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Abstract

In the current study three different STEM-focused programs are presented in which teachers and students are immersed in authentic learning experiences and benefit from the rigors of a structured mentoring program. All three projects have been supported by United States federal funding and offered different STEM models with the general aim to enhance STEM learning and motivation among students and teachers. The longitudinal mixed-methods design employed in all studies, in which quantitative and qualitative data have been collected, allowed for in-depth analysis of data. Each project adopted a different model of STEM learning and curriculum. In one study, teachers and students alike interacted with a mentor scientist in the classroom, and were presented with learning opportunities that greatly enhanced their science motivation and academic learning. In another study, inservice teachers are immersed in a science mentoring program working alongside mentor scientists and the host lab team. And finally in another study, preservice teachers are presented with a STEM-focused curriculum which greatly contributed to the development of their STEM knowledge and skills, and science teaching identity. All three programs were designed to increase STEM knowledge, literacy, and enhance motivation and domain identification with STEM among participants.

Introduction

Immersive experiences with Science Technology Engineering and Mathematics (STEM) programs hold a special significance in developing participants' STEM literacy, specialized knowledge and skills, as well as directly influencing their academic motivation and science identity (Thomson & Mara, 2021). Research findings show that both teachers and students benefit tremendously from participating in STEM immersive programs, in which they learn specialized knowledge from mentor scientists (Thomson, 2024). Mentoring has been described as a valuable learning activity for students and for teachers alike; beginners or experienced practitioners such as teachers, administrators, educators, or other professionals, significantly benefit from mentoring, and in turn help support student achievement (Abiddin & Hassan, 2012; Capraro, Capraro, & Helfeldt, 2010).

Research shows that participating in a STEM mentoring program or following a STEM-focused curriculum during teacher training, is related to personal and professional development and befits not just the students and the teachers, but communities at large, such a whole-schools or educational programs (Hubbard et al., 2022; Hubbard et al., 2024; Thomson et al., 2020). In the current article, three different STEM programs are presented, each featuring a different STEM immersive model. Each has been shown to positively impact education, particularly teacher and student development of scientific literacy, increase motivation, and contributed to driving instructional changes that lead to quality teaching (Hubbard et al., 2022; Thomson et al., 2019; Thomson et al., 2024).

The STEM-focused Projects: Design, Context and Participants

The three STEM-focused programs which are described here, are separate projects, each funded by a federal agency in the United States. The author of the current article is the project director (i.e., Project investigator, PI) in two of the projects, and the co-director (i.e., Co-Project investigator, Co-PI) in the other project, thus has been involved in the designing, development and implementation of all projects presented. Each project described below, illustrates a different educational setting, context and model, and shows how immersive experiences along with mentoring are powerful tools for enhancing teacher and student knowledge in understanding science research and inspire positive instructional changes. The programs described are focused on increasing student and teacher STEM knowledge and skills, and to a certain degree attempting to explain how scientists are conducting their research and inform students and teachers about the nature of scientific work.

Project 1. Teachers' STEM Experiences, A Professional Development Program

The project described in this section, entitled *Environmental Health Research Experiences for Teachers in High-Poverty Schools: A Professional Development Program* is a 5-year funded project by the National Health Institutes (NIH), a major federal funding agency from the United States. The project has been implemented in United States and provided science mentoring opportunities for K-12 teachers with a focus on environmental health research. The majority of program participants were high-school science teachers (96%), and a small number were middle-school teachers (4%), as the program's structure was more aligned with high-school science curriculum standards.

The mentoring program was hosted by a major research university in the United States in partnership with two main affiliated research centers. One research center focused on Human Health and the Environment is developing and carrying a research agenda aiming at educating schools, communities, education and science at large about environmental health issues. The other research center, focused on Comparative Medicine, leads a research agenda aiming at funding and implementing translational research that educates scholars and public at large about various aspects of comparative medicine research.

Over a period of five years, teachers (*N*=40) from different schools participated in the science immersive mentoring research program focused on environmental health research. The program participants were from five different cohorts of the program, as each year over the five years a new cohort of teachers were recruited. Teacher participants were full-time teachers at schools that have high-poverty levels, and many program participants were themselves individuals from minority groups, and women.

Additionally, most teacher participants in the program novice teachers, with a teaching experience less than 10 years. Mentor scientists who were research scientist with an active research agenda at the university and affiliated with either one or both of the research centers abovementioned, hosted the teachers in their labs over the summer, engaging teachers in ongoing research lab projects. In this immersive science program, teacher participants have been integrated into genuine research projects and participated in lab meetings and activities with scientists, gaining knowledge of how scientific research is conducted and learning specialized knowledge related to ongoing projects in the host research labs. Each teacher has been assigned to a mentor scientist and the scientist's lab hosted the teacher for duration of the summer program.

For program evaluation purposes and for educational research, data was collected throughout the program from the teacher participants to understand more about their program experiences, motivation for participation, expectations, changes in beliefs about science instruction, and changes that occurred in their classroom science teaching after the program attendance. A mixed methods designed was implemented, and both quantitative and qualitative data were collected each year from the program participants. Quantitative data collected via online surveys (at three different times), included participants' demographics, teaching experience, previous professional development program participation, number and types of courses taught, as well as cognitive measures (i.e., teacher beliefs about science, science teaching, and classroom instruction), and non-cognitive measures (i.e., motivations, expectations, emotions) related to program attendance. Qualitative data was collected via focus groups and individual interviews with each participant at different time-points during the program. Appendix A presents the data collection measures and timeline.

Project 2. Preservice Teachers STEM-Focused Training Program

The program described in this section, entitled *Accomplished Teachers of Mathematics and Science* (ATOMS) is a 5-year funded project by the National Science Foundation (NSF), a federal funding agency from United States. The STEM-focused teacher training program has been developed and implemented at a manor research university in the United States with the aim to train elementary teachers in STEM. This is one of the very few STEM-focused programs in the United States for elementary teachers and is distinctly characteristic for being highly innovative and easily sustainable with traditional university-based resources.

Each year, sixty new elementary teacher candidates are admitted into the STEM-focused program described in this section. The preservice teachers' program begins in their first year in college (i.e., freshman year) with a required education orientation class and multiple opportunities to participate in campus wide programs and youth advocacy groups. The key features of the ATOMS model characterize a strong teacher education program, given its focus on (1) program coherence, (2) rigor in the general education program, (3) innovative, conceptually focused methods courses, and 4) extensive field experiences aligned to coursework.

In the ATOMS project, participants were all (*N*=245) preservice teachers (and eventually graduates) of the STEM-focused elementary teacher preparation program. The study participants were from four different graduating cohorts of the program. Most participants were females (*n*=96%), white (*n*=87%), and with an age range between 18-22 years (when they were preservice teachers) and 22-24 years (during their first two years of teaching). Participants' demographics are typical for beginning elementary teachers (white and female) as identified in the NSSME (Banilower et al., 2015; Thomson et al., 2019).

The study employed a longitudinal mixed-methods design; both quantitative and qualitative data were collected. Quantitative data was collected via online surveys at six different time points during participants' teacher preparation program and into their first two years of teaching. Qualitative data was collected via focus groups and individual interviews at different time-points during the project.

The six time points when data were collected are presented in Appendix B along with measures. Each time point in data collection represented a critical event for participants: T1 (freshman year) data were collected at the beginning of undergraduate coursework and their teacher education program preparation; T2 (junior year) data were collected at the beginning of professional coursework/methods courses; T3 (beginning of senior year) data were collected at the end of methods courses/beginning of field experiences; T4 (end of senior year) data were collected at the end of teacher education program/college preparation; T5 (1st year of teaching), data were collected the end of their 1st year of teaching; T6 (2nd year of teaching), data were collected at the end of their 2nd year of teaching.

Project 3. A STEM Mentoring Program for Middle-School Students

In this section a STEM mentoring project for middle school students is presented. The project entitled *Fostering Academic Motivation, and a STEM Growth Mindset in High Poverty Schools through Authentic Research Experiences* was a one-year research project funded by the United States Fulbright Commission. The project describes an immersive mentorship STEM project implemented in public schools from Romania, generally schools with high-poverty levels. Middle school students (*N*=326) from three different schools participated in the program aimed at developing STEM literacy and science, as well as domain identification with sciences.

Mentor scientists who were affiliated with a local major research university were invited to come and teach biology lessons to middle-school students, who were in 6th and 7th grade. Ten mentor scientists volunteered, all female scientists. In addition to research, the mentor scientists were involved in local and national community outreach projects as well. The biology lessons and instructional content for the middle-school students included, besides the required science curriculum content, stories about struggling scientists, in which elements of struggle were featured (e.g., scientist struggling with poverty, or scientists struggling with prejudice). The presence of female scientists in the classroom, along with embedded stories of struggling scientists helped students to see scientists as individuals that persisted in order to achieve, and as role models they can follow.

For this study, a mixed methods designed was employed; both quantitative and qualitative data were collected from the students participating in the study. Quantitative data collected via paper surveys (at two different times, pre and post study), included participants' demographics, cognitive measures (i.e., student beliefs about science, beliefs about intelligence, effort measures, career orientation) and non-cognitive measures (i.e., student academic and science motivations, expectations). Appendix C presents the data collection measures and timeline.

Conclusions

Overall study findings from these projects showed that both teachers and students demonstrated: *increased understanding of* STEM fields; developed *specialized domain knowledge* and *understanding of research process*. Additionally, study results also showed that all participants *increased their values* (utility value/relevance) for the programs they attended and indicated that they are interested in participating in future similar mentoring programs if they will have the opportunity.

For participants directly interacting with mentor scientists (e.g., project EHRE and Fulbright) a positively surprising finding indicated how important it was for all participants *to interact with* and *learn from the mentor scientists*. Scientists were perceived *as role models* which facilitates identity development and help develop science career goals. Mentor scientists and instructional content that specifically described stories about struggling scientists (e.g., scientists can struggle in their work as any other individuals) helped participants see scientists as individuals that they could identify with.

Scientists became role models and students could see the possibility of becoming scientists because they could see themselves and identity with certain individual features that scientists exhibited (e.g., gender, ethnic background, or SES characteristics). Finally, the mentoring opportunities offer teachers and students the chance to be immersed in science experiments, understanding how science and scientists work, contributing overall to the public understanding of science.

The projects described also illustrate how different STEM-focused models and STEM-build in curriculum help develop academic and STEM career motivation among students. Research shows that immersive program such as these described in the current article, have the potential to build strong school or professional communities, drive quality instruction in the classroom and develop science or STEM identity (e.g., Carrier et al., 2017; Klein-Gardner, Johnston, & Benson, 2012).

Additionally, schools and communities with high-poverty levels lack quality STEM mentoring programs or learning opportunities, which often leads to inadequate teaching and poor student outcomes. Research shows that economically disadvantaged students rarely identify themselves with science or STEM careers but given that their teachers or the students themselves are presented with quality mentoring immersive programs, the schools and communities can undergo major positive transformations (Banilower et al., 2010, 2013; Bransford, Brown, & Cocking, 2000; Thomson, 2024). Designing and implementing such programs not only help students develop STEM literacy, academic motivation and domain identification with STEM, but provide strong communities and networks between schools, universities, and the various scientific groups within the local community.

References

Abiddin, N. Z., & A. Hassan (2012). A Review of effective mentoring practices for mentees development. *Journal of Studies in Education, 2* (1), 72–89.

Banilower, E., Cohen, K., Pasley, J., & Weiss, I. (2010). *Effective science instruction: What does research tell us*. Portsmouth, NH: RMC Research Corporation, Center on Instruction.

Banilower, E.R., Smith, P.S., Weiss, I.R., Malzahn, K.A., Campbell, K.M., & Weiss, A.M. (2013). *Report on the 2012 national survey of science and mathematics education*. Chapel Hill, NC: Horizon Research, Inc.

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).

Bransford, J. D., Brown, L., & Cocking, R. R. (Eds.). (2000). How people learn: Brain, mind, experience and school. Washington, DC: U.S. Department of Education.

Capraro, M. M., Capraro, R. M., & Helfeldt, J. (2010). Do differing types of field experiences make a difference in teacher candidates' perceived level of competence? *Teacher Education Quarterly, 37*(1), 131–154.

Carrier, S.J., Whitehead, A.N., Luginbuhl, S.C., Walkowiak, T.A., & Thomson, M.M. (2017). The development of elementary teacher identities as teachers of science. *International Journal of Science Education, 39* (13), 1733-1754.

Hubbard, L., Jackman-Ryan, S., & Thomson, M.M. (2022). Immersive research experiences: Influences on science motivation and practices. *International Academic Forum, 8* (1), 69-86.

Hubbard, L., May, K., Jackman-Ryan, S., & Thomson, M.M. (2024). Understanding the process of changes in science beliefs and classroom practices from immersive research experience for science teachers. *International Journal of Research in Education and Science, 10* (2),502-523.

Klein-Gardner, S. S., Johnston, M. E., & Benson, L. (2012). Impact of RET teacher-developed curriculum units on classroom experiences for teachers and students. *Journal of Pre-College Engineering Education Research, 2* (2), 21–35.

Mara, D. & Thomson, M.M. (2021). *Theoretical and practical approaches to non-formal education* (Eds). Irvine, CA: BrownWalker Press, Inc. ISBN 9781599426129.

Thomson, M.M., Huggins, E. & Williams, W. (2019). Developmental science efficacy trajectories of novice teachers from a STEM-focused program: A longitudinal mixed-methods investigation. *Teaching and Teacher Education, 77*, 253-265.

Thomson, M.M., Walkowiak, T. & Whitehead, A., & Huggins, E. (2020). Mathematics teaching efficacy and developmental trajectories: A mixed-methods investigation of novice K-5 teachers. *Teaching and Teacher Education, 87,* 1-14.

Thomson, M.M. (2024). *Motivation and engagement in various learning environments: Interdisciplinary perspectives* (Ed). Charlotte, NC: Information Age Publishing. ISBN 979-8-88730-538-7.

Thomson, M.M., Pop-Pacurar, I., Negru-Subtirica, O. (2024). A Fulbright research project: Interdisciplinary approaches to developing STEM motivation for students in a mentorship program intervention. In Thomson, M.M. (Ed), *Motivation and engagement in various learning environments: Interdisciplinary* *perspectives* (pp.1-18). Charlotte, NC: Information Age Publishing.

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Appendix A. Data Collection Timeline Project 1

Time 1: Beginning of the PD program AND Time 2: End of the PD program	**Quantitative Data: Online Survey** Data collected via online survey as related to participants' summer program experiences: Demographic data Number of courses taught prior to the summer program that have enhanced STEM curriculum • Professional development involvement prior to the summer program, (e.g. ,types and number of hours in other science related PD programs) Motivations and Values • Motivation for engagement in the summer program • Expectations and learning goals for the summer program • Emotions related to the summer program engagement (i.e., positive and negative emotions before program attendance) • Values and beliefs associated with the summer program (i.e., efficacy beliefs, instructional beliefs, mindset)	**Qualitative Data: Focus Group Interview** Data collected via focus group interviews: • Weekly reflective activities (open-ended items on survey) about program relevance for teachers • Focus group interviews with teachers (twice during the program)
Time 3: During the academic year, following the PD program	**Quantitative Data: Online Survey** Data collected via online survey as related to participants' summer program experiences: • Number of STEM courses taught in subsequent years • Changes in science content and teaching strategies as related to	**Qualitative Data: Individual Interviews** Data collected via individual interviews: • Individual in-depth interviews with teachers (follow-up of the survey) about program relevance and instructional changes

	the summer program involvement • Engagement in regional or school related events as a result of the summer program experiences • Impact on teacher career advancement or impact on students' career track as a result of the summer program experiences • Changes in professional networking as a result of the summer program engagement	

Appendix B. Data Collection Timeline for Project 2

Time	Teacher Education Program	Measure
T1	Beginning of Freshman Year	Science Efficacy (PSTE, STOE)
		Science Knowledge (DTAMS)
		LT
T2	Beginning Junior Year/ Pre-Methods	Science Efficacy (PSTE, STOE)
		Science Knowledge (DTAMS)
		LT
T3	Beginning Senior Year / Post Science Methods Courses	Science Efficacy (PSTE, STOE)
		Science Knowledge (DTAMS)
		LT
T4	End of Senior Year/ End of Teacher Preparation	Science Efficacy (PSTE, STOE)
		Science Knowledge (DTAMS)
		LT
T5	End of First Year of Teaching	Science Efficacy (PSTE, STOE)
		Science Knowledge (AIM Ecosystems and Matter)
		LT
T6	End of Second Year of Teaching	Science Efficacy (PSTE, STOE)
		Science Knowledge (AIM Ecosystems and Matter)
		LT

Note: PSTE =Personal Science Teaching Efficacy Beliefs; STOE= Science Teaching Outcome Efficacy Beliefs; LT=Learning Theory; DTAMS= Diagnostic of Teacher Assessment Mathematics and Science [DK=Declarative Knowledge; *IK=Inquiry Knowledge; *SK=Schematic Knowledge]; AIM/ Ecosystems =Assessment of Instruction/ Ecosystems; AIM/ Matter =Assessment of Instruction/ Matter.

Appendix C. Data Collection and Timeline for Project 3

Time		Measures
*T1	Beginning of intervention	Motivation for a Career in Biology
		STEM Motivation
		Goal Orientation
		Beliefs about Effort
		School Achievement Beliefs
*T2	Post Intervention	Motivation for a Career in Biology
		STEM Motivation
		Goal Orientation
		Beliefs about Effort
		School Achievement Beliefs
**T3	Individual Interviews with students in the treatment group	Interview questions related to experiences in the mentorship program; STEM motivation, Biology career motivations, beliefs about effort and achievement

Note: *Measures for T1 and T2 were administered to both the control group and the treatment group. **The T 3 interview was conducted with participants in the treatment group only.