Northwest Journal of Teacher Education

Volume 19
Issue 2 *Grappling with New and Persistent Challenges*

Article 3

10-6-2024

Exploring Teacher Perspectives of STEM Outreach Sessions

Jennifer M. Jakobi
University of British Columbia

Rebecca McCullough
University of British Columbia

Sabre Cherkowski
University of British Columbia

Haizley Trevor-Smith
University of British Columbia, haizley.trevorsmith@ubc.ca

Recommended Citation

Jakobi, Jennifer M.; McCullough, Rebecca; Cherkowski, Sabre; and Trevor-Smith, Haizley (2024) "Exploring Teacher Perspectives of STEM Outreach Sessions," *Northwest Journal of Teacher Education*: Vol. 19 : Iss. 2 , Article 3.
DOI: https://doi.org/10.15760/nwjte.2024.19.2.3

Exploring Teacher Perspectives of STEM Outreach Sessions

Abstract

Teachers have a responsibility to create and foster engaging learning environments which encourage underrepresented persons in Science, Technology, Engineering, and Mathematics (STEM). Outreach programs have been shown to increase STEM engagement of students. We use a positive psychology lens to investigate STEM outreach and teacher wellbeing. This exploratory study uses a survey and focus group to assess how a STEM outreach program can create teacher feelings of support, confidence, and enjoyment. Results demonstrate that most teachers felt more confident in teaching STEM following the STEM-mentor facilitated outreach sessions. The positive benefits to teacher wellbeing from outreach program mentorship, is discussed.

Keywords

Teacher Wellbeing, STEM education, STEM outreach

Cover Page Footnote

Acknowledgements The authors want to acknowledge the teachers who participated, as well as the STEM Curriculum staff in the schools administering the outreach program. Funding Funding for this study from National Science and Engineering Council of Canada (NSERC) and Chairs for Women in Science and Engineering.

Introduction

This study assesses how the experience of engaging in hands-on classroom outreach sessions in Science, Technology, Engineering, and Mathematics (STEM) contributes to teachers' confidence in, and enjoyment of, teaching STEM. This study is part of a larger outreach project aimed at improving underrepresented students' experiences in STEM. We designed a series of hands-on STEM classroom sessions that were delivered by STEM mentors. This paper reports on the findings of a survey distributed to teachers after the classroom sessions and a focus group to examine teachers' experiences of the hands-on activities and their interaction with the STEM mentors.

The specific aims of this study were to assess teachers' feelings of support, confidence, and enjoyment teaching hands-on STEM following participation in outreach sessions. In this study, we found that teachers can increase their sense of wellbeing, in relation to STEM teaching, as they engage in positive experiences designed to improve their sense of support, confidence, and enjoyment. Our positive approach to STEM engagement is different from other studies that focus mostly on barriers to teaching STEM or barriers to student STEM development. We draw on positive psychology research that focuses on positive thoughts and emotions, including wellbeing and happiness, that lead to positive actions and the ability to thrive (Fredrickson & Branigan, 2005; Seligman, 2011; Seligman & Csikszentmihalyi, 2000). Focusing on positive aspects of what educators need to succeed in their professional practice and personal experience, may provide insights on how specialized support creates more engaging classroom experiences which are valuable for increasing interest in STEM.

Literature Review

The aim of this study was to assess teachers' sense of support, confidence and enjoyment following engagement with hands-on STEM lessons. In the next section, we offer a brief review of literature on both the importance of teachers in improving student engagement in STEM, and teacher wellbeing. Here is where we identify the focus of this study on teacher confidence, sense of support, and enjoyment in STEM teaching experiences.

Importance of Teachers for improving STEM engagement

Many students face barriers to STEM participation, such as the opportunity to attend specially designed STEM programs or having access to STEM role models due to resource and geographical constraints (Duodu et al., 2017). Most girls will experience STEM through school settings where student experience is dependent on teacher effectiveness (Deemer, 2004; Nathan et al., 2010). Teachers have an influence on increasing awareness and interest in STEM from their early years through to the end of secondary years. Providing exposure to STEM opportunities (Blickenstaff, 2005), specialized STEM programs (Mosatche et al., 2013) and interaction with confident STEM role models (Fuesting & Diekman, 2017; N. Aish et al., 2017;

Saville et al., 2023; Shin et al., 2016) in traditional school settings, has the potential to increase girls' interest in STEM fields and learning.

Research suggests, as an example, that exposure to math and science has a stronger effect on students' interest and engagement in STEM than their achievement in math, "which was once deemed the single best predictor of students' future STEM entrance" (Wang, 2013, p. 1107). Early exposure in primary and elementary school is an effective method for increasing the intent to study STEM (Blickenstaff, 2005), and long-term interest is achieved through environments and activities that stimulate curiosity (Eccles & Wang, 2016; Halpern et al., 2007; Saville et al., 2023).

Role models are another positive influence for increasing interest in STEM. Connecting with someone who "can positively shape a student's motivation by acting as a successful exemplar" (Gladstone & Cimpian, 2021), who has achieved success in math and science (Lin, 2016; Prieto-Rodriguez et al., 2020; Zeldin & Pajares, 2000) has great impact on girls' interest and engagement. Not only do role models influence interest, but also career choice (Quimby & De Santis, 2006). It is important to note that not all role models will positively impact students (Kim & Sax, 2018), particularly if they are not confident in what they are teaching. Research on STEM role models discusses the importance of demonstrated confidence in STEM concepts, to successfully interest girls (Gladstone & Cimpian, 2021; Nathan et al., 2010). Additionally, teachers' statements and beliefs relating to the relevance of science changes students' views of science (Schmidt et al., 2019).

Research on STEM engagement for students is largely focused on remedying deficits or overcoming negative states of learning, such as math anxiety, lower confidence, lack of role models, and less early exposure to STEM learning (Ashcraft, 2002; Leaper et al., 2012; Shin et al., 2016). Research also shows that negative mindsets or beliefs about STEM extend to the classroom through teachers who experience math anxiety (Beilock et al., 2010) creating learning environments that may inhibit interest in STEM (Mosatche et al., 2013). Countering this trend, in this study we focused our approach on a positive intervention aimed at increasing confidence, support, and enjoyment in STEM teaching.

Teacher Wellbeing connected to STEM teaching

Teachers in elementary grades are often generalists, and many do not have specialized STEM training. As such, teachers in these grades can often have decreased confidence in teaching STEM topics (Dare et al., 2018; Ling et al., 2020). Many teachers experience stress due to increasing expectations to use technology (Fernández-Batanero et al., 2021). This creates a situation where teachers are not familiar with, or confident in, the subjects or classroom learning tools. This is an issue for both the teacher and students as doubtful role models have a negative impact (Marx et al., 2013). For example, for STEM programs to be successful in engaging under-represented persons in STEM and building interest and confidence, facilitators must be comfortable with STEM (Mosatche et al., 2013).

Teacher confidence in STEM can also have an impact on their own sense of wellbeing. For teachers to project themselves as confident, curious, and knowledgeable in STEM they must have a sense of wellbeing. Teacher wellbeing has a positive effect on teaching practice and student learning (Turner & Theilking, 2019). Typically, research into teacher wellbeing begins with questions relating to teacher professional development (Huang et al., 2022), pedagogical content knowledge (Ling et al., 2020), avoidance of negative outcomes such as demanding

workloads, (Yin, Huang & Wang, 2016) or burnout (Antoniou et al., 2013). There are increasing numbers of studies on teacher wellbeing, and teacher wellbeing related to student learning, but there is a knowledge gap in in how interventions designed to increase student engagement in STEM influence teacher wellbeing.

Researchers use a variety of measures of wellbeing. Caprara et al., (2006) measures self-efficacy beliefs and job satisfaction, and Duckworth et al., (2009) measures grit, life satisfaction, and optimism. Despite "broad agreement that wellbeing should be conceptualized as a multidimensional construct, there is little consensus about how wellbeing should be defined, potentially hampering the development of a concise theory and precluding good practice using evidence-based knowledge" (Hascher & Waber, 2021).

Seligman's PERMA Model (2018) defines wellbeing as a construct including positive emotions, engagement, positive relationships, meaning, and accomplishment, to create a picture of wellbeing without having to rely on one definition. Thus, wellbeing can be measured using component factors.

Wellbeing includes engagement, positive relationships, meaning, and accomplishments (Seligman, 2011, 2018). In a classroom setting this means teachers will experience wellbeing when they feel supported, have resources, and are confident in, and enjoy, the topics they teach. For this study we focus on confidence, support, and enjoyment as factors contributing to teacher wellbeing in relation to STEM teaching.

Research Question

Herein, we focus on a strength-based, positive approach to discover ways in which educators successfully experience wellbeing in relation to teaching STEM. Specifically, perceived feelings of support, confidence, and enjoyment. We suggest that STEM teachers who feel supported through training or professional learning, have access to resources, are confident in science and math, and enjoy teaching activities, will be more likely to create environments where girls develop interest in STEM. The objective of this study was to determine how teachers experience improved wellbeing through positive feelings of support, confidence, and enjoyment through participation in STEM outreach activities and mentorship sessions.

Methodology

Context

The study was conducted with K-12 teachers in British Columbia who participated in hands-on, in-person STEM outreach sessions that were designed and facilitated by STEM mentors. The outreach sessions were co-created with teachers and piloted in a few classrooms the year prior (2021/22) to the study. The mentors were science professionals, trained in providing hands-on STEM activities and student engagement.

The goal of the STEM outreach program is to offer teachers support to positively influence learners, and ultimately improve STEM experiences for all students, and particularly for underrepresented students in STEM. To achieve this aim, STEM outreach sessions include four hands-on in-person sessions during which STEM mentors model teaching and learning practices, provide all materials required, and follow-up with copies of the lesson plans for teachers' future use. The sessions embed STEM into the curriculum. The purpose of each session is to increase interest, engagement, and enjoyment through hands-on STEM learning activities.

This study was conducted over the 2022-2023 school year. Teachers from two school districts in British Columbia who had participated in at least one STEM outreach series were invited to complete a survey designed to examine their sense of support, confidence, and enjoyment of teaching STEM through these experiences. A question at the end of the survey asked respondents to provide a contact email to arrange focus group participation. The study was approved by Institutional Review Board (H22-02601).

Survey

The qualitative survey asked questions about participants' perceived feelings about participation in the outreach sessions, including personal reflection regarding experience of support, confidence, and enjoyment in teaching STEM.

The survey questions were informed from previous work on teacher wellbeing in schools (Cherkowski, 2018; Seligman, 2018; Selvaraj & Subramoniam, 2023). We extended Seligman's conceptualization of support to include the support felt by using prepared STEM teaching resources. In addition to social support predicting engagement (Orgambídez-Ramos & de Almeida, 2017), we include job-related resources which have been shown to influence wellbeing and engagement (Bermejo-Toro et al., 2016).

Focus Group

The survey results were further explored with a semi-structure 90-minute focus group using guiding themes, and then followed-up with questions or comments presented by the attendees. To determine the positive factors that would support the teachers in feeling more confident after the sessions, and to discover what future support they believed would help, we developed questions asking teachers to expand on their responses to the surveys. The questions asked were:

> What makes you feel engaged in teaching STEM lessons?
> How do you think enjoyment relates to student engagement?
> How and why do you feel supported during the outreach programs?
> What do you think contributes to your sense of confidence in teaching STEM?

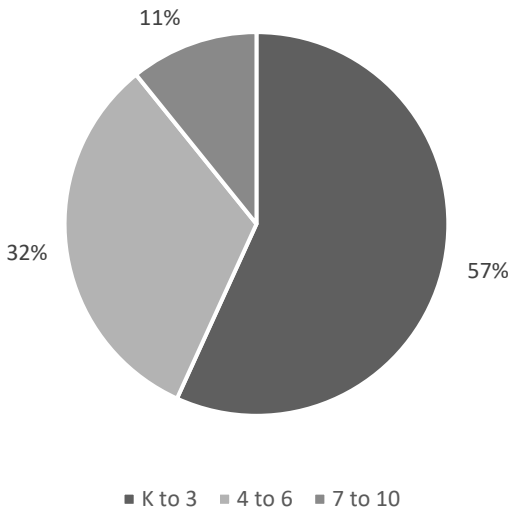
Focus group conversations were transcribed and inductively analyzed using the constant comparison method (Johnson & Christensen, 2019) with information classified into categories that emerged through analysis. Asking the focus group participants about confidence, support, and enjoyment revealed themes of access to types of materials needed to feel support, how role models increased confidence, and how integration into non-STEM subjects increased STEM teaching enjoyment.

Results

Teachers in K-12 classrooms who participated in the in-class, in-person, STEM sessions were surveyed. Emails were sent to sixty-seven participating teachers and thirty-six responded (54% response rate). Over half of the respondents were from kindergarten to grade three, grade levels (Figure 1). The teachers were ninety percent female and ten percent male.

Figure 1.

Teachers by Grade Level



The average years of teaching was 8.14, however, for those same teachers, the average years of teaching STEM was 4.24. Only three of the thirty-six respondents were STEM-specific education trained. The teachers responded favorably to most questions (Table 1), except for having support.

Table 1:

Response Frequencies

N=36 Question	Strongly Agree (%)	Somewhat Agree (%)	Somewhat Disagree (%)	Strongly Disagree (%)
Generally, I enjoy teaching STEM topics	69.4	30.6		
I enjoyed my interaction with the outreach team	91.7	8.3		
I will be able to engage the students using the outreach provided lesson plans in the future	75.0	25.0		

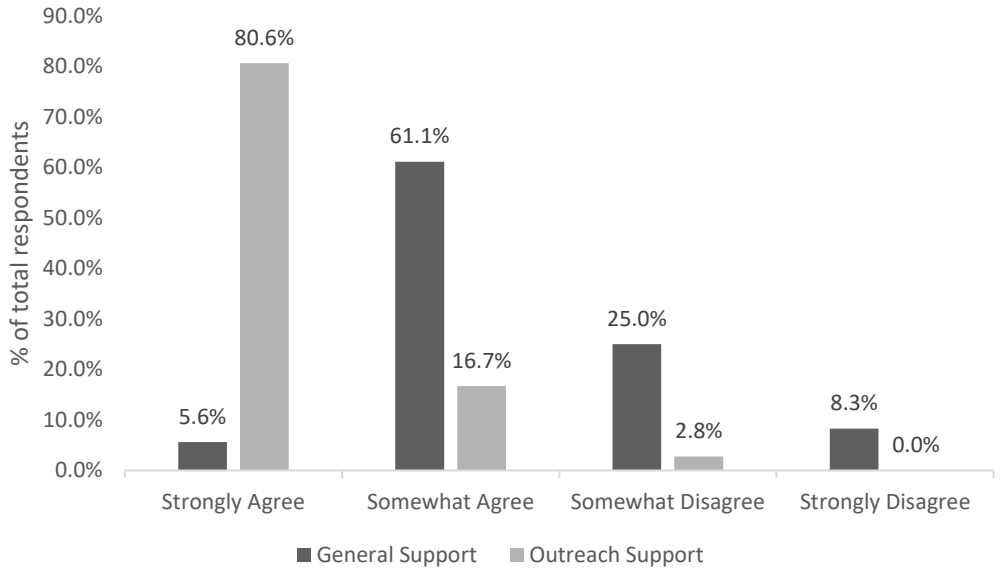
Generally, I am confident teaching STEM topics	38.9	58.3	2.8	
I feel my students learned the STEM topics well	66.7	30.6	2.8	
I will be more confident teaching this topic using the outreach provided lessons plans in the future	75	22.2	2.8	
I will enjoy using the outreach provided lesson plans in the future	80.6	19.4		
I get support to create and teach STEM lessons	5.6	61.1	25.0	8.3
I support others and share STEM lesson plans and resources	13.9	75.0	11.1	
This experience made me feel supported as a teacher	80.6	16.7	2.8	

Feelings of Support

Only 5.6% of the teachers strongly agreed that they get support to create and teach STEM lessons with 61.1% somewhat agreeing. In contrast, Figure 2 shows 80.6% of the teachers felt supported by the STEM outreach experience. This change in feelings of support demonstrates the positive impact of the mentors and how, as few as four outreach sessions, can be beneficial. There was no difference in feelings of support between those with more experience teaching STEM than those with less, suggesting that all teachers would benefit from more support.

Figure 2.

Feelings of Support

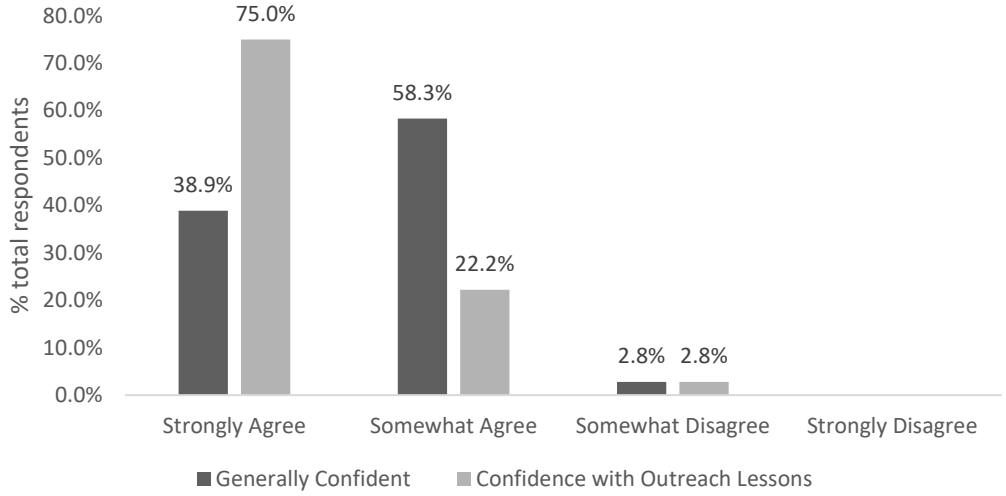


Confidence

Most teachers feel confident teaching STEM; 38.9% strongly agree, and 58.3% somewhat agree. There is an increase in, strongly agree 38.9% general confidence teaching STEM to 75.0% more confident when using STEM outreach lesson plans. This suggests that 36% of participants gained confidence after the mentors demonstrated the sessions. The teachers that were still not confident remained at 2.8% indicating a consistent lower confidence with STEM. Of the teachers who had STEM degrees, 83.3% strongly agreed and 16.3% somewhat agreed they would be more confident using the outreach lessons. This positive response from those with STEM backgrounds demonstrates the positive feelings created by the mentors.

Figure 3.

Confidence

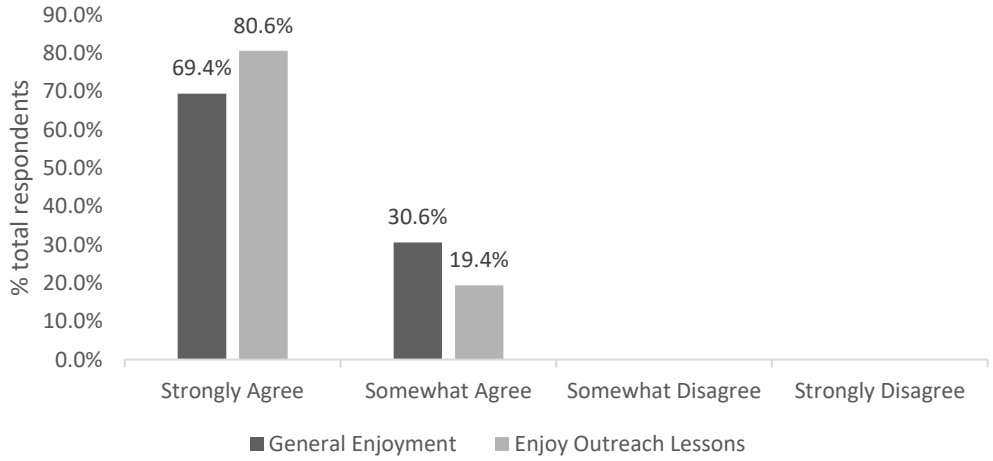


Enjoyment

Figure 4 shows 69.4% of the teachers strongly agreed that they enjoy teaching STEM topics, and 30.6% somewhat agreed. This number increased to 80.6% strongly agreeing they would enjoy using the STEM outreach provided lesson plans in the future. As all of the teachers agreed or strongly agreed they enjoyed STEM, the increase in the number that strongly agreed they would enjoy using the outreach lessons, supports the need for engaging STEM activities.

Figure 4.

Enjoyment



75% strongly agree they will be able to engage the students using the outreach lesson plans in the future. Comparing the hands-on STEM outreach session to their usual lesson plans, 57.7% strongly agreed that student engagement was higher, and 42.3% somewhat agreed.

Focus Group

Five primary (K-5 grade level) teachers attended the focus group, 4 female and 1 male. The researchers encouraged participants to respond to the questions posed based on their personal experiences and stories regarding teaching STEM.

The teachers survey responses were positive for each of the factors, perceived feelings of support, confidence, and enjoyment, but it was not clear exactly which aspects of the outreach contributed to these feelings.

Support

Participants in the focus groups indicated that support was related to availability of materials, time, and difficulty finding activities that integrate curriculum that teachers trust. One of the teachers shared: *"One of the things that I find kind of daunting about STEM is actually collecting materials and having it prepared. It takes a lot of time."*

Teachers' limited preparation time is a contributing factor in avoiding new activities. Even when having access to resources, teachers do not know how the activity will work in the class. The teachers expressed feeling supported by the STEM outreach program because the activities are in-person demonstrations within their classroom. One conveyed *"You can go on the Internet and find a bazillion different STEM activities, but to have something that's tried, trusted and true is most helpful."* They also indicated support from having prepared packages and seeing how these can be used with the students*, "To give us a package of STEM activities is fantastic, but once you've seen it, there's way more buy-in to using them and knowing what they mean."*

Providing quality, field-tested material that teachers feel comfortable with was more important than the quantity of materials they can access. Also, the teachers felt that using proven and trusted activities made a difference in lesson and delivery preparation time. The reduction in time and corresponding lower stress was the biggest contributing factor to the teachers' feelings of support.

Confidence

Participating teachers shared that the STEM outreach educators brought a new perspective and that demonstrating how activities worked boosted their confidence. They felt that the role-modeling provided by the facilitator contributed to their confidence in understanding how to teach these topics. One teacher shared, "*Watching somebody else do it, you think, oh yeah, I could probably do that. Or, I can change this and make it my own*."

The teachers expressed, "*…by having someone come in and do it and show it…that it's going to be messy and it's going to be loud and there's going to be epic fails*" made them more comfortable in how they would be able to teach these topics. During the discussion the teachers expressed enthusiasm about having another educator in the classroom with them. When asked about the outreach, teachers responded they enjoyed "*having a mentor*" or that "w*atching or co-teaching was fantastic*", "*I think you learn from them.*" This aspect of feelings of confidence

relates to support. In addition to the professional development aspect of the outreach, the mentors supported teachers' learning.

Activities where students can experiment also helped teachers' confidence. Respondents shared that they appreciated the session because "*It's getting over the fear of getting messy."* Instead of being worried about the activity being done "correctly", the teachers were able to see how experimentation supported student learning, which resulted in teachers gaining more confidence. They shared how these sessions gave them a chance to learn from what didn't work, *"Then when it did fail, we had an opportunity to kind of unpack it. Why did it not work and what would you do differently next time."*

Enjoyment

Teachers expressed that their interest in a topic influenced their enjoyment. A participant noted, "*I think if you're interested in the topic, it's going to shine through, and you'll want to bring it into the classroom. But if you're not interested in or you're a little intimidated, you're not going to bring it in.*" However, the teachers in these sessions seemed to become more interested when STEM activities were integrated into other subjects. Their enjoyment was higher when the activities related to subjects they enjoyed and felt more confident teaching. For example, one of the teachers mentioned, "[Taking] the storytelling piece, then turning that into a math lesson actually increased the reading because the kids are more engaged."

Increasing enjoyment is related to support and confidence as without the outreach program, the teachers would not have had the confidence to integrate STEM into storytelling or arts activities.

Limitations

The findings and the discussion that follows are presented within the limitations of this study. These include the small sample of school districts participating in the STEM outreach initiative and the low responses to surveys and focus groups. Given that the teachers who participated in the outreach chose to engage in this initiative, the results reflect those teachers who may already enjoy STEM teaching or who are actively seeking opportunities to improve their STEM teaching capacities. This survey was also completed after the sessions and may not have captured the teachers' perceptions of how they felt prior. We acknowledge that further research is needed to expand and deepen the results from this study, that showed how experiences in a STEM outreach program with teachers' classrooms can increase teachers' sense of wellbeing through improved feelings of support, confidence and enjoyment.

Discussion

Our findings demonstrate STEM outreach sessions have a positive influence on teacher wellbeing and that interaction with the STEM mentors, and having access to materials, increased teachers' feelings of enjoyment, confidence, and support. The results suggest teachers' feelings of support increased by having in-class, in-person, STEM outreach sessions. The greatest need was shown in the number of teachers (eighty-six percent) that felt they lacked support in general, but reported feeling supported by the STEM outreach sessions.

STEM outreach programs with mentors who support teachers "help teachers maintain and reinforce their own sense of identity as STEM professionals" (Aslam et al., 2018). Lack of support and dissatisfaction from demanding workloads (Yin et al., 2016) can negatively impact teacher wellbeing. Studies on burnout and work-related stress show that overload and lack of time (Kokkinos, 2007; Van der Doef & Maes, 2002) contributes to a lack of wellbeing, STEM mentor programs that provide teachers with required materials, resources and mentorship may contribute to increasing a sense of teacher wellbeing.

Teachers reported a positive experience and found the knowledge provided by the mentors was of great value. Support through access to materials and lesson plans was important. Moreover, access to field-tested lesson plans which included in-person demonstrations was desired over simply being able to find resources that may or may not be effective. For example, the STEM mentors guide students through the lessons and teachers can see how mistakes and issues are worked through. Building confidence and interest in STEM goes beyond demonstrating the activity, it includes examples of failures or challenges and how to overcome them. As the participating teachers stated, there are numerous STEM lessons online, but there is no way of knowing how effective or successful they are within a classroom unless time, which is limited, is invested into testing prior to delivery. The focus group comments from the teachers expressing their need to "*get it right*" highlights that STEM outreach mentoring facilitates an increase in confidence, and that seeing how the mentors demonstrate activities and approach the possible "*failures*" that could occur, was an integral component to support.

Demonstrations by the mentors increased confidence for the teachers to later deliver the activities independently. Just as role modelling can influence students, STEM outreach support can positively influence teacher confidence to deliver STEM. The support provided by the STEM outreach mentors allowed for self-reflection and discussion on how teachers are approaching STEM teaching and the experimental nature of STEM. Previous research has shown participating in STEM outreach activities helps teachers maintain and reinforce their own sense of STEM identity (Aslam et al., 2018). Confidence in professional abilities is the counter to losing self-efficacy and motivation which lead to burnout through depersonalization and lack of personal accomplishment (Fernet et al., 2012). Not only do effective role models demonstrate confidence and competence (Gladstone & Cimpian, 2021), confidence is important for teachers to integrate STEM into curriculum (Dare et al., 2018).

Teachers' perceived enjoyment was related to two aspects of the outreach sessions: mentoring and integration. Teachers reported feeling more enjoyment when they felt more comfortable with the activities, which was directly related to mentor support to increase teacher confidence. Integration into other subjects also increased teacher enjoyment. When an activity integrates a teacher's special interest, the teacher's enjoyment increases. When asked about their favorite activity, one of the teachers commented on how much they enjoyed seeing science in a traditionally non-STEM activity *"I was kind of skeptical of the rainsticks [being science]. I'm a musical person as well so it kind of tickled my fancy that way, but I wouldn't have chosen it as a STEM activity because I didn't see the science and math connection*." Similar to students whose interest in math and science is maintained when learning activities are personally relevant (Bottia et al., 2015), teachers found personal interest increased their level of enjoyment. Based on our results, we recommend the creation of additional activities that integrate STEM into traditional non-STEM subjects such as English, History, or Art.

Conclusion

Mentoring teachers through hands-on, in-person STEM outreach can contribute to improving their wellbeing in relation to STEM teaching. As teachers build their confidence and enjoyment through the support of the STEM mentor during the outreach experience, they may offer a model of more positive and engaged learning of STEM alongside their students during these experiences. Teachers integrating STEM into curricular subjects (including non-traditional STEM) that have mentorship and professional learning opportunities demonstrate increased confidence and feelings of support, and thereby, enjoyment. Improving teacher wellbeing through supported STEM mentorship may positively influence student learning in STEM. Further research is needed to understand how improving STEM teacher wellbeing connects to improving student learning, with a particular focus on underrepresented student engagement in STEM education and career fields.

References

Antoniou, A.-S., Ploumpi, A., & Ntalla, M. (2013). Occupational stress and professional burnout in teachers of primary and secondary education: The role of coping strategies. *Psychology*, *4*(03), 349. https://doi.org/10.4236/psych.2013.43A051

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science*, *11*(5), 181–185.

Aslam, F., Adefila, A., & Bagiya, Y. (2018). STEM outreach activities: An approach to teachers' professional development. *Journal of Education for Teaching*, *44*(1), 58–70.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences*, *107*(5), 1860–1863. https://doi.org/10.1073/pnas.0910967107

Bermejo-Toro, L., Prieto-Ursúa, M., & Hernández, V. (2016). Towards a model of teacher well-being: Personal and job resources involved in teacher burnout and engagement. *Educational Psychology*, *36*(3), 481–501.

Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education*, *17*(4), 369–386.

Bottia, M. C., Stearns, E., Mickelson, R. A., Moller, S., & Parler, A. D. (2015). The relationships among hgh school STEM learning experiences and students' intent to declare and declaration of a STEM major in college. *Teachers College Record*, *117*(3), 1–46. https://doi.org/10.1177/016146811511700308

Caprara, G. V., Steca, P., Gerbino, M., Paciello, M., & Vecchio, G. M. (2006). Looking for adolescents' well-being: Self-efficacy beliefs as determinants of positive thinking and happiness. *Epidemiology and Psychiatric Sciences*, *15*(1), 30–43. https://doi.org/10.1017/S1121189X00002013

Cherkowski, S. (2018). Positive teacher leadership: Building mindsets and capacities to grow wellbeing. *International Journal of Teacher Leadership*, *9*(1), 63–78. Education Source. https://search.ebscohost.com/login.aspx?direct=true&AuthType=shib&db=eue&AN=130245870&site=ehost-live&scope=site&custid=s5672194

Dare, E. A., Ellis, J. A., & Roehrig, G. H. (2018). Understanding science teachers' implementations of integrated STEM curricular units through a phenomenological multiple case study. *International Journal of STEM Education*, *5*, 1–19.

Deemer, S. (2004). Classroom goal orientation in high school classrooms: Revealing links between teacher beliefs and classroom environments. *Educational Research*, *46*(1), 73–90. https://doi.org/10.1080/0013188042000178836

Duckworth, A. L., Quinn, P. D., & Seligman, M. E. (2009). Positive predictors of teacher effectiveness. *The Journal of Positive Psychology*, *4*(6), 540–547. https://doi.org/10.1080/17439760903157232

Duodu, E., Noble, J., Yusuf, Y., Garay, C., & Bean, C. (2017). Understanding the delivery of a Canadian-based after-school STEM program: A case study. *International Journal of STEM Education*, *4*, 1–11.

Eccles, J. S., & Wang, M.-T. (2016). What motivates females and males to pursue careers in mathematics and science? *International Journal of Behavioral Development*, *40*(2), 100–106. https://doi.org/10.1177/0165025415616201

Fernández-Batanero, J.-M., Román-Graván, P., Reyes-Rebollo, M.-M., & Montenegro-Rueda, M. (2021). Impact of educational technology on teacher stress and anxiety: A literature review. *International Journal of Environmental Research and Public Health*, *18*(2), 548.

Fernet, C., Guay, F., Senécal, C., & Austin, S. (2012). Predicting intraindividual changes in teacher burnout: The role of perceived school environment and motivational factors. *Teaching and Teacher Education*, *28*(4), 514–525.

Fredrickson, B. L., & Branigan, C. (2005). Positive emotions broaden the scope of attention and thought-action repertoires. *Cognition and Emotion*, *19*(3), 313–332. https://doi.org/10.1080/02699930441000238

Fuesting, M. A., & Diekman, A. B. (2017). Not by success alone: Role models provide pathways to communal opportunities in STEM. *Personality and Social Psychology Bulletin*, *43*(2), 163–176. https://doi.org/10.1177/0146167216678857

Gladstone, J. R., & Cimpian, A. (2021). Which role models are effective for which students? A systematic review and four recommendations for maximizing the effectiveness of role models in STEM. *International Journal of STEM Education*, *8*(1), 59. https://doi.org/10.1186/s40594-021-00315-x

Halpern, D. F., Aronson, J., Reimer, N., Simpkins, S., Star, J. R., & Wntzel, K. (2007). Encouraging girls in math and science *(NCER 2007-2003). National Center for Education Research, Institute of Education Science, U.S. Department of Education.* http://nrs.harvard.edu/urn-3:HUL.InstRepos:4889482

Hascher, T., & Waber, J. (2021). Teacher well-being: A systematic review of the research literature from the year 2000–2019. *Educational Research Review*, *34*, 100411.

Huang, B., Jong, M. S.-Y., Tu, Y.-F., Hwang, G.-J., Chai, C. S., & Jiang, M. Y.-C. (2022). Trends and exemplary practices of STEM teacher professional development programs in K-12 contexts: A systematic review of empirical studies. *Computers & Education*, 104577.

Johnson, R. B., & Christensen, L. (2019). *Educational research: Quantitative, qualitative, and mixed approaches*. Sage publications.

Kim, Y. K., & Sax, L. J. (2018). The effect of positive faculty support on mathematical self-concept for male and female students in STEM majors. *Research in Higher Education*, *59*(8), 1074–1104. https://doi.org/10.1007/s11162-018-9500-8

Kokkinos, C. M. (2007). Job stressors, personality and burnout in primary school teachers. *British Journal of Educational Psychology*, *77*(1), 229–243.

Leaper, C., Farkas, T., & Brown, C. S. (2012). Adolescent girls' experiences and gender-related beliefs in relation to their motivation in math/science and English. *Journal of Youth and Adolescence*, *41*, 268–282.

Lin, G.-Y. (2016). Self-efficacy beliefs and their sources in undergraduate computing disciplines: An examination of gender and persistence. *Journal of Educational Computing Research*, *53*(4), 540–561. https://doi.org/10.1177/0735633115608440

Ling, L. S., Pang, V., & Lajium, D. (2020). A Case study of teachers' pedagogical content knowledge in the implementation of integrated STEM education. *Jurnal Pendidikan Sains Dan Matematik Malaysia*, *10*(1), 49–64.

Marx, D. M., Monroe, A. H., Cole, C. E., & Gilbert, P. N. (2013). No doubt about it: When doubtful role models undermine men's and women's math performance under threat. *The Journal of Social Psychology*, *153*(5), 542–559. https://doi.org/10.1080/00224545.2013.778811

Mosatche, H. S., Matloff-Nieves, S., Kekelis, L., & Lawner, E. K. (2013). Effective STEM programs for adolescent girls: Three approaches and many lessons learned. *Afterschool Matters*, *17*, 17–25.

N. Aish, P. Asare, & E. E. Miskioğlu. (2017). People like me increasing likelihood of success for underrepresented minorities in STEM by providing realistic and relatable role models. *2017 IEEE Frontiers in Education Conference (FIE)*, 1–4. https://doi.org/10.1109/FIE.2017.8190454

Nathan, M. J., Tran, N. A., Atwood, A. K., Prevost, A., & Phelps, L. A. (2010). Beliefs and expectations about engineering preparation exhibited by high school STEM teachers. *Journal of Engineering Education*, *99*(4), 409–426. https://doi.org/10.1002/j.2168-9830.2010.tb01071.x

Orgambídez-Ramos, A., & de Almeida, H. (2017). Work engagement, social support, and job satisfaction in Portuguese nursing staff: A winning combination. *Applied Nursing Research*, *36*, 37–41.

Prieto-Rodriguez, E., Sincock, K., & Blackmore, K. (2020). STEM initiatives matter: Results from a systematic review of secondary school interventions for girls. *International Journal of Science Education*, *42*(7), 1144–1161. https://doi.org/10.1080/09500693.2020.1749909

Quimby, J. L., & De Santis, A. M. (2006). The influence of role models on women's career choices. *The Career Development Quarterly*, *54*(4), 297–306. https://doi.org/10.1002/j.2161-0045.2006.tb00195.x

Saville, E., Cherlowski, S., & Jakobi, J. (2023). *C*onnection, engagement and belonging: Exploring young women's positive experiences for building inclusive STEM classrooms. *Alberta Journal of Educational Research* 69 (1):103-17. https://doi.org/10.11575/ajer.v69i1.75063

Schmidt, J. A., Kafkas, S. S., Maier, K. S., Shumow, L., & Kackar-Cam, H. Z. (2019). Why are we learning this? Using mixed methods to understand teachers' relevance statements and how they shape middle school students' perceptions of science utility. *Contemporary Educational Psychology*, *57*, 9–31.

Seligman, M. (2011). *Flourish: A Visionary New Understanding of Happiness and Well-being* (Kindle). Free Press.

Seligman, M. (2018). PERMA and the building blocks of well-being. *The Journal of Positive Psychology*, *13*(4), 333–335. https://doi.org/10.1080/17439760.2018.1437466

Seligman, M., & Csikszentmihalyi, M. (2000). *Positive psychology: An introduction.* (Vol. 55, Issue 1). American Psychological Association.

Selvaraj, R., & Subramoniam, S. (2023). *A Systematic review of research on training faculty on well-being in STEM*. 2023 ASEE Annual Conference & Exposition, Baltimore , Maryland. https://peer.asee.org/42531

Shin, J. E. L., Levy, S. R., & London, B. (2016). Effects of role model exposure on STEM and non-STEM student engagement. *Journal of Applied Social Psychology*, *46*(7), 410–427. https://doi.org/10.1111/jasp.12371

Turner, K., & Theilking, M. (2019). Teacher wellbeing: Its effects on teaching practice and student learning. *Issues in Educational Research*, *29*(3), 938–960.

Van der Doef, M., & Maes, S. (2002). Teacher-specific quality of work versus general quality of work assessment: A comparison of their validity regarding burnout,(psycho) somatic well-being and job satisfaction. *Anxiety, Stress & Coping*, *15*(4), 327–344. https://doi.org/10.1080/1061580021000056500

Wang, X. (2013). Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support. *American Educational Research Journal*, *50*(5), 1081–1121. JSTOR. https://doi.org/10.3102/0002831213488622

Yin, H., Huang, S., & Wang, W. (2016). Work environment characteristics and teacher well-being: The mediation of emotion regulation strategies. *International Journal of Environmental Research and Public Health*, *13*(9), 907. https://doi.org/10.3390/ijerph13090907

Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological Careers. *American Educational Research Journal, 37*(1), 215–246. https://doi.org/10.3102/00028312037001215