through the student digital badges, as most educators are reviewing their own students' badge submissions.

A number of educators completing the digital badges have used the structure and activities within the digital badges to do professional development and/or after school activities within their school districts. For example, after implementing the activities in her class, one of the reviewers invited the NASA STEM EPDC educator to lead a professional development for 12 teachers in preparation for using the digital badges in a spring after-school program. The teacher educator who evaluated the badges used the activities with pre-service teachers to focus on STEM and problem-based activities. A STEM teacher used the activity within the Aeronautics digital badge and implemented the activities with Kindergarten students to teach sequencing. The same teacher then implemented the Aeronautics activity with fifth graders to talk about the four forces of flight. Educators in Puerto Rico have translated the activity sheets in order to implement them in their classrooms.

The majority of educators attending the bi-monthly live online discussions, required for step 4 of the educator digital badge, express that this is their first time learning about digital badges. Since December 2016, with the start of the online discussions, the number of participants working through the digital badges increased from three to thirty-one participants by the end of March 2017.

## CONCLUSION

The NASA LaRC Centennial Digital Badges have been a unique way to learn about NASA activities and research. These digital badges have introduced educators to digital badges and their application in professional development and in the classroom. Although the number of educators participating in the offerings is low, most participants have never heard of or used digital badges.

These observations, in addition to feedback through the digital badge blogs, emails, and discussions during the online sessions, suggest there is excitement among educators with the structure and activities. This has allowed educators to join this new type of professional development and learn about techniques to use similar structures for their students. Educators and students participating in the program have learned about NASA LaRC's missions and 100th anniversary.

Digital badges are new to many educators. The LaRC Centennial Badges provide a forum through which educators can learn not only about NASA content and applications, but also about this new format of professional development. Educators report that these badges are worth their time and effort as part of their professional development. LaRC looks forward to building new badges in the future to expand beyond middle school and reach across the K-12 continuum.

## REFERENCES


DeNisco, A. (2016, June 27). Micro credentials provide highly personalized PD. Retrieved from https://www.districtadministration.com/article/microcredentials-provide-highly-personalized-pd

Gamrat, C., H. Toomey Zimmerman, J. Dudek, and K. Peck (2014). Personalized workplace learning: An exploratory study on digital badging within a teacher professional development program. *British Journal of Educational Technology*, *45*(6), 1136-1148. doi: 10.1111/bjet.12200

Hurst, E.J. (2015). Digital Badges: Beyond Learning Incentives. *Journal of Electronic Resources in Medical Libraries, 12*(3), 182-189. doi: 10.1080/15424065.2015.1065661

Waters, J.K. (2013, May 30). Everything you ever wanted to know about badging in the classroom: Our definite guide. Retrieved from https://thejournal.com/articles/2013/05/30/everything-you-ever-wanted-to-know-about-badging-in-the-classroom-our-definitive-guide.aspx


## ABOUT THE AUTHORS


Marilé Colón Robles was a NASA STEM Educator Professional Development Collaborative Education Specialist through Texas State University and is now an Education Outreach Coordinator for the Science Directorate at NASA Langley Research Center through Science Systems and Applications, Inc. in Hampton, VA.

Marjorie Thrash is a sixth grade science teacher at Williamsburg/James City County Public Schools in Williamsburg, V.A.

Candace Walker is a pre-service teacher at Liberty University in Lynchburg, V.A.

Dr. Kimberly M. Brush is the STEM Engagement and Professional Development lead at NASA Langley Research Center in Hampton, VA.

# Global Learning Using Biology PBL: A Texas-China Collaboration in Middle Grade Genetics

**Blair O'Connor and Rebecca Hite**
Texas Tech University, Texas

**Abstract:** *Twenty-first century and global skills are generally described as competencies for communication and problem solving. Additionally, these skills involve developing the ability to view content-specific issues through a multicultural perspective. Preparing K-12 students for STEM careers in an ever-changing workplace means they must have opportunities to concurrently acquire skills in twenty-first century and global learning. Additionally, the professional biology community has called for advancing middle grades students' knowledge of complex scientific phenomena using novel pedagogies like Project-Based Learning (PBL).*

*Thus, middle grade educators are now tasked to design classroom opportunities for STEM-focused PBL using global interaction to hone global and twenty-first century skills, while developing students' content knowledge. In this article, we provide an account of a classroom-centered project that paired middle school students in Texas with Chinese peers to collaborate on a biology-based PBL activity on the topic of genetics. During the seven-day unit on heredity, the goal was to utilize global collaboration in STEM to achieve learning objectives in the biology curriculum (understanding inheritance and differentiating between dominant and recessive traits), while embedding skills that foster global competency and twenty-first century skills. The context, planning, and outcomes of the global collaboration are discussed, as well as recommendations for future global collaborative STEM initiatives in middle school.*

*Keywords: Twenty-first century skills, Genetics; Global Competency, Global Collaboration, Heredity; Project Based Learning, STEM Education*

## GLOBAL COLLABORATION IN TWENTY-FIRST CENTURY LEARNING AND SCIENCE EDUCATION

According to Greenhill (2010), there are three reasons why the United States needs educational reform: 1) close achievement gaps, 2) address the new educational demands from our changing economy, and 3) prepare students with the skills necessary to work in a global job market. This response to reform requires students to grasp global or twenty-first century skills such as creativity, critical thinking, problem solving, communication, and collaboration (Partnership for twenty-first century Learning, 2016).

The call for these global skills has uniquely challenged the education community where global collaboration has been historically viewed as an add-on to the curriculum (Tye, 2003), instead of a pedagogical approach (Bell, 2010; Saavedra & Opfer, 2012). According to Lindsay and Davis (2013), "Global competition for jobs means that today's students must not only be well-educated, creative problem solvers, but also be equipped to collaborate globally" (p. 3). Yet, students are afforded few opportunities to collaborate with their international peers, due to challenges in cross-cultural communication (Shih & Cifuentes, 2003), minimal or non-existent pre-service teacher preparation in global classroom activities (Neal, Mullins, Reynolds, & Angle, 2013), and curricular pressures of mandatory testing, including time constraints and mandated curricula (Au, 2007). Educators need tangible strategies in which they can provide their students opportunities to collaborate globally, through the use of internet-based technologies, with engaging content that also meets state standards and assessment requirements.

## TWENTY-FIRST CENTURY LEARNING USING PROJECT BASED LEARNING (PBL)

According to the Buck Institute (n.d.), the twenty-first century workplace requires more than basic knowledge and skills. They propose students work collaboratively on activities and projects, which enable them to build confidence and develop skills such as problem solving, communicating, leadership, and accountability (Greenhill, 2010).

Project Based Learning (PBL) has emerged as a novel pedagogical practice in which students are tasked with long-term projects investigating complex real-world problems, questions, or challenges to co-construct knowledge, while also building interpersonal, twenty-first century skills (Krajcik & Blumenfeld, 2006; Larmer & Mergendoller, 2010).

An inherently student-centered model, PBL-derived research plans and products are student designed and produced. PBL stands apart from other instructional designs in its authenticity, as well as the ability to allow students to learn and work autonomously with teacher facilitation (Thomas, 2000). By providing students opportunities to address real-world problems, their learning is more relevant (Thomas, 2000) and engaging (Ahlfeldt, Mehta, & Sellnow, 2005). Research by Morrison, McDuffie, and French (2015) recommended leveraging PBL as a pedagogical strategy for developing problem solving via authentic inquiry ,which is vital to the new world economy. Using PBL with STEM may be a useful practice for fostering the "STEM fields [which] propelled the United States to the forefront of an innovation-based global economy" (National Research Council, 2011, p. 4).

## PBL IN MIDDLE GRADES SCIENCE EDUCATION

PBL has shown great promise in STEM education; a study by Han, Capraro, and Capraro (2014) found this pedagogy benefitted lower performing students in mathematics scores, especially students who were ethnic minorities and low socio-economic students (SES). Lou, Shih, Diez, and Tseng (2011) found that students increased their STEM knowledge, and learned how to apply STEM in real world contexts, leading to more positive attitudes towards STEM careers.

Other research has shown that developing positive attitudes toward the sciences improves interest and identity in the sciences (Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011). The research literature suggests that developing a robust science identity within students is critical to engagement and persistence within STEM careers (Perez, Cromley, & Kaplan, 2014), especially among those in marginalized populations (Chemers, Zurbriggen, Syed, Goza, & Bearman, 2011), and with students in the middle grades (Carlone, Scott, & Lowder, 2014). Therefore, the social focus and collaborative nature of PBL may be a strategy to enhance science identity development (Calabrese-Barton et al., 2013).

## A CASE OF GLOBAL COLLABORATION: A MIDDLE SCHOOL TEXAS-CHINA PBL PROJECT ON GENETICS

**Participating Schools.** Little Middle School (LMS, pseudonym) has approximately 900 students in grades six through eight in Texas. It is a Title I school; with 85% of students categorized as economically disadvantaged and 75% are Hispanic. The global partner, was Southern Middle School (SMS, pseudonym), in southern China near Hong Kong. The cooperating teacher at SMS, X.H. (pseudonym), taught five eighth grade classes, all of which have 40 or more students. X.H.'s students are Asian and mostly from wealthy families, whose parents come from different provinces, as this area is largely made up of migrants.

**Participating Teachers.** The teacher-partner at LMS R.B. (pseudonym) has taught seventh grade science for 15 years and coaches girls' athletics. She taught four classes totaling 100 seventh grade students all of which participated in the project. The Chinese teacher X.H. has taught biology for one year at SMS in China. She taught eighth grade classes made up of about 240 students, 55 of which participated in the project.

**Participating Students.** LMS students are categorized as economically disadvantaged, with few or limited opportunities to access the world outside of their neighborhood. A stereotypical viewpoint of low-SES students like the LMS context is that they are of poorer academic abilities (Spencer & Castano, 2007), lower academic achievement (Perry & McConney, 2010), have a mistrust of different cultures (Glazer & Moynihan, 1970), and are less aware of global issues (Ferreira, 2011).

In contrast, SMS was a private urban school, where many of the students come from wealthy families. Students who come from similar middle to upper-class families often have advantages in developing a more robust worldview, due to the economic advantages and multicultural opportunities their families can provide (Barton, 2001; Crawford & Meyer, 2011).

**Relationship to the Standards.** In Texas, the Texas Essential Knowledge and Skills (TEKS) mandate that students are able to define heredity and recognize that inherited traits are passed from parents to offspring (TEKS 7.14 A and C). As supporting standards, students may be tested on this content on the yearly State of Texas Assessments of Academic Readiness (STAAR) test (STAARTM, 2013).

SMS follows the National curriculum or Compulsory Education Biology Curriculum Standards. According to Gardner, Enshan, and Fuchs (n.d.), Chinese students begin learning about biology in ten major topic areas, including genetics, in the seventh grade. These studies narrow to three areas in high school, one of which is genetics and evolution. In middle school, Chinese students gain a basic understanding of heredity, focusing on differences between dominant and recessive traits. This project extended that learning by including the concepts of genotypes and phenotypes, which are typically not learned until high school (Gardner et al., n.d.).

**Global PBL on Heredity.** Due to limitations in exchange media, the students were not able to interact directly. The students gathered the data and discussion points to share with their Chinese partners and interaction occurred through the teachers via email and chat apps. The unit was structured using the 5E model, a teaching method consisting of five sequential components: engaging student interest, exploration using inquiry, student driven explanation of phenomena, extending student understanding, and evaluation of learning (Bybee et al., 2006). This model was selected based upon its successful use in science education and development of twenty-first century skills (Bybee, 2009). The following outlines the progression of the global PBL collaboration by sequencing the heredity unit through a description of the students' activities.

*Engage (Day 1, 10-15 minutes).* To engage the lesson, R.B.'s students completed a card sort, in small groups, comparing examples and non-examples of inherited traits (see Appendix A). Once the cards were sorted, the students discussed where each example/non-example went and why.

*Explore (Day 1, 30 minutes).* Following the card sort, students worked in groups to create a diagram of traits noted in their own classroom such as eye, skin, or hair color, eye shape, height, etc. Once the diagrams were complete, students completed a gallery walk around the room to compare with their classmates.

*Explain (Day 2 and 3, 30-45 minutes each day).* Students worked in groups to research definitions of heredity, inherited traits, dominant traits and recessive traits followed by direct instruction to clarify, provide examples of, and address misconceptions regarding these terms.

*Elaborate (Day 4-6, at home and in the classroom).* The Chinese partners proceeded in a similar manner. X.H. taught eighth graders who have already had lessons on heredity in the seventh grade, so the beginning mostly consisted of review. However, her students had not learned about genotypes, so she infused this into the review prior to completing the Elaborate component. Students conducted interviews with their family members to determine inherited traits in their family lineage (see Appendix B) and compared dominant traits among the different participating classrooms. From this process, the students made some curious discoveries such as the homogeneity of traits of their Chinese partners versus the wide variety of traits found in their own classroom.

*Evaluate (Day 7, 45 minutes).* The project ended with a survey to gauge student knowledge and understanding of genetics after the global collaboration (see Appendix C). The survey was followed up with driving questions, which served to pique students' interest, as well as extend their thinking on a national and global scale. For example, are the dominant traits on our campus indicative of dominant traits in other parts of [our town]? How about across Texas? The U.S.? What traits do you think are dominant in [their town]? What about across China? The World?

**Evaluation and Assessment.** Other than content knowledge, an expectation of the PBL was for students to address the misconception that stereotypes are not based on genetic traits, but are built from the perceptions of society. Global science education is about students participating in traditional science, and also includes students making connections to society (Barton, 2000). When studying heredity, students often question trait inheritance when offspring do not look like their parents (Visscher, Hill, & Wray, 2008). Students could reconcile genetic similarities and differences with their collected data and peer communication.

## DISCUSSION

Overall, this global collaboration was a success in that the students successfully learned the content and could apply that content to a larger, global scale. Not only did students become proficient in their ability to identify dominant and recessive traits, as well as their inheritance in offspring, but they were also to hold discussions and debates regarding that inheritance. On recent district benchmarks, students who participated in the global PBL had an 85% pass rate on the standard specific to this project compared to non-participating students (69% mastery). Evidence for students extending their learning was based upon their individual and group-derived questions for further exploration; students asked questions about the role that race plays in genetic variation, and geographical impacts of genetic variation.

Hence, they had a unique exchange on questions of the commonality of traits between groups of students, citing their geographic and racial separation. LMS has a large English Language Learner (ELL) population; in order to help develop global competencies in changing student demographics, students need opportunities to embrace their cultural perspectives, learn how to share these with the world, and develop empathy for other cultures to be truly competitive in the global marketplace (Greenhill, 2010). By collecting and sharing their own data, the global PBL afforded them the opportunity to make authentic connections with the content, making the learning of even complex topics relevant to them (Thomas, 2000).

Not only did these questions allow for extended learning in science, but also presented the opportunity for interdisciplinary learning including social studies. When Texan students were looking at the homogeneity of the Chinese students' traits, students at LMS raised questions about the lack of genetic variation due to immigration.

They considered if this were an artifact due to politics or industry; where it may be difficult for foreign businesses to work in China or if immigration is difficult due to natural boundaries? These questions not only aligned with several middle school Texas Social Studies standards but also demonstrated growth towards becoming a globally competent person, possessing both multicultural awareness and a respect for diversity (Atwater, 2010).

## CONCLUSION

In a study by Camicia and Zhu (2012), they discuss the need for global education to teach students about seeing issues from multiple perspectives so they may recognize their roles on a global scale, as well as their civic duties in government. While authenticity is imperative to a strong science curriculum (Buck Institute for Education, n.d; Larmer & Mergendoller, 2010; Thomas, 2000), there is also a need to present content from multiple or global perspectives (Schlein & Garii, 2011). This study of a global collaboration in middle school biology presented a unique opportunity for students to gain perspective of a different culture, as well as increased perspective of their own, while investigating and sharing data with international peers. Recommended changes based upon this experience concern planning, technology use, and teacher preparation, which has often belied global collaboration projects (Neal et al., 2013).

## REFERENCES


Ahlfeldt, S., Mehta, S., & Sellnow, T. (2005). Measurement and analysis of student engagement in university classes where varying levels of PBL instruction methods are in use. *Higher Education Research & Development*, 24, 5–20.

Atwater, M. M. (2010). Multicultural science education and curriculum materials. *Science Activities*, 47(4), 103-108.

Au, W. (2007). High-stakes testing and curricular control: A qualitative metasynthesis. *Educational Researcher*, 36(5), 258-267.

Barton, A. C. (2001). Science education in urban settings: Seeking new ways of praxis through critical ethnography. *Journal of Research in Science Teaching*, 38(8), 899-917.

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House*, 83(2), 39-43.

BUCK INSTITUTE FOR EDUCATION. (n.d.). Why Project Based Learning? Retrieved from http://Buck Institute for Education.org/Bybee, R. W. (2009). The BSCS 5E instructional model and 21st century skills. *Colorado Springs, CO*: BSCS.

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes,

N. (2006). *The BSCS 5E instructional model: Origins and effectiveness.* Colorado Springs, CO: BSCS.

Calabrese-Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2013). Crafting a future in science: Tracing middle school girls' identity work over time and space. *American Educational Research Journal*, 50(1), 37-75.

Camicia, S. P., & Zhu, J. (2012). Synthesizing multicultural, global, and civic perspectives in the elementary school curriculum and educational research. *The Qualitative Report, 17*(103), 1-19.

Carlone, H. B., Scott, C. M., & Lowder, C. (2014). Becoming (less) scientific: A longitudinal study of students' identity work from elementary to middle school science. *Journal of Research in Science Teaching, 51(7)*, 836-869.

Chemers, M. M., Zurbriggen, E. L., Syed, M., Goza, B. K., & Bearman, S. (2011). The role of efficacy and identity in science career commitment among underrepresented minority students. *Journal of Social Issues*, 67(3), 469-491.

Crawford, B. A. & Meyer, X. (2011). Teaching science as a cultural way of knowing: Merging authentic inquiry, nature of science, and multicultural strategies. *Cultural Studies of Science Education,* 6(3), 525-547.

Lindsay, J. & Davis, V. (2013). *Flattening Classrooms, Engaging Minds: Move to Global Collaboration One Step at a Time.* Upper Saddle River, NJ: Pearson Education.

Ferreira, R. (2011). Development of an Instrument to Measure High School Students' Global Awareness and Attitudes: Looking Through the Lens of Social Sciences. *FIU Electronic Theses and Dissertations.* 373.

Gardner, A., Enshan, L, & Fuchs, B. (n.d.). Biology Programs in the Peoples Republic of China and the United States. [PowerPoint Slides]. Retrieved from

https://bscs.org/sites/default/files/_legacy/pdf/Research_Life%20Science%20Standards%20and%20HS%20Textbooks_NABT.pptx

Glazer, N., & Moynihan, D. (1970). *Beyond the Melting Pot*. Cambridge, MA: The MIT Press.

Greenhill, V. (2010). 21st Century Knowledge and Skills in Educator Preparation. Washington, D.C.: American Association of Colleges for Teacher Education, Partnership for 21st Century Skills. Retrieved from ERIC database (ED519336).

Han, S., Capraro, R., & Capraro, M. M. (2014). How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement. *International Journal of Science and Mathematics Education,* 13(5), 1089-1113.

Hayden, K., Ouyang, Y., Scinski, L., Olszewski, B., & Bielefeldt, T. (2011). Increasing student interest and attitudes in STEM: Professional development and activities to engage and inspire learners. *Contemporary Issues in Technology and Teacher Education,* 11(1), 47-69.

Krajcik, J. S., & Blumenfeld, P. (2006). Project-based learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 317–334). New York: Cambridge.

Morrison, J., McDuffie, A. R., & French, B. (2015). Identifying key components of teaching and learning in a STEM school. *School Science and Mathematics,* 115, 244–255.

National Research Council. (2011). *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics.* Washington, DC: The National Academies Press.

Neal, G., Mullins, T., Reynolds, A., & Angle, M. (2013). Global collaboration in teacher education: A case study. *Creative Education*, 4(9), 533-539.

Partnership for 21st Century Learning. (2016). Framework for 21st Century Learning. Retrieved from http://www.p21.org/storage/documents/docs/P21_framework_0816.pdf

Perez, T., Cromley, J. G., & Kaplan, A. (2014). The role of identity development, values, and costs in college STEM retention. *Journal of Educational Psychology,* 106(1), 315-329.

Perry, L. B., & McConney, A. (2010). Does the SES of the school matter? An examination of socioeconomic status and student achievement using PISA 2003. *Teachers College Record,* 112(4), 1137-1162.

Saavedra, A. R., & Opfer, V. D. (2012). Learning 21st-century skills requires 21st-century teaching. *Phi Delta Kappan,* 94(2), 8-13.

Schlein, C., & Garii, B. (2011). Cross-cultural interpretations of curricular contextual crossings. *Issues in Teacher Education, 20(2),* 81.

Shih, Y. C. D., & Cifuentes, L. (2003). Taiwanese intercultural phenomena and issues in a United States-Taiwan telecommunications partnership. *Educational Technology Research and Development, 51(3),* 82-90.

Spencer, B., & Castano, E. (2007). Social class is dead. Long live social class! Stereotype threat among low socioeconomic status individuals. *Social Justice Research, 20*(4), 418-432.

State of Texas Assessments of Academic Readiness (STAARTM) Assessments. (2013). *STAAR Standard Setting Technical Report.* Retrieved from: tea.texas.gov/WorkArea/DownloadAsset.aspx?id=25769804117

Texas Education Agency (2017). *Test Information At A Glance.* Retrieved from http://tea.texas.gov/TxCHSE_Test_Information_At_A_Glance.html

Thomas, J. W. (2000). *A review of research on project-based learning.* San Rafael, CA: Autodesk Foundation.

Tye, K. A. (2003). Global education as a worldwide movement. *Phi Delta Kappan, 85*(2), 165-168.

Visscher, P. M., Hill, W. G., & Wray, N. R. (2008). Heritability in the genomics era—concepts and misconceptions. *Nature Reviews Genetics, 9*(4), 255–66.

## ABOUT THE AUTHORS

Blair O'Connor is a doctoral student in the Global PRiSE Ph.D. Programs at Texas Tech University. Rebecca Hite, a 2010 Kenan Fellow is an assistant professor of Science Education in the STEM Education & Global PRiSE Ph.D. Programs at Texas Tech University.

## APPENDIX A

Card Sort of Examples and Non-examples of Inherited Traits

| Inherited Traits Examples | Inherited Traits Non-Examples |
|---|---|
| Eye Color | Good at Math |
| Hair Color | Intelligence |
| Shape of Eyes, Ears, or Nose | Laziness |
| Skin Color | Athleticism |
| Brain Structure | Bad Drivers |
| Migration Patterns | Good Behavior |
| Addiction | Hard Worker |
| Camouflaged Fur, Feathers, or Scales | Favorite Foods |

## APPENDIX B

Traits Data from X.H.'s and R.B.'s Classroom

| Traits | Number of Students X.H./**R.B.** |
|---|---|
| Attached ear lobe. (ee) | 35/**6** |
| Unattached earlobe. | 20/**49** |
| Blue eyes. (bb) | 0/**13** |
| Non blue eyes. | 55/**42** |
| Widow's peak. | 10/**15** |
| Non widow's peak. (ww) | 35/**40** |
| Tongue roller. | 37 /**47** |
| Non tongue roller. (rr) | 18 /**8** |
| Bent pinkie. | 20/**19** |
| Straight pinkie. (pp) | 34/**36** |
| Hair on mid joints. | 12/**29** |
| No hair on mid joints. (hh) | 43/**26** |
| Red hair. (nn) | 0/**3** |
| Any other color of hair. | 55/**52** |
| Curly hair (CC) Wavy hair (Cc) straight hair (cc) | 0/**12** |
| | 4/**22** |
| | 51/**21** |
| Cleft chin. (cc) Non cleft chin. | 0/**7** |
| | 55/**48** |
| | 41/**28** |

## APPENDIX B Cont'd

Traits Data from X.H.'s and R.B.'s Classroom

| Traits | Number of Students X.H./**R.B.** |
|---|---|
| Almond eyes. | 49/39 |
| Round eyes. (aa) | 6/17 |
| Eyes straight. | 55/50 |
| Eyes slanted. (ss) | 0/5 |
| Bushy eyebrows. | 26/21 |
| Fine eyebrows. (bb) | 27/34 |
| Connected eyebrow. (cc) | 4/5 |
| Non-connected eyebrow. | 51/50 |
| Freckles. | 5/15 |
| No freckles. (ff) | 50/40 |
| Dimples. | 13/27 |
| No dimples. (dd) | 41/28 |
| Hitchhiker's thumb. (hh) | 34/32 |
| Non hitchhiker's thumb. | 21/23 |
| Cross right thumb over left(tt) | 33/29 |
| Cross left thumb over right. | 21/26 |
| Right handed. | 51/50 |
| Left handed. (hh) | 4/5 |

## APPENDIX C

Post PBL Survey

1. It is important to be able to communicate science information.
   Strongly Agree Agree Neutral Disagree Strongly Disagree

2. All cultures have the same dominant and recessive inherited traits.
   Strongly Agree Agree Neutral Disagree Strongly Disagree

3. Inherited traits are passed directly from parent to offspring.
   Strongly Agree Agree Neutral Disagree Strongly Disagree

4. All members of a family have the exact same DNA.

Strongly Agree Agree Neutral Disagree Strongly Disagree

# Effective Educational Leadership Training for Transformative Leadership

**Neria Sebastien**
Walla Walla University, Washington

**Abstract:** *In the required course work of many programs in Educational Leadership, doctoral candidates typically engage in various forms of analysis and synthesis about transformative leadership. Coursework in ethical education; transformational learning; creativity, inquiry, and innovative leadership; quantitative research methods; qualitative research methods, and leading organizational change form the basis of many courses of study. Evidence in the literature overwhelmingly support the position that educational leaders are highly effective, when engaging in both transformational and organizational development practices. Their effectiveness can also benefit student-learning outcomes. This paper draws from the main points of all of the aforementioned to illustrate how the effective educational leadership training can benefit student transformative educational leaders. The paper concludes that investment in educational leadership training is a pathway for large-scale education improvement.*

*Keywords: education, leadership, transformative, learning, students*

Educational leaders and researchers often set goals to demonstrate the influence school leaders have on student achievement. Here, school leadership is an all-inclusive term comprised of teacher leaders, principals, and district administrators. In fact, researchers believe that the total direct and indirect effects of leadership on student learning account for about twenty-five percent of school effects (Leithwood, Seashore-Louis, Anderson, & Wahlstrom, 2004). As a result, engaging educational leaders through reflection on the dynamics of diverse school communities towards development and change will benefit student achievement.

## TRANSFORMATIVE LEADERSHIP

There is agreement in the literature (Leithwood et al., 2004; Mezirow, 1991; Printy, Marks, and Bowers, 2003) that educational leaders are transformative learners and leaders. In fact, Printy et al. (2003) acknowledge that while the effect of leadership on student gains may vary in some quantitative and qualitative research inquiries, the distinction has more to do with the type of data collected and research question asked.

In reality, the evidence overwhelmingly suggest that the school leader is most effective when engaging in both transformational and organizational development practices that create conditions where teachers and students are empowered and motivated. This is also attainable when leadership display genuine concern and commitment to the growth of the whole person, whether student or staff (Printy et al., 2003).

Within the field of education, transformative learning can occur for the school leader, teacher and student. As Kumi-Yeboah (2012) found out, for some leaders the process of transformative teaching and learning can be a long journey. “It takes time, dedication, hard work, and learning for new teachers to be able to reflect on personal experiences” (Kumi-Yeboah & James, 2012, p. 170). Mezirow viewed transformative learning as “an enhanced level of awareness of the context of one’s beliefs and feelings, a critique of one’s assumptions, and particularly premises, and an assessment of alternative perspectives” (1991, p. 161).

The path of transformative learning necessitates the development of critical reflection, which involves challenging one’s assumptions and understandings in the effort to find new meaning. Mezirow (1991) advances critical reflection as a major objective of transformative learning. Transformational leadership draws attention to a broader array of school and classroom conditions that may need to be changed (challenging the status quo) if learning is to improve.

## EDUCATIONAL LEADERS ACQUIRE SKILLS AND KNOWLEDGE

Learning and leadership respectively, speak to how people learn and how people lead (Brown & Posner, 2001) and are more often than not, called upon to work in concert with each other. According to Mezirow (1991), transformative learning involves appropriating new meaning to previously held beliefs and ideas. Brown and Posner (2001) assert that "…transformative learning centers squarely on the cognitive process of learning" (p. 2). Most importantly, leadership demands cognitive processes to move people and organizations. When leadership involves transformative learning processes, leaders are more effective (Mezirow, 1991).

## TRANSFORMATIVE LEADERS ARE REFLECTIVE LEARNERS

Furthermore, Cranton (2006) emphasizes that educators can be transformative through active reflection. Reflection involves actively thinking about how culture and tone of the school can help to challenge students thinking and learning. Furthermore, Cranton (2006) advises that transformative learning is helped by critical discussions, not just between students and teachers but also between teachers and administration as they examine ideas and approaches to helping students develop.

In a research inquiry designed to study the effectiveness of transformational leadership and student satisfaction, Noland & Richards, (2014) discovered a positive correlation between teacher's transformational leadership and students' level of satisfaction with their instructor. This is to say that transformative leaders were more highly favored by students. In addition, students' reports of instructor performance, and students' respect for the instructor were at high levels when the instructor was received as being transformative. In fact, transformative learners will begin to increase their desire to learn and begin to develop positive attitudes towards work (Noland & Richards, 2014).

## ETHICAL LEADERSHIP

Educational leaders demonstrate ethical and moral leadership. The function of teaching is amongst the most important in our world today (Markie, 1994). Consequently, effective educational training involves coursework in ethical leadership. Part of this involves high degrees of professional ethics, which place students' needs first. This includes just decision-making and protecting them while they are in the teacher's care without intentionally exposing them to personal biases, prejudices, and harm.

For the educational leaders, a life focused on real ethics is where genuine liberty and prosperity can reside (Borgmann, 2006). Educational leaders who place students' needs first also make an indirect contribution to student learning through their influence on the student's parents (Branch, Hanushek & Rivkin, 2013).

According to Bonhoeffer (1995), "the man with a conscience fights a lonely battle against the overwhelming forces of inescapable situations which demand decisions". According to Ciulla (2004) good is "morally good and technically good or effective" (p. 305). Ethics is the heart of leadership and a good leader is ethical and effective (Ciulla, 2004).

## EDUCATIONAL LEADERS DEVELOP PEOPLE AND FORSTER COLLABORATION

Educational leaders who are teacher leaders, principals, and administrators are also managers of people. Hallowell (2011) emphasizes that best managers have the wherewithal to bring the best out of their employees and Nass and Yen (2012) emphasize the magnitude of the task by establishing that individual employees are different. They think and feel differently, so managers must take time to get to know each employee. Along these lines, Hallowell (2011) repeatedly asserts that people perform better when they are in happy situations, when they are motivated and they believe that their contributions are valued. Not surprisingly, disengaged employees often appear to lack commitment, drive, and dedication.

While most educational leaders have the best of intentions, it is undoubtedly true that at times leaders may appear detached from their staff or vice versa. Hallowell (2011) advances ideas that can help bridge the divide. Noticing people, paying attention to them and their contributions, giving some time during the day to listen to their concerns, being open to listening to advice and being able to put yourself in others' shoes are important ways whereby the roadblocks of interpersonal disconnectedness can be overcome. Hallowell (2011) believed that "Disconnection and overload pose particularly modern obstacles to peak performance" (p. 26). Not only do effective educational leaders support and develop staff, but they also understand the importance of nurturing staff and fostering a positive growth atmosphere. By developing people, leaders are providing teachers and others in the system with the necessary support and training to succeed. School leaders, teachers and parents need to not only project creativity and productivity but are able to harness these from their students (Beghetto & Kaufman, 2013; Stewart, 2004).

Educational leaders help develop staff productivity by encouraging collaboration. In particular, educational leaders help people think differently at work, collaborate with others, and lead by example. These leaders help build and actively promote a shared vision at the school (Leithwood et al., 2004). This may involve sharing an instructional activity, getting help with differentiating, developing or implementing a discussion protocol or receiving translation help during a parent conference. It is often overlooked but assuredly, when searching for help on an issue at school, it is always best to collaborate with peers first before seeking outside help, because there may be someone on staff who is very verse with the issue.

## INSTRUCTIONAL LEADERSHIP

Instructional leaders keep teaching and learning at the forefront of their minds and promote scholarship. Educational leaders manage the educational program charting a clear course that everyone understands, establishing high expectations and using data to track progress and performance. Some compelling evidence of this can be found in the Wahlstrom and Louis (2008) informative study designed to measure which leadership patterns promote good instruction. Their results indicate that leadership can be measured in two ways: first, as teachers' trust of their principal (highly indicative of transformational leadership) and second, as instructional influence shared among teachers. These promote good instructional outcomes.

## ORGANIZATION DEVELOPMENT IN EDUCATION

The need for Organizational Development (OD) is born out the reality that invariably, educational environments will have issues or problems, which can hinder the organization from reaching its stated purpose. While this is no truer in the business sector than the public sector, much of this discussion focuses on facilitation of organizational development in schools. "Successful educational leaders develop their districts and schools as effective organizations that support and sustain the performance of administrators and teachers, as well as students" (Leithwood et al., 2004, p. 9)

Engaging individuals in the process of change rests on the concept of transformational leadership. Transformative learning influences the effectiveness of OD. Mezirow (1991) stressed the implication of the realization that one is holding a distorted view. Thus, transformation begins when one ponders alternative points of view. In OD, one seeks to change the status quo or this distorted view and elevate productivity or some part of the work environment.

While there are many factors, which relate to dynamics involved in successful OD, real change can only take place when one has internalized the need for it. This is similar to the internal realization needed to make transformative learning work. As a change leader, (Fullan, 2011) the OD leader in the educational setting can engage staff in team building, improving school culture and norms, and using teacher teams to improve school-wide performance assessments, to name a few.

## EDUCATIONAL LEADERS WORK TOWARDS ORGANIZATIONAL DEVELOPMENT GOALS

Hallowell (2011) emphasizes that the best managers have the wherewithal to bring the best out of their employees. In a case where a school is not functioning properly, an educational leader must be able to make the organization work by ensuring that the entire range of conditions and incentives are present to make this happen. Leithwood et.al, (2004) explain that in certain cases "…organizational conditions sometimes blunt or wear down educators' good intentions and actually prevent the use of effective practices" (p. 13). Problems may arise between staff members, which can also be toxic in the learning environment.

Simply put, for effective educational leaders to benefit student achievement they must always put students first, which means that when problems arise they must do more than simply know what to do; alternatively, it means knowing when, why to do it and how it should be done (Waters, Marzano & McNulty, 2003). Deaner's (1994) principle of participation states that all people affected by the OD change should have the opportunity to be involved in the change, promoting the concept of shared power — developing a sense of belonging by encouraging employees to be part of the decision-making process.

## CONCLUSION

Studies in ethical education; transformational learning; creativity, inquiry, and innovation; quantitative research methods; qualitative research methods, and leading organizational change contribute to the development of transformative leaders. Educational leaders need to know how to foster an environment where teachers know what instructional methods work best for every student. This means knowing what to do, how to do it and when to do it.

One might argue that this discussion on the effectiveness of educational leadership does not differentiate among educational leaders of elementary, middle, or high schools. It is certainly true that the challenges faced by leaders across grades K – 12 are not all the same. However, I adopt this position because there is little in the literature to suggest that leadership differences based on grade level contribute in a meaningful way to fostering student-learning outcomes. With this in mind, it is important that the educational leader develop an inventory of critical behaviors that can serve as markers for success. Some of which are: fostering a sense of community; protecting teachers and students from issues that would distract from teaching and learning; becoming visible (engaging in high quality contact with teachers and students); and developing and sustaining strong lines of communication with teachers, staff, students, parents and the community. Effective educational leaders are flexible, transformative, ethical and adaptable on order to adjust leadership behavior to ever changing organizational needs.

## REFERENCES

Beghetto, R. A. & Kaufman, J. C. (2013). Fundamentals of creativity. *Educational Leadership 70*(5), 11- 15

Bonhoeffer, D. (1995). *Ethics.* (N. H. Smith, Trans.). New York, NY: Touchstone

Borgmann, A. (2006). *Real American ethics:* Taking responsibility for our country. Chicago, Il: University of Chicago Press

Branch, G., Hanushek, E., & Rivkin, S. G. (2013). School leaders matter: measuring the impact of effective principals. *Education Next,* 13.

Brown, L. M., & Posner, B. Z. (2001). Exploring the relationship between learning and leadership. *Leadership & Organization Development Journal,* 22(6), 274-280. doi:10.1108/01437730110403204

Ciulla, J. B. (2004). Ethics and leadership effectiveness. *The nature of leadership*, 302-327.

Cranton, P.A. (2006). Fostering authentic relationships in the transformative classroom. *New Directions for Adult and Continuing Education, 6*(109), 5-13. doi:10.1002/ace.203

Deaner, C. D. (1994). A model of organization development ethics. *Public Administration Quarterly,* 435-446.

Fullan, M. (2011). *Change leader: Learning to do what matters most.* San Francisco, CA: John Wiley & Sons.

Hallowell, E. M. (2011), *Shine: Using brain science to get the best from your people.* Boston, MA: Harvard Business Review Press

Henry, O. (2009). Organizational Conflict and its effects on Organizational Performance. *Research Journal of Business Management,* 2(1), 16-24. doi:10.3923

Kumi Yeboah, A. (2012). Factors that promote transformative learning experiences of international graduate-level learners. Retrieved from www.scholarcommons.usf.edu/cgi/viewcontent.cgi?article=5309&context=etd

Leithwood, K., Seashore Louis, K., Anderson, S., & Wahlstrom, K. (2004). Review of research: How leadership influences student learning. *Center for Applied Research and Educational Improvement.* University of Minnesota. Retrieved from http://conservancy.umn.edu/handle/11299/2035

Markie, P. J. (1994). *A professor's duties: Ethical issues in college teaching.* Rowman & Littlefield.

Mezirow, J. (1991). *Transformative dimensions of adult learning.* San Francisco, CA: Jossey-Bass.

Noland, A., & Richards, K. (2014). The relationship among transformational teaching and student motivation and learning. *JET, 5*. Retrieved from http://files.eric.ed.gov/fulltext/EJ1060434.pdf

Printy, S., Marks, H., & Bowers, A. (2010). Integrated leadership: How principals and teachers share transformational and instructional influences. *Jsl* Vol 19-N5, 19, 504.

Wahlstrom, K. L., & Louis, K. S. (2008). How teachers experience principal leadership: The roles of professional community, trust, efficacy, and shared responsibility. *Educational administration quarterly*, 44(4), 458-495.

## ABOUT THE AUTHOR

Neria Sebastien is an associate professor of education at Walla Walla University in Washington.

# Bringing Formal and Informal Science Education in Elementary Teacher Preparation: An Evaluation of Health Center Collaboration

**Sarah J. Carrier, Kylie S. Hoyle, and Sarah C. Luginbuhl**

**Abstract:** *The purpose of this study was to explore how a health-based informal science education course, as part of an elementary undergraduate teacher preparation program, influenced pre-service teachers' ideas about formal and informal science teaching and learning. Additionally, the study explored how the course impacted their understandings of the value of bridging informal science to supplement formal instruction. Qualitative study data were gathered through two (mid- and end-of-semester) focus group interviews with five pre-service teachers enrolled in a health-based informal science course. Analysis of data indicated that the inclusion of informal science education experiences during PST preparation has the potential to support novice teachers' developing ideas about science teaching and learning including ways to connect science to students' lives and make science engaging and meaningful. Findings are reported in four key themes that emerged from the data: (a) formal teacher preparation and informal education, (b) connections between formal and informal science education, (c) personal and professional collaborations, and (d) benefits of informal science education.*

*Keywords: Elementary science education, informal science education, health science, teacher preparation*

## INTRODUCTION

Elementary school teachers are responsible for teaching all subjects, yet many feel they lack the disciplinary knowledge or confidence in teaching science. Many pre-service teachers (PST) report few or weak models of effective science teaching during elementary school and in field placement schools (Abell & Roth, 1992; Avraamidou, 2014; Davis, Petish, & Smithey, 2006). Calls for reform have emphasized the need for teachers to prepare today's children with the ability to think critically and be creative problem solvers (National Research Council [NRC], 2007; NRC, 2012). Helping children learn strategies for investigating their world with a critical lens includes building a solid foundation in elementary school science. However, preparing elementary school teachers to identify as science teachers is challenged by elementary pre-service teachers' (PST) memories when they were elementary students (Thomas & Pederson, 2003). One legacy of No Child Left Behind (NCLB, 2003) legislation is the marginalization of science through an emphasis on mathematics and language arts and their related test scores (Goldston, 2005). To address this deficit, researchers have identified the potential to supplement what children learn in school by bridging formal science education with informal experiences and outreach (Avraamidou, 2015; Rennie & Johnston, 2004; Russell, 2002). Relatedly, expanding elementary teacher preparation to include informal science opportunities offers potential to enrich and expand pre-service teachers' learning experiences (Avraamidou, 2015; Carrier, 2009).

## INFORMAL SCIENCE EDUCATION

Formal science education, in the context of this paper, is defined as traditional classroom teaching and learning, whereas informal science education references learning that occurs outside of school, such as field trips to museums or nature centers (Eshach, 2007). Braund and Reiss (2006) report that two-thirds of students' waking lives are spent outside of formal school settings. Their review of international research studies identifies positive impacts of free choice learning inherent to informal settings on students' attitudes and motivation for science learning, and on connecting science to students' lives (Griffin, 2004). Here we add to studies that examine the affordances of bridging of informal science experiences in formal science teacher preparation (Avraamidou, 2015; Carrier, 2009; Hofstein & Rosenfeld, 1996; Kelly, 2000; Kisiel, 2013).

**Informal science education and teacher preparation.** Bridging formal and informal science learning environments to address science education reform goals may enhance pre-service science teacher preparation (Avraamidou, 2014; McGinnis et al., 2012). For example, Jung and Tonso (2006) found that PSTs who taught elementary school students in museum and nature centers perceived their experiences as supportive of their own classroom-based science teaching and learning practices. PSTs reported that the experience felt non-threatening, thus building their confidence in teaching science. In another study, PSTs credited their improved science teaching self-efficacy to experiences teaching students at a forestry preserve (Carrier, 2009). PSTs described the how students' excitement and interest in the informal settings strengthened their confidence in their abilities to teach science. Research suggests this connection to informal science experiences can shape PSTs' views on the nature of science teaching and learning, build confidence, and support science learning that occurs in formal instruction (Anderson, Lawson, Mayer-Smith, 2006).

## METHODS

### Context

The present research examined the informal science education field experiences of five PSTs enrolled in an undergraduate STEM-focused elementary teacher preparation program. The teacher preparation program includes two science methods courses; requirements beyond those of many teacher preparation programs as identified in a recent national survey in the U.S. (Trygstad, 2013). Following the first science methods course, PSTs have the option to enroll in a supplemental informal science education course, concurrent with their second science methods course. The informal education course consists of working with informal health educators at a local health education center (Center) that serves elementary and middle school field trip groups. Each PST worked individually with an informal health educator from the Center who guided PSTs to develop programs on health topics to present to visiting school groups from across the state. The topics included: dental health, nutrition, family life, general health, and drug education.

PSTs' experiences were captured to help inform teacher preparation programs about the potential impact of informal science education experiences during teacher preparation. Additionally, through their experience at the Center, the PSTs had the opportunity to work closely with their first science methods professor, the informal health educators at the Center, as well as collaborate with one another.

### Participants

The five pre-service teachers represented the common demographic for beginning elementary teachers (white and female) as identified in the National Survey of Science and Mathematics Education (NSSME) (Banilower, Trygstad, & Smith, 2015). At the time of the study, the pre-service teachers were 21-22 years old and enrolled in the second semester of their junior year in a four-year elementary teacher preparation program.

Our research question asked:

How does participation in an informal science education experience during formal elementary teacher preparation impact elementary pre-service teachers' views of science education?

### Data collection

The PSTs were invited to participate in two hour-long focus groups, one mid-semester and one later in the semester. Williams and Katz (2001) have identified focus groups as providing collective and individual ideas that empower participants in this research process. The PSTs were asked about their observations of children visiting the Center during school field trips, their experiences with the informal educators, and the impact of their former and current views of science education. During focus groups, the researcher audio recorded the conversations with PSTs using pseudonyms to protect PSTs' identity. The audio data were then transcribed and coded using NVivo qualitative analysis software. Three researchers individually coded transcripts, identifying themes that emerged from the data. Common themes were discussed and differences in interpretation were resolved. A second round of coding narrowed the identification of themes and researcher interpretation; this was followed by a third round and resolution of differences. Researchers' common codes were compared and interrater reliability of 95% was established during a second round of coding and discussion.

### Data analysis

Focus group transcripts were open coded to identify common themes that emerged (Creswell, 2007).

The main themes were:

1. Formal teacher preparation and informal education
2. Connections between formal and informal science education
3. Culture of collaboration
4. The benefits of informal science education

## RESULTS

Overall assessment of PSTs' experiences revealed their professional and personal growth related to their semester-long involvement at the Center. Focus group data (excerpts) are reported below and organized by main themes that emerged from the interview transcripts across both focus group meetings. These data illustrate ways that the experience broadened PSTs' conceptions of formal and informal science education during their teacher preparation.

### Formal Teacher Preparation and Informal Education

The PSTs reported that they could link what they learned in their formal science methods classes with practices they observed at the Center. Ann described learning from her methods courses that science instruction "has to have some relevance to students' lives and science is all about our lives." She explained, "I think our methods courses are frequently aligned with the idea of informal science, of capturing the energy of informal science in the classroom." PSTs recognized how science content and practices presented in their science methods courses applied to informal settings, and their informal science education course working at the Center solidified their understanding of these collective practices. PSTs further made connections with engaging science instruction practices. Bonnie explained, "Seeing the kids really excited to be there and enjoying the programs…kids tend to learn better when they're moving around."

### Connections Between Formal and Informal Science Education

PSTs' collaborations with informal educators at the Center showed them that the educators spend a large amount of time planning and trying to balance a fun, low-pressure environment with learning, which they strategically linked to the state's science standards. In the second focus group Cathy stated, "I know how much work goes into teaching, but planning these programs and thinking about what will be fun for the kids but still educational and get the point across, it's a lot of work." Sharon explained, "You need to have a game plan...kids can still get excited, but they still need to learn at the end of the day." Sally reported feeling surprised by how closely related classroom educators' and informal educators' tasks and goals are, and she recognized from her observations of school group visits that teachers can enhance student learning from informal settings by providing students with related activities prior to the field trip.

### Culture of Collaboration within Informal Science Environments

Many PSTs described the benefits of having deep conversations about teaching and learning with their professor and the Center's informal educators, which they believed would strengthen their abilities to collaborate with experienced teachers in the future. The PSTs reported that their work with the health educators made them feel valued and they began to see themselves as professionals. They appreciated the relaxed connections with their professor in the informal science education setting. Ann stated, "Working with [Professor] is awesome and getting to know [Professor] on a personal basis, I think we all have the stigma of our professors being scary…"

PSTs also described that working and communicating with their peers about their projects contributed to a deeper understanding of what they could do for their projects. These interactions also built camaraderie and enriched their learning. Bonnie said, "The conversations that we've had as a group … has really helped me to develop a much better understanding of...informal science education."

### The Benefits of Informal Science Education

The PSTs' observations of school groups at the Center helped them gain an appreciation for the varied opportunities and benefits afforded by the Center. They recognized that informal education could be engaging for children and provide students with opportunities they may not otherwise experience. Sharon described the engagement they witnessed, "It's a different experience so you're getting the informal science and you're getting them excited about learning." Bonnie stated, "I think kids tend to learn better when they're moving around and experiencing it on a different level than they do in the classroom."

The PSTs recognized that when schools incorporate informal science learning they expand students' visions of science. Sally explained, "They might never get to go to a museum…Their parents might not have the resources." Ann described how informal science education enriches students' learning because (formal education) teachers "might not have the time in the classroom."

## DISCUSSION

These focus groups suggest that the inclusion of informal science education for PSTs can enrich their formal teacher preparation program experiences (Avraamidou, 2014, 2015; Carrier, 2009). Such experiences have the potential to broaden PSTs' notions of science instruction by providing them with exposure to science teaching and learning that occurs outside of formal classrooms. Interviews with PSTs in this study revealed four dominant outcomes of their participation with the Center that expanded their visions of science learning beyond formal school settings to embrace the benefits of informal science education:

(a) PSTs were able to recognize how programs at the Center connected science to students' lives, a concept promoted in their science methods courses. As they developed programs for visiting school groups, PSTs witnessed students' interest and engagement (Griffin, 2004) while participating in activities learning about their bodies and healthy living;

(b) PSTs recognized the mutual goals for active and engaged learning that formal and informal science educators share (Hofstein & Rosenfeld, 1996); the PSTs described plans to incorporate learning activities from the informal education setting into their future classrooms;

(c) PSTs' collaborations with other PSTs, the Center's health educators, and the course instructor supported their developing identities of themselves as professionals and provided them confidence for future collaborations with fellow teachers and administrators (Anderson et al., 2006; Carrier, 2009);

(d) PSTs in this study recognized how formal educators may encourage student engagement in science by supplementing formal instruction with learning opportunities in informal settings (Hofstein & Rosenfeld, 1996).

PSTs' work in an informal science setting helped prepare them as teachers to better supplement formal education with informal experiences. They learned that when teachers provide students with activities before and after their informal education experiences, they increase the potential for student learning.

### Limitations

PSTs self-selected for their participation in the course, which limits the generalizability of the findings to broader populations. Data collected in this study were focus group interviews, which have the potential to limit as well as expand discussion ideas. The small sample size further limits generalizability of the findings beyond this study.

## CONCLUSION

The findings from this study indicate that informal science experiences have the potential to support pre-service teachers' developing notions of effective science teaching and learning. As identified in the present study and by other researchers (Anderson et al., 2006; Avraamidou, 2015; Carrier, 2009; Kisiel, 2013), informal science environments offer motivating free-choice learning experiences and connect science to students' lives. The inclusion of informal science experiences as part of teacher preparation has potential to expand novice teachers' visions of science teaching and learning. Further research can follow beginning teachers whose teacher preparation included informal education experiences into their novice teaching years to examine their inclusion of informal strategies and experiences with their future students.

## REFERENCES

Abell, S. K., & Roth, M. (1992). Constraints to teaching elementary science. A case study of a science enthusiast student. *Science Education, 76*(6), 581–595.

Anderson, D., Lawson, B., & Mayer-Smith, J. (2006). Investigating the impact of a practicum experience in an aquarium on pre-service teachers. *Teaching Education, 17*(4), 341-353.

Avraamidou, L. (2015) Reconceptualizing elementary teacher preparation: A case for informal science education their development.

*International Journal of Science Education, 37*(1), 108-135.

Avraamidou, L. (2014). Developing a reform-minded science teaching identity: The role of informal science environments. *Journal of Science Teacher Education, 25*(7), 823-843.

Banilower, E.R., Trygstad, P.J., & Smith, P.S. (2015). The first five years: What the 2012 national survey of science and mathematics education reveals about novice science teachers and their teaching. *In Newly Hired Teachers of Science: A Better Beginning* (J.A. Luft and S. Dubois Eds.) Rotterdam, The Netherlands: Sense Publishers (p. 3-29).

Braund, M., & Reiss, M. (2006). Towards a more authentic science curriculum: The contribution of out-of-school learning. *International Journal of Science Education, 28*(12), 1373-1388.

Carrier, S. (2009). The effects of outdoor science lessons with elementary school students on preservice teachers' self-efficacy. *Journal of Elementary Science Education, 21*(2), 35-48.

Creswell, J. W. (2007). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches* (2nd ed.). Thousand Oaks, California: SAGE Publications.

Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of educational research, 76*(4), 607-651.

Eshach, H. (2007). Bridging in-school and out-of-school learning: Formal, non-formal, and informal education. *Journal of science education and technology, 16*(2), 171-190.

Goldston, D. (2005). Elementary science: Left behind? *Journal of Science Teacher Education, 16*(3), 185-187.

Griffin, J. (2004). Research on students and museums: Looking more closely at the students in school groups. *Science education, 88*(1), S59.

Hofstein, A., & Rosenfeld, S. (1996). Bridging the gap between formal and informal science learning. *Studies in Science Education, 28,* 87-112.

Jung, M. L., & Tonso, K. L. (2006). Elementary preservice teachers learning to teach science in science museums and nature centers: A novel program's impact on science knowledge, science pedagogy, and confidence teaching. *Journal of Elementary Science Education, 18*(1), 15-31.

Kelly, J. (2000). Rethinking the elementary science methods course: A case for content, pedagogy, and informal science education. International *Journal of Science Education, 22*(7), 755-777.

Kisiel, J. (2013). Introducing future teachers to science beyond the classroom. *Journal of Science Teacher Education, 24*(1), 67-91.

McGinnis, J. R., Hestness, E., Riedinger, K., Katz, P., Marbach-Ad, G., & Dai, A. (2012). Informal science education in formal science teacher preparation. *In Second international handbook of science education* (pp. 1097-1108). Netherlands: Springer.

National Research Council. 2007. *Taking Science to School: Learning and Teaching Science in Grades K-8.* Washington, DC: The National Academies Press. doi:https://doi.org/10.17226/11625.

National Research Council. 2012. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington, DC: The National Academies Press. doi:https://doi.org/10.17226/13165.

Rennie, L. J. & Johnston, D. J. (2004). The nature of learning and its implications for research on learning from museums. *Science Education, 88*(S1), S4-S16.

Russell, R. L. (2002). Museum outreach. *Informal Learning, 52,* 12-17.

Thomas, J. A., & Pedersen, J. E. (2003). Reforming elementary science teacher preparation: What about extant teaching beliefs? *School Science and Mathematics, 103*(7), 319-330.

Trygstad, P. J. (2013). 2012 *National Survey of Science and Mathematics Education: Status of elementary school science.* Chapel Hill, NC: Horizon Research, Inc.

Williams, A., & Katz, L. (2001). The use of focus group methodology in education: Some theoretical and practical considerations, 5 (3). *IEJLL: International Electronic Journal for Leadership in Learning, 5.*

## ABOUT THE AUTHORS

Sarah J. Carrier is an associate and Sarah C. Luginbuhl is a doctoral student in the College of Education at North Carolina State University in North Carolina. Kylie S. Hoyle is an assistant professor in the College of Education at the University of Colorado in Colorado Springs, Colorado.

# Prospective Teachers' Beliefs about Mathematics: An Overview

**Katherine Baker**
Elon University, North Carolina

**Abstract:** *The Mathematics Enthusiast Special Issue (2014) presented an extensive review of the literature around the content knowledge of prospective elementary teachers (PTs). The issue excluded articles around PTs' beliefs. Understanding research around PTs' beliefs is important to understanding how to design and support their teaching preparation. Attending to PTs' beliefs helps to ensure their content knowledge and instructional methods are aligned with reform-based mathematics. This article highlights a literature review that addressed the omission of beliefs and explored how teacher preparation might address PTs' held beliefs.*

*Keywords: mathematics, beliefs, prospective teacher (PT), elementary*

The Mathematics Enthusiast Special Issue (Thanheiser & Browning, 2014) featured extensive literature reviews regarding the mathematical content knowledge of prospective elementary teachers (PTs). The intent was to inform future research and design of mathematics education coursework. Because of the content knowledge focus, articles that discussed PTs' beliefs were excluded from review (Browning et al., 2014). However, by understanding PTs' beliefs around mathematics, insight is gained about the pedagogical choices they may make in classrooms. A thorough review of the literature around PTs' beliefs about mathematics was completed (Baker, 2014). Provided next is an overview of that process with emphasis on influencing PTs' beliefs towards reformed-based mathematics.

## TERMINOLOGY

The word belief was interpreted with Pajares' (1992) lens, in that a belief is a form of knowledge in the deeply personal sense; knowledge is based on objective fact, but belief is based on judgment. Ambrose, Clement, Philipp, & Chauvot (2004) cautioned that since beliefs are personal, those who research beliefs make inferences about participants' expressed beliefs while also holding their own beliefs. That being the case, all of the studies presented are assumed true for that set of researchers within that particular context.

The term reform-based mathematics reflects the National Council of Teachers of Mathematics (2000) expectation that high quality mathematics education is based around the guiding principles of equity, appropriate use of technology, coherent curriculum, teachers who understand what students know and are able to do, students who learn with understanding, and assessments that are useful to both teacher and learner.

## BACKGROUND

Taken together, pieces from Pajares (1992) and Battista (1994) provided a backdrop to the literature around PTs' beliefs in mathematics and aided in understanding why shifting PTs' beliefs towards reform is challenging. Much of the research on teacher beliefs referenced Pajares' (1992) in which he asserted that while one must examine the content and teacher thinking that impacts reform movements, what teachers believe and the ways they believe must also be examined. Pajares (1992) acknowledged beliefs are difficult to research because they are not easily identified and evaluated, nor is there a consistent definition for beliefs across research. However, researchers do agree that all teachers hold beliefs about the role, thus understanding beliefs is important to future initiatives.

Battista's (1994) work established a background for research on teacher beliefs within the context of mathematics. Historically, mathematics was seen as computation, so teaching mathematics meant providing students with a set of skills and learning mathematics meant remembering and progressing through set skills. Reform-based mathematics asks that students do mathematics through problem solving and sense making instead of through rote memorization. Battista (1994) felt that teachers holding traditional beliefs around mathematics teaching and learning were “robbing their students of opportunities to ‘do’ mathematics” (p.467). However, like Pajares (1992), Battista acknowledged that beliefs are difficult to shift. If PTs experienced traditional mathematics learning as K-12 students, then traditional beliefs may be ingrained and must be addressed if reform is desired.

## SELECTION AND ANALYSIS OF STUDIES

The search for studies for the original review was done through ERIC using the parameters of Full Text, Peer-Reviewed, and September 2004-September 2014. The search “Preservice Teacher Beliefs” returned 97 records, and adding the key word of “Mathematics” resulted in 26 records. “Prospective Teacher Beliefs” with “Mathematics” produced seven records. The 26 and seven were taken together as 33 records and were read in order to determine their applicability to the literature review. Narrowing in on the topic meant records were disregarded if they discussed research around PT beliefs outside of the realm of mathematics. Two records that discussed practicing teacher beliefs about mathematics were retained as they suggested why examining PT beliefs might be of importance. In total, 16 records met applicability parameters and were re-read in detail, noting commonalities and emerging themes.

Extensive summaries of the 16 records were written and three prominent themes emerged. The records were organized within the following themes: Teachers’ Beliefs and Student Achievement, Revealing Prospective Teachers’ Beliefs about Mathematics, Influencing Prospective Teachers’ Beliefs About Mathematics. Tables were created for each theme and are provided in Appendix A for reference of the organization and context of the reviewed studies. What follows is a glimpse into the themes to shed light on efforts to influence and maintain PTs’ beliefs towards reform-based mathematics.

## THEME 1: TEACHERS’ BELIEFS AND STUDENT ACHIEVEMENT

Polly et al. (2013) helped validate the importance of attending to teacher beliefs about mathematics by studying how beliefs are related to student performance. Polly et al. (2013) found that those teachers whose beliefs aligned with traditional teaching and learning had a higher frequency of teacher-centered practices, such as presenting mathematics as a set of facts to students in a didactic manner. In turn, teachers whose beliefs aligned with reformed approaches to teaching and learning used more student-centered pedagogies that relied on experiences to help students explore and make connections among mathematical concepts. Students in the traditional-oriented, teacher-centered classrooms had significantly smaller gains on curriculum-based assessments, whereas the students in reform-based classrooms saw higher growth from pre-test to post-test.

The study highlighted the importance of attending to teacher beliefs about mathematics teaching and learning for the sake of students. However, the findings were from practicing teachers’ classrooms. The remainder of the studies examined how teacher preparation programs might uncover and address the mathematical beliefs of PTs before entering the profession.

## THEME 2: REVEALING PROSPECTIVE TEACHERS’ BELIEFS ABOUT MATHEMATICS

Understanding the effects of teacher beliefs on student performance is crucial, but in order to address beliefs, PTs’ held beliefs must be uncovered. Two approaches from this theme’s literature are highlighted next: (a) constructed response and (b) drawing.

Ambrose, Clement, Philipp, & Chauvot (2004) described the process of assessing the mathematical beliefs and belief change of PTs through a self-designed instrument called the Integrating Mathematics and Pedagogy (IMAP) Web-Based Belief Survey. The instrument development was based around free-responses rather than Likert scale responses because free-response allowed for rich description and greater insight into PTs’ beliefs. The survey was designed around three overarching belief systems: beliefs about mathematics, beliefs about knowing/learning mathematics, and beliefs about children’s doing and learning of mathematics. The IMAP Web-Based Belief Survey contains constructed responses around teaching scenarios, such as videotapes of student/teacher interactions, and also asks PTs to explain their thinking around mathematics problem structures and various student solution strategies. In development stages, the survey was administered to PTs at the beginning and end of a course to evaluate its sensitivity in capturing individuality amongst PTs’ beliefs and belief changes. Findings revealed varied responses from

PT to PT in the pre-survey, and revealed that some PTs' beliefs changed towards reform ideals from pre to post survey and other PTs' beliefs did not change. These findings supported the researchers' aim of eliciting PTs' beliefs and any belief changes in order to provide insight on instrument development and a potential tool for others.

Burton (2012) used the task of drawing to elicit and analyze PT perceptions about mathematics. She asserted that through PT self-examination and reflection of their perceptions, PTs can "begin to explore and deepen their own understanding, overcome anxiety, and connect the content to elementary students" (p.2). Burton asked 62 PTs to "draw math" (p.4) at the beginning and end of a mathematics methods course. Grounded theory (Strauss and Corbin, 1994) was used to explore the drawings and they were coded as positive, neutral, or negative. At the beginning, 52% of the drawings expressed negative emotions, but 0% of the post-drawings were negative. Instead, post-drawings became 39% neutral and 61% positive. An unexpected outcome was that PTs referred to their drawings throughout the entirety of the course. Burton believed that this reflection, and the openness for it, allowed PTs to acknowledge and evaluate their own perceptions, leading to changing beliefs and emotions around mathematics.

## THEME 3: INFLUENCING PROSPECTIVE TEACHERS' BELIEFS ABOUT MATHEMATICS

If it is acknowledged that beliefs about mathematics teaching and learning matter to PTs' future students' learning, and if instruments are available to reveal those beliefs, then examination is needed around what to do upon reveal. Embedding interviews into coursework to enact belief change was a common thread in the studies within the third theme and is explored next.

Ambrose (2004) challenged the university role of blindly tearing down beliefs and instead asked that coursework build upon held beliefs and help PTs form new ones. She proposed field experiences in PTs' first mathematics course and using the experiences as a "stimulus for expanding their views of teaching and affecting their beliefs about learning mathematics" (p.92).

Ambrose offered four possible mechanisms to affect PTs' beliefs: create emotion-filled experiences in courses, develop a positive community to instill positive beliefs in relation to mathematics, reflect on beliefs so that hidden beliefs become overt, and offer experiences or reflections that help PTs connect beliefs to other beliefs. Ambrose used a field experience with PTs in which they worked in pairs to interview individual children about their inherent problem-solving skills and mathematical sense making. The interview partnerships developed questions, reflected on the interviews, and adjusted methods for subsequent interviews. Ambrose's goal was to provide the aforementioned four mechanisms for belief change within this fieldwork with children. After the experience, many of the PTs' reflections showed changes in beliefs about teaching and learning towards reformed ideals, suggesting that this intensive work with children can spur belief evolution for PTs.

The PTs' reflection responses allude to the Circles of Caring model (Philipp, 2008). The Circles of Caring model asserts that in order to see improvement in the mathematics skills in our country, PTs must understand and value children's mathematical thinking. The Circles of Caring model assumes that PTs chose a career in teaching because they care about children and through this care of children, teacher educators can help PTs care about mathematics.

Philipp (2008) suggested the use of interviews in which a PT asks students to solve rigorous mathematics problems. This hooks a PT's interest in engaging with children's mathematical thinking and then in turn, hooks the PT's interest in mathematics content. Interviews can address the false belief held by many PTs that elementary mathematics content is simplistic. When PTs watch, students solve problems they begin to understand that elementary content is complex and that their content and pedagogical skills must be expanded if they are to meet students' instructional needs.

The literature in this theme emphasized that PTs become interested in student learning when they can hear how students think and watch how students solve problems. Interviews can challenge PTs' preconceived ideas of what students know or are able to do mathematically, and can reveal that children are capable of far more than is expected. Interviews also take the intimidation out of teaching situations, as they allow for PTs to work with students one-on-one. This removes the complicating factor of management of a group and allows a PT to concentrate on the mathematical thinking at hand.

## IMPLICATIONS FOR FUTURE RESEARCH AND TEACHER EDUCATION

Within the body of literature on PT beliefs, there is an emphasis on identifying the beliefs of PTs. The more challenging aspect of this work is how to impact beliefs in a manner that best supports the initiatives of teacher education coursework and the reform-based mathematics initiatives. When studies discuss influencing PT beliefs, they typically do not follow the PTs outside particular coursework or beyond teacher preparation. The field needs future research around if and how reformed beliefs hold when PTs are faced with their own classroom decisions during student teaching practicums and induction years. Reform-based beliefs instilled during PT preparation might mean that PTs provide a more meaningful and successful mathematics experience for their future students.

## REFERENCES


Ambrose, R. (2004). Initiating change in prospective elementary school teachers' orientations to mathematics teaching by building on beliefs. *Journal of Mathematics Teacher Education*, 7(2), 91-119.

Ambrose, R., Clement, L., Philipp, R., & Chauvot, J. (2004). Assessing prospective elementary school teachers' beliefs about mathematics and mathematics learning: Rationale and development of a constructed-response-format beliefs survey. *School Science and Mathematics, 104*(2), 56-69.

Baker, K. (2014). A review of prospective teachers' beliefs about mathematics. Unpublished manuscript, University of North Carolina at Chapel Hill.

Battista, M.T. (1994). Teacher beliefs and the reform movement in mathematics education. *Phi Delta Kappan, 75*(6), 466-468.

Browning, C., Thanheiser, E., Edson, A., Kimani, P. M., Olanoff, D., Tobias, J. M., & Whitacre, I. (2014). Prospective elementary mathematics teacher content knowledge: An Introduction. *Mathematics Enthusiast, 11*(2), 203-216.

Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 106*(4), 173-180.

Burton, M. (2012). What is math? Exploring the perception of elementary pre-service teachers. *Issues in the Undergraduate Mathematics Preparation of School Teachers,* 5.

Gülten, D. Ç. (2013). An investigation of pre-service primary mathematics teachers' math literacy self-efficacy beliefs in terms of certain variables. *International Online Journal of Educational Sciences, 5*(2). 393-408.

Hart, L. C., Oesterle, S., & Swars, S. L. (2013). The juxtaposition of instructor and student perspectives on mathematics courses for elementary teachers. *Educational Studies in Mathematics, 83*(3), 429-451.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American educational research journal, 42*(2), 371-406.

Malinsky, M., Ross, A., Pannells, T., & McJunkin, M. (2006). Math anxiety in pre-service elementary school teachers. *Education, 127*(2), 274-279.

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

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of educational research,* 62(3), 307-332.

Peker, M. (2009). Pre-service teachers' teaching anxiety about mathematics and their learning styles. *Eurasia Journal of Mathematics, Science & Technology Education, 5*(4), 335-345.

Philipp, R. A. (2008). Motivating prospective elementary school teachers to learn mathematics by focusing upon children's mathematical thinking. *Issues in Teacher Education, 17*(2), 7-26.

Philipp, R. A., Ambrose, R., Lamb, L. L., Sowder, J. T., Schappelle, B. P., Sowder, L., & Chauvot, J. (2007). Effects of early field experiences on the mathematical content knowledge and beliefs of prospective elementary school teachers: An experimental study. *Journal for Research in Mathematics Education, 38*(5), 438-476.

Polly, D., McGee, J. R., Wang, C., Lambert, R. G., Pugalee, D. K., & Johnson, S. (2013). The Association between Teachers' Beliefs, Enacted Practices, and Student Learning in Mathematics. *Mathematics Educator, 22*(2), 11-30.

Staub, F. C., & Stern, E. (2002). The nature of teachers' pedagogical content beliefs matters for students' achievement gains: Quasi-experimental evidence from elementary mathematics. *Journal of educational psychology, 94*(2), 344.

Strauss, A. & Corbin, J. (1994). *Basics of Qualitative Research.* London: Sage.

Thanheiser, E., Philipp, R. A., Fasteen, J., Strand, K., & Mills, B. (2013). Preservice-teacher interviews: A tool for motivating mathematics learning. *Mathematics Teacher Educator, 1*(2), 137-147.

Thanheiser, E., & Browning, C. (Eds.). (2014). TME Volume 11, Number 2, *The Mathematics Enthusiast, 11*(2). http://scholarworks.umt.edu/tme/vol11/iss2/11

Timmerman, M. A. (2004). The influences of three interventions on prospective elementary teachers' beliefs about the knowledge base needed for teaching mathematics. *School Science and Mathematics, 104*(8), 369-382.

Uusimaki, L., & Nason, R. (2004). Causes underlying pre-service teachers' negative beliefs and anxieties about mathematics. In *Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education, 4,* 369-376.

Wilkins, J. L., & Brand, B. R. (2004). Change in preservice teachers' beliefs: An evaluation of a mathematics methods course. *School Science and Mathematics, 104*(5), 226-232.

## ABOUT THE AUTHOR

Katherine Baker, a 2013-14 Kenan Fellow, is an assistant professor of Education at Elon University in North Carolina. She is an instructor and supervisor of prospective teachers, and a mathematics professional development facilitator around student-centered mathematics.

## APPENDIX A

**Table 1:** *Theme 1—Teachers' Beliefs and Student Achievement*

| **Author(s)** | **Year** | **Number of PTs in study** | **Methodology: Quantitative or Qualitative Belief Measure** | **Means of Access to Beliefs and Assessment** (questionnaire, instrument, interview, etc.) | **Context** (Mathematics Methods Course, Mathematics for Teachers Content Course, etc.) |
|---|---|---|---|---|---|
| Polly, D., McGee, J. R., Wang, C., Lambert, R. G., Pugalee, D. K., & Johnson, S. | 2013 | 0 (53 Elementary Classroom Teachers, 688 students) | Quantitative | Teachers: Teachers' Belief Questionnaire and Teachers' Practices Questionnaire (Swan, 2007), The Mathematical Knowledge for Teaching assessment (Hill, Rowan, & Ball, 2005), <br><br> Students: Investigations in Number, Data, and Space student assessment (TERC, 2008) | N/A |
| Staub, F. C., & Stern, E. | 2002 | 0 (487 students, 22 teachers) | Quantitative | Teachers: Fennema et al. Belief Survey <br><br> Students: Pre and Post word problem assessments, speed fact tests | N/A |

**Table 2:** *Theme 2- Revealing Prospective Teachers' Beliefs about Mathematics*

| **Author(s)** | **Year** | **Number of PTs in study** | **Methodology: Quantitative or Qualitative Belief Measure** | **Means of Access to Beliefs and Assessment** (questionnaire, instrument, interview, etc.) | **Context** (Mathematics Methods Course, Mathematics for Teachers Content Course, etc.) |
|---|---|---|---|---|---|
| Ambrose, R., Clement, L., Philipp, R., & Chauvot, J. | 2004 | 150 | Qualitative (data later quantified for comparison) | Self-designed belief survey with free response, evaluated by self-designed rubrics | Methods Course |
| Burton, M. | 2012 | 62 | Qualitative | Drawings (around "What is math?") and Open Coding | Methods Course |
| Bursal, M., & Paznokas, L. | 2006 | 65 | Quantitative | Revised-Mathematics Anxiety Survey (R-MANX), Math Teaching Efficacy Belief Instrument (MTEBI) | Methods Course |
| Gülten, D. Ç. | 2013 | 152 | Quantitative | Survey utilizing the Self-Efficacy Scale | N/A |
| Hart, L. C., Oesterle, S., & Swars, S. L. | 2013 | 12 | Qualitative | Interviews and Observations | Mathematics For Teachers (MFT) Content Course |
| Malinsky, M., Ross, A., Pannells, T., & McJunkin, M. | 2006 | 279 (of 481 students with other majors) | Quantitative | Mathematics Anxiety Scale- Revised (MARS-R) | N/A |
| Peker, M. | 2009 | 205 (of 506 prospective teachers of all levels) | Quantitative | Learning Style Inventory (LSI), Mathematics Teaching Anxiety Scale (MATAS) | N/A |
| Uusimaki, L., & Nason, R. | 2004 | 18 | Qualitative | Semi-structured interviews | Methods Course |

**Table 3:** *Theme 3- Influencing Prospective Teachers' Beliefs about Mathematics*

| **Author(s)** | **Year** | **Number of PTs in study** | **Methodology: Quantitative or Qualitative Belief Measure** | **Means of Access to Beliefs and Assessment** (questionnaire, instrument, interview, etc.) | **Context** (Mathematics Methods Course, Mathematics for Teachers Content Course, etc.) |
|---|---|---|---|---|---|
| Ambrose, R. | 2004 | 15 | Qualitative | Analyzing videotapes and audiotapes, PT reflections, pre and post open-ended belief surveys, and pre and post interviews | Special Course with Methods Course |
| Philipp, R. A. | 2008 | - | - | Reflections based on the 2007 Philipp et al. study | N/A |
| Philipp, R. A., Ambrose, R., Lamb, L. L., Sowder, J. T., Schappelle, B. P., Sowder, L., & Chauvot, J. | 2007 | 159 | Mixed (Experimental Study) | Online belief survey with open-ended responses (The Integrating Mathematics and Pedagogy Web Based Belief Survey), | |
| Paper-and-pencil Content Assessment | Math Content Course | | | | |
| Thanheiser, E., Philipp, R. A., Fasteen, J., Strand, K., & Mills, B. | 2013 | 13 | Qualitative | Interviews | Math Content Course |
| Timmerman, M. A. | 2004 | 24 | Quantitative | Baroody and Coslick (1998) Belief Survey (pre-and post semester) | Methods Course |
| Wilkins, J. L., & Brand, B. R. | 2004 | 89 | Quantitative | Hart's (2002) Mathematics Belief Instrument (MBI) | Methods Course |

## Contact


Kenan Fellows Program
for Teacher Leadership
Box 7006, Raleigh, NC 27695
919-515-5118
kenanfellows@ncsu.edu
kenanfellows.org/journals

# 2017-18 SPONSORS

PLATINUM

Biogen Foundation
GSK
Kenan Institute for Engineering, Technology & Science
USDA

GOLD

Belk Foundation
Charlotte-Mecklenburg Schools
Goodnight Educational Foundation
Google Fiber
IBM
Merck Foundation
Surry County Farm Bureau

SILVER

Alamance County Farm Bureau
Carteret County Farm Bureau
Four County EMC
NC's Electric Cooperatives
NC State University
PLY Gem
SAMSI
UNC Chapel Hill
Wilson County Farm Bureau