Mentoring Teachers in STEAM Improves Likelihood of Application

By: Jackie Klar

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Mentoring Teachers in STEAM Improves Likelihood of Application

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by

Jackie Klar

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Abstract

In 2014, teachers and administration at Juda School resolved to move forward with progressive science, technology, engineering, arts, and mathematics, (STEAM) education. By 2016, school administration and staff recognized potential problems and wanted the best principles in place as they engaged their students with STEAM opportunities. The purpose of this research is to study the effect of mentoring classroom teachers on implementation of STEAM activities in the classroom. The research found that professional in-service, mentoring, and supplying materials in the classroom, increased likelihood that STEAM practices would be implemented and continued in the elementary classroom.

Keywords included in the research are: Science, Technology, Engineering, and Mathematics (STEM).
Students with science, technology, engineering, and mathematics (STEAM) training are more likely to be employed in the changing careers of the future. Teachers should be prepared to teach students in a way to meet new STEAM skill expectations, but many are not (Ejiwale, 2013). National leaders have called for reform of STEAM literacy and improvement of educational practices (Ufnar, Bolger, and Shepherd 2017). In 2013, President Barack Obama, at the Third Annual White House Science Fair said, “We need to make this a priority to train an army of new teachers in the subject areas, and to make sure that all of us as a country are lifting up these subjects for the respect they deserve.” (as cited by Bell, 2015)

In 2017, Carroll and Scott found that “teachers feel ill prepared to teach STEM” to preK-3 students confirming the need for mentoring support of teachers. Additional findings from a pre-service training found many teachers could easily identify the STEAM acronym but did not know how to implement the STEAM practices in the classroom. Further evidence, as Zimmerman (2016) reports, is that rather than engaging in authentic STEAM practices because essential knowledge of science is lacking, teachers are mistaking hands-on activities as STEAM applications. Ejiwale (2013) states that many teachers are unprepared to teach STEAM concepts because they lack training.

**Statement of the Problem**

A problem exists because there is a shortage of qualified elementary school STEAM classroom teachers trained to properly teach STEAM applications. Zimmerman (2016) notes that teachers should “engage in STEM activities,” have “structures and social networks” designed to facilitate collaboration, and “be afforded the opportunity to be apprenticed into authentic ambitious STEAM practices.” Would mentoring elementary school teachers increase the likelihood that STEAM applications are carried out with effectiveness in the elementary
classroom? If so, would the practice of mentoring elementary school teachers in STEAM practices prove impactful?

**Significance of the Study**

Those impacted by well-mentored teachers will be students and future employees. In a report provided by the United States Department of Education, *STEM 2026* (2016), it was found that students with science, technology, engineering, art, and mathematics (STEAM) skills will be more likely to be employed in the changing careers of the future.

Those graduates who have practical and relevant STEM precepts embedded into their educational experiences will be in high demand in all job sectors. It is estimated that in the next five years, major American companies will need to add nearly 1.6 million STEM-skilled employees (Business Roundtable & Change the Equation, 2014). Labor market data also show that the set of core cognitive knowledge, skills, and abilities that are associated with a STEM education are now in demand not only in traditional STEM occupations, but in nearly all job sectors and types of positions (Carnevale, Smith, & Melton, 2011; Rothwell, 2013). The nation has persistent inequities in access, participation, and success in STEM subjects (United States Department of Education, 2016, p. i).

The work of mentoring teachers in STEAM applications is important because mentors are needed to develop qualified teachers capable of teaching STEM concepts to students (Hudson, 2009). “The quality of teacher preparation is crucial in helping students reach higher academic standards” Ejiwale (2013). In a longitudinal study, Monk (1994), as cited by Ejiwale (2013), found that how much a teacher knows about his subject has a positive impact on learning.”
Therefore, if mentor training is given to elementary teachers, then the application of STEM practices is more likely to continue as a curricular practice in the classroom. If mentor training is not given to teachers, then the application of STEAM practices will not be likely to continue as an embedded practice in the classroom.

**Purpose of the Study**

Leaders at Juda School recognized that while curriculum, training, time for tasks, and supplies had been in place for middle and high school level teachers (grades 6 -12 in this environment), an inequity of curriculum, practices, and policies for STEAM curriculum existed in the 4k -5 classrooms. The institutional problem was brought to the attention of the Juda STEAM Team in 2015. Assessment and confirmation regarding the lack of curriculum supported practices regarding STEAM applications was easily attained as Juda School is a 4k-12 district that is self-contained in one building. An assessment by the STEAM Team of the implemented curriculum and available supplies supported the lack of support the elementary teachers were facing.

The school administration recognized that to move forward with science, technology, engineering, arts, and mathematics, (STEAM) applications at all grade levels, the elementary teachers needed support to begin using STEAM curricula. Literature regarding STEAM education was reviewed and the following components that impact the mentoring and confidence level of elementary teachers were identified: the presence of obstacles that impact provision of training for teachers, the necessity for the effective mentoring of women, understanding of why providing materials to classroom teachers is important, as well looking at the impact of changing STEAM standards and curriculum and community involvement practices, such as after-school programs like STEAM Family Nights, rocket clubs, and invention clubs.
Definition of Terms

STEM: an acronym that describes science, technology, engineering, and math (Bell 2015).

STEAM: an acronym that describes science, technology, engineering, arts, and mathematics (Harper 2017).

Mentoring: “Mentoring is about establishing and nurturing mutually beneficial relationships, either face-to-face or virtually” (Johnson, 2017).

Peer group mentoring: a type of mentoring where groups of people support each other in a group rather than in “one-to-one” relationships (Thomas, Bystydzienski, & Desai, A., 2015).

Delimitations of Research

Discussion regarding the Juda School STEAM Initiative began September 2015. The review for this literary review was conducted August thru April 2018. In searching for information about Mentoring STEAM in the classroom, this author used the terms “STEM,” STEAM,” “classroom,” and “mentoring” were used following the navigation provided through Badger Link. Resources were limited primarily to peer review writing essentially during the last five years.
Chapter Two: Review of Related Literature

STEAM Education

Why STEAM Education? What is it about science, technology, engineering, arts, agriculture, and mathematics that is so important? Johnson (2017) states, “Adaptation to rapid change, orientation toward innovation and creativity, flexibility, ability to deal with uncertainty and apply knowledge across a range of situations, and ability to work collaboratively” are the “21st-century skills” that schools are needing to develop in their students to prepare them for the future. STEAM education and reform of STEAM educational practices is important to meet these emerging challenges (Bell, 2015). STEM education meets those challenges by using “an approach to learning that removes the traditional barriers separating the four disciplines and integrates them into real-world, rigorous, relevant learning experiences for students” (Vasquez, 2014).

STEM education that is an integrative process that uses problem-based learning to tackle real world problems in meaningful, relevant ways. Students use cross-curricular skills while working collaboratively to solve problems that are currently relevant (Havice 2015).

Providing Training for Teacher Obstacles

Two important factors are lacking for teachers to be effective STEAM teachers according to Ejiwale (2013). First, teachers must possess a very sound content knowledge. Second, strong pedagogy in related STEAM areas is necessary for teacher-to-student success. Mentoring is essential to successfully overcoming both factors.

Overcoming the content knowledge obstacle can happen through better training and retention of women in STEM education. Some knowledge concerns can be overcome through
collaboration with other STEAM professionals. Both concepts will be addressed later in this writing.

Regarding pedagogy, Jones, Dana, LaFramenta, Adams, and Arnold (2016) identified the following areas as teacher needs: “lesson planning, classroom mentoring, decision-making, routine school procedures, the coach/mentor, teacher, relationship, peer observations, model teaching, administrative support of new teachers, and reflective teaching.”

Jones et al. (2016) found that mentoring support given to teachers had a positive impact for both the teacher and the student in the following areas: instructional strategies, subject matter taught, using data to identify student needs, differentiating based upon individual student needs and characteristics, creating supportive, equitable classrooms where differences are valued, enlisting the help of family members, parents and/or guardians, working collaboratively with other teachers within the school building, connecting with key resource professionals, complying with policies and procedures, completing administrative paperwork, and providing emotional support.

Lack of training for complete understanding is often an issue for teachers. Carroll and Scott (2017) reported that a preservice survey showed that teachers could identify STEM, but could not communicate what a classroom STEM structure be for the classroom. STEM teaching does not have to incorporate all four components, science, technology, engineering, or mathematics, with every lesson. STEM education is also not always project- or problem-based, making STEM education even more confusing for teachers and administrators. Yet, according to Vasquez (2014) all STEM learning has one thing in common - giving “students opportunities to apply skills and knowledge they have learned or are in the process of learning. Application is at
the heart of STEM education.” This provides the answer to the question, “Why do I have to learn this?”

To resolve the pedagogical issue, Carroll, et al. (2017) offered a teacher in-service to expand levels of teacher understanding. Providing a framework to the participants proved helpful.

In the article, *STEM -- Beyond the Acronym*, Vasquez (Dec 2014-Jan 2015) defined another framework to help teachers to look at the integration of STEM into the classroom is provided through the Inclined Plane of STEM Integration. Through four steps, teachers visualize the increasing levels of integration of STEAM applications with *The Inclined Plane of STEM Integration*. The levels are respectively: disciplinary, multidisciplinary, interdisciplinary, and transdisciplinary as reported in *STEM Lesson Essentials, grades 3-8: Integrating Science, technology, Engineering, and Mathematics*, (Vasquez, Snieder, & Comer, 2013, pg. 73).

Respecting teacher and mentor time can be a concern for both parties. Baiduc, Linsmeier, and Ruggeri (2015) conclude from their research that an introductory program with even low time commitment is enough to encourage interest in Teaching STEAM applications and teaching practices in the classroom, pointing to the value of teacher mentoring for classroom practices.

**Supporting Women in STEAM Careers**

While teacher training is vitally important, better intellectual support is not the only support necessary for successful teacher mentoring to occur regarding STEAM practices and implications. Dawson, Bernstein, & Bekki (2015) report that effective mentoring may be one of the most important factors in the success of women in professional STEAM fields and that “not belonging, isolation, and shortage of mentoring appear to be instrumental in women’s decisions
to leave science.” Further, Johnson (2017) reported that outcomes for women who received mentoring were not as successful as the outcomes for men, and the mentors of women were not perceived as holding as much esteem as mentors for their male counterparts. Regarding mentoring in STEAM fields, Dawson et al. (2015) further reports, “Environmental obstacles include problematic advising and severely competitive academic environment that run counter to women’s preferences for collaboration.”

Jones (2010) notes that, while boys’ interest in STEAM applications comes early and often immediately, girls develop those applications later and often over a period of time. Teaching and mentoring girls allows them to develop positive beliefs about STEAM skills, build essential relationships, and facilitates problem solving development over time. By providing mentoring opportunities, women can compete in STEAM academics and careers.

Failing to include a diverse group of people, including women, potentially has dire consequences. As pointed out in Unlocking the Clubhouse: Women in Computing, by Magolis and Fisher (as cited by Jones 2010), valuable perspectives to tough problems may not be included if women are left out. The author cited a male engineering team who worked to develop the first automobile airbags. Gender perspective, however, led them to develop air bags suitable for the size of men, but not the size for women and children.

Female teachers will find relevant strategies are now being implemented to assure women are included in successful in STEAM pursuits. One such strategy for supporting women in STEAM careers and addressing the unique mentoring issues women face, was reviewed by Thomas et al. (2015) in the article Institutional Culture Through Peer Mentoring of Women in STEM Faculty. In this comprehensive Equity Study at Ohio State University from 2009 through 2012, four principles for peer group mentoring were established:
1. What is said in the circle stays in the circle; confidentiality is crucial.

2. We listen to each other with curiosity and compassion—we replace judgement with discernment and keep an open mind.

3. We ask for what we need and offer what we can.

4. When we are unsure how to proceed, we stop action, pause, and reflect.

Following the study, the authors drew the following positive conclusions. First, dropping out of the peer mentoring group did not mean the individual did not receive benefit. Second, members of the peer mentoring groups appreciated the networking and community support. Third, it was found that an overall likelihood to develop and suggest policy and practices was more likely to occur when women had the opportunity to work in peer mentoring groups.

Some negative conclusions were drawn including some frustration of lack of structure and continuity and peer mentoring group attendance. Thomas et.al. (2015) reported peer mentoring groups only worked well when women were willing share their concerns and issues regarding both professional struggles and concerns about group habits. Some participants expressed frustrations with individuals who monopolized the conversations and group’s time. Other participants reported that they would prefer scheduled, formal meetings with faculty members rather than meeting in peer mentoring groups. However, despite the negative findings, overall, the study found the climate for women both individually and institutionally, improved after involvement with peer mentoring groups.

Finding time to join face-to-face peer groups may prove challenging for the already busy teacher. Another issue reported by women in professional STEAM fields is support for psychological needs such as “difficulty in balancing a demanding career and family life” (Dawson et.al. 2015). Therefore, creative-mentoring approaches are needed to support women
who pursue STEM education and careers. The website CareerWISE (http://careerwise.asu.edu) (Arizona State University 2016) has one such program. CareerWISE provides online support to help support some of the “psychological” needs women face. The following is a summary of the components of the website:

1. HerStories – is intended to provide women with access to stories of other women in STEAM careers that they would not have access to by traditional means. There are over 200 video clips of interviews regarding educational and professional experiences. The clips also provide insight into strategies and coping skills that many women uniquely face.

2. Problem Solving Skills – is designed to help with resiliency and focus.

3. Communication Skills – is designed to model for women in STEAM education and careers about how to listen, express, and respond to feedback. Communication simulations are designed to support women in research-reported areas of concern such as (Dawson et.al, 2105):
   - difficulties with getting needed help from advisors
   - dealing assertively with conflicting commitments to a partner and research
   - managing critical feedback from a research supervisor that is tinged with gender bias

4. Common Concerns – is designated to support women regarding issues many women in STEAM education and careers face such as gender bias and age.

It important to consider that “three key studies” have found CareerWISE to be effective. Dawson et.al (2015) reports gains in problem solving skills, resilience, coping, retention of women in careers, and communication as essential skills in STEAM careers. Additionally,
CareerWISE is a free resource. Yet, are supports such as CareerWise enough for a classroom teacher to be successful in STEAM applications?

Providing Material Resources and Time

In addition to insufficient support of women in STEAM careers and lack of professional development, teachers face many other obstacles when trying to implement and integrate STEAM applications into the classroom. Lack of resources, as well as, lack of time are a primary issues of concern.

To help classroom teachers be successful school leaders should provide for and deliver materials to teachers. Mentors should obtain, organize, and deliver materials for the classroom teacher. Inexpensive, everyday recyclable materials could be gathered. Consumables for projects could include “Plastic water bottles, egg cartons, bottle caps, paper towel or toilet paper tubes, bubble wrap, glass jars…” (Harper et.al. 2017).

Roberts and Chapman (2017) suggested that implementation of STEAM in the classroom needs to be “creative and intentional” when scheduling time. The pair cited using days that traditionally had low attendance and productivity rates such as school days before holiday breaks.

Support from Administrators and Community

Support and encouragement from administrators and community is essential to teacher success in the classroom. “Unfortunately, school leader’s explicit and implicit messages don’t always encourage novelty, innovation, or risk taking in the classroom” (Harper 2017). “Schools must cultivate an inventive spirit that invites risks and welcomes failures-and learns from both.” Roberts and Chapman (2017) indicate that while school reform happens frequently, school institutions tend to continue with traditional schedules, practices, and outdated standards.
Roberts and Chapman further believe a culture of acceptable risk is important and feel a strategy of “embracing the unknown” is important to shifting focus away from rote memory to “application of content and to reasoning.”

Teachers need to be given scheduled time to reflect on the practices and philosophies they employ. They also need scheduled time to explore any interdisciplinary links that may be beneficial. Harper (2017) agrees that teachers need time to reflect on the practices and philosophies they employ as well as any interdisciplinary links that may be beneficial.

Administrators, teachers, and parents alike must understand that teaching STEM is a complicated process. “Developing integrated STEM experiences is not a linear process. It takes collaboration and preparation” (Vasquez 2014). Teachers need scheduled time to explore any interdisciplinary links that may be beneficial. Harper (2017) states that teachers need time to reflect on the practices and philosophies they employ, as well as, any interdisciplinary links that may be beneficial. Berg and Mensah (2014) found that STEM development in teaching practices follows a “complicated” and “nonlinear pathway.” Yet, teachers were open to and felt “invigorated” when given support with veteran teachers being most receptive to support for their science practices.

A program that shows promising results is The Scientist in the Classroom program. In a review of the program in which scientists work collaboratively in the classroom with teachers, Unfar, Bolger, and Shepard (2017) recorded gains in hands-on science applications, partnership, pedagogical knowledge, and student impact. One classroom teacher stated, “We would not have nearly as many hands-on science activities had I not had a fellow in the classroom.” Additionally, the authors reported a solution to a previously noted problem of lack of content
knowledge as one teacher surveyed noted, “The students were taught skills through hands-on experience that I did not have the content knowledge to teach myself.”

Other successful approaches include providing qualified STEM instructors for after-school programs, running STEM contests, providing design and build projects, and funding summer programs (Edjiwale 2013).

Further, teachers are often using their own money to fund STEAM projects. Nationwide, teachers spend $1.3 billion to buy classroom materials from their own personal accounts. Providing teachers with access to on-line sources of funding could prove beneficial. (DeNisco 2012). Programs like Fuel Your School, a partnership between DonorsChoose.org and Chevron are working to reduce financial impact of STEM programs for teachers.

Standards

Clear-cut STEM standards may need to be developed within each state. A study conducted by researchers, Carr, Bennett IV, and Strobel (2102), at Purdue University, found that while as many as forty-one states have some engineering standards, they remain inconsistent in sequence or scope. Berg et al. (2014) state, “If educational policy continues to make literacy and mathematics a priority, science will continue to suffer.”

In addition to inconsistence of scope or sequence of curriculum, Tank, Moore, Babajide, & Rynearson (2015) found another problem facing teachers is that there is no common model for schools to use in implementation of programs. Carr et al. (2012) of Purdue University, concluded something similar in their study, “While engineering standards do exist, uniform or systematically introduced engineering standards are less prevalent.”

Also problematic is that curriculum in practice is often very different than the officially mandated curriculum (Brown, Brown, & Merrill 2012). The authors argue that this is because of
limitations on teaching time, demands placed on teachers, underestimating time needed, and the “dropping” of a portion of material or only briefly covering a portion. Sometimes subject matter is dropped because teachers lack the knowledge or skills to teach it. Berg et.al. (2014) found that teachers often focused on literacy and mathematics leaving less or no time for science. Such disparity between official, curricula in practice, and the experienced curriculum can be due to many factors such as how a text book is used, how hands-on practices are applied, and the pacing of the instruction. If educational policy continues to make literacy and mathematics a priority, science will continue to suffer.

After School Programs

Finally, while it may seem surprising on the surface, successfully run Family STEAM Nights provide for reinforcement of skills and visual support from families, support essential to the classroom teacher. Krishnamurthi (2016) states, “Research shows what happens outside of school can be equally as important as what happens in school to set children’s direction and activate their interest in STEM.” The collaboration that happens between school and community fosters an understanding and lasting impact that best serves our current students and future. Those skills can be transferred to the classroom, strengthening the STEAM program in the classroom (Havice 2015).

One reason programs like family STEAM nights and Night at the Museum may be successful is families may move about from station to station at their own pace allowing the parent and child to interact at their own paces. Yanowitz & Hahs-Vaughn (2016) found that the parental role had a strong impact on the child’s confidence and attitude toward science. “Family science nights present a unique opportunity to explore the ways in which parental involvement in school-based science activities may impact parents’ beliefs and understanding about their child.”
Yanowitz et al. (2016) noted the importance of the positive correlation between parent belief of their child and the child’s belief of self. In Family STEAM Nights, parents become participants and model for their child while working with them. Also noted was the parent’s desire to be involved with their child’s education, bolstering the idea that providing afterschool programming like Family STEAM Nights is essential. It was expected that gender would influence perception about family STEAM Night, however it was noted that no demographic factors contributed to perception, even though it had been anticipated before the study, that gender would affect perceptions.

The America After 3PM survey has been conducted in three different years, 2104, 2009, and 2014 (Krishnamurthi, 2016). The survey found that “53%” of parents felt that STEM learning opportunities after school were important in choosing an after-school program. “Of those parents, 85% were happy and satisfied with their afterschool program’s STEM-learning opportunities.”

Results from the report are mixed. Interestingly, according to the report, girls attended after-school programs at the same rate at which boys did. Children from “African-American and Hispanic/Latino backgrounds are twice as likely to attend as non-Hispanic White children.”

While that is hopeful, Krishnamurthi (2016) does report a concern. Children from rural areas are more likely to experience scarcity of programs.

“Rural students are generally less likely to have access to high-quality STEM learning opportunities either in or out of school. There are fewer qualified teachers in math and science, STEM role models, resources, or community partners such as STEM corporations or science museums in rural communities.”
Krishnamurthi (2016) also reported that The Afterschool Alliance had six key recommendations about afterschool stakeholders. They are briefly summarized in the following:

1. Engage the parents and emphasize the importance of quality STEM afterschool programs.
2. Further explore parent perceptions of STEM afterschool learning.
3. Increase the technology and engineering programming available after school.
4. Strengthen partnerships between the community and the school regarding STEM.
5. Improve assessment measures to determine overall impact, not just for school data.
6. Increase investment to improve access to and participation in afterschool programs.

**Summary**

In summary, a literary review of STEAM education, providing training regarding teacher obstacles, supporting women in STEAM careers, and providing material resources and time were reviewed. Additionally, support from administrators and community, as well as implementation of standards were analyzed regarding provision of insights into mentoring supports for STEAM applications for the elementary classroom teachers. Regarding supporting women in STEAM careers, evidence was found that indicates special supports like peer group mentoring and specialized websites geared towards women in STEAM might prove impactful.
Chapter Three: Conclusions and Recommendations

In summary, demands of STEAM Education might be met when the mentoring needs of the elementary classroom teacher are met (Hudson 2009). Successful mentoring might be achieved by providing training for teacher obstacles (Ejiwale 2013). Understanding and supporting women in STEAM careers through unique programs like CareerWISE, an Arizona State University on-line forum (careerwise.asu.edu 2016), and peer group mentoring (Thomas et al. 2015) might provide unique psychological support many female elementary teachers of STEAM need. Providing material resources and time to teachers might enable teachers to focus on the skills of STEAM, rather than spending time gathering supplies (Denisco 2013). Support from administrators and community might be critical as the dynamics of the classroom change to meet STEM requirements (Brown et.al 2012). Aligning standards, providing curriculum, and explaining the expectations and how to apply the standards and curriculum clearly might help teachers understand the goals that must be reached in a STEAM classroom (Harper 2017). Finally, out-of-school or afterschool programs might help strengthen the classroom by providing children who are confident in STEAM applications and are eager to participate in STEM applications (Yanowitz et al. 2016).

Based on the existing literature, the following conclusion was drawn. STEAM applications might improve in the elementary classroom if mentoring in STEAM applications are provided. Therefore, elementary teachers might find support from, personal modeling of STEAM applications, provision of supplies and curriculum, and the offering peer-support venues. The elementary teacher might also find it beneficial to receive support from the administrator for embedded time for STEAM practices, as well as, financial support. The elementary teacher might benefit from the community mentoring as the traditional classroom is
changing. Finally, out-of-school day programs, like Family STEAM nights, rocket clubs, and invention clubs might benefit teachers by building content knowledge and confidence in the students who attend their classrooms.

Based on these conclusions, it is recommended that mentoring support be implemented for elementary school STEAM teachers. Further research to examine the success of current mentoring programs for STEAM educators in the elementary classrooms is recommended.
References


