Participant Feedback Regarding STEM-Related Learning Experiences and Associated Implications for Program Development and Evaluation

Jessica Cortez[1], John Kegley[2]
[1]Cubic Global Defense Inc., [2]Aptima, Inc.
Wright-Patterson AFB, Ohio
Jessica.Cortez.3.ctr@us.af.mil, jkegley@aptima.com

Winston Bennett, Jr
Air Force Research Laboratory
Wright-Patterson AFB, Ohio
Winston.Bennett.@us.af.mil

ABSTRACT

Some of the objectives of the Air Force Research Laboratory's Gaming Research Integration for Learning Lab® (GRILL®) are to leverage commercial modeling and simulation technology to address Air Force education and training gaps, to support Science, Technology, Engineering, and Math (STEM) content and to enable challenge problem development. As with any community-focused intervention, traditional evaluation approaches are not always well-suited for assessing outcomes. As such, researchers identified methodological opportunities to explore student and community impacts in novel ways. This paper outlines participant feedback as it relates to the training criterion space we developed for each participant group, i.e., Wright Scholars (high school juniors and seniors, or college freshman), educators (K-12), and mentors (student interns). The findings presented foster the understanding of the degree to which STEM outreach activities, such as the summer STEM program, are influencing the formal education community and generating desirable outcomes for participants. The objective is therefore to refine the measures of progress for STEM initiatives by evaluating multi-dimensional data sources. Constructs explored include the extent to which outreach activities increase educator awareness and confidence in implementation of STEM curricula, types of positive student outcomes (e.g., access to STEM materials and the pursuit of STEM related careers), and student-requested STEM learning experiences. These identify investment priorities and focus areas concerned with the underlying structure of learning opportunities. This paper highlights currently identified impacts and describes our continued efforts to increase the precision for gathering more direct and quantifiable data. Lessons learned and future directions provide guidance for evaluating STEM exposure and its impact on the community, regional workforce, and educational opportunities in other similar initiatives and programs.

ABOUT THE AUTHORS

Dr. Jessica Cortez is a research psychologist with experience consulting with business leaders on solutions to improve the effectiveness of their organization through organizational diagnosis on people, systems, and structure. She received her PhD from Capella University in Industrial and Organizational Psychology with a specialization in Organizational Leader Development in 2014. Her research interests focus on evidence-based methodologies to evaluate community impact, the development of measures to sustain and reinforce behavioral change resulting from training interventions, progressive human capital models and tools that identify competency, knowledge and talent gaps, and transparency and reporting innovation as it relates to value-added accountability and assessment systems.

Dr. John Kegley is a Research Scientist with experience in designing and evaluating simulation-based training programs in the military and healthcare domains. He has led projects involving battlespace management, assessment of simulator fidelity, after-action review augmentation, and usability evaluations for the Department of Defense. Dr. Kegley holds a Ph.D. in Human Factors Psychology from Wright State University, a M.A. in Industrial and Organizational Psychology from Western Kentucky University, and a B.A. in Psychology from the University of South Florida.

Dr. Winston Bennett, Jr. is the Product Line Lead for the Warfighter Readiness Research Division located at Wright Patterson AFB Ohio. He is an Air Force Research Laboratory Research Fellow and a Fellow of the Association for Psychological Science, the Society for Military Psychology, and the Society for Industrial and Organizational Psychology. He is currently leading research developing methods to monitor and routinely assess individual and team competencies and performance across live and virtual environments and evaluating game-based approaches for training, work design, and job restructuring. He is an Associate Editor for the journal Military Psychology and serves as a contributing editor and/or as a reviewer for other professional journals. He received his Ph.D. in Industrial Organizational Psychology from Texas A&M University in 1995.

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Winston, Bennett, Jr
Air Force Research Laboratory
Wright-Patterson AFB, Ohio
Winston.Bennett@us.af.mil

INTRODUCTION

The Gaming Research Integrated Laboratory for Learning (GRILL®) provides students, teachers, and mentors with the means to engage in STEM education efforts and perform outreach at a local and national level on behalf of the Air Force Research Laboratory (AFRL) and the United States Air Force (USAF). To facilitate STEM-related academic and professional development, the environment affords a flexible and inclusive learning space for groups of individuals and organizations to immerse learners in technology-supported inquiry activities and learning experiences with real-world challenges. During the nine-week, hands-on summer STEM instructional program, participants gain a basic understanding of hardware, software, and networking design and implementation, testing, and iterative development techniques.. Wright Scholars work directly with customers (local businesses, academic institutions, and USAF and Department of Defense (DoD) organizations) to gather requirements, develop tasking plans and deliverable guidelines, elicit iterative feedback, and present a final product with an out-brief at the end of the program. In addition, learners are exposed to multiple programming languages (such as Python and C++); virtual and augmented reality technology; training simulations and game development; and 3D modeling, robotics, and system engineering. Practicing STEM professionals (i.e., scientists, engineers, and researchers) work alongside Wright Scholars, educators, and undergraduate student interns (mentors).

Educators pursue research-based curriculum development. The needs and unique interests of teachers determine respective projects (or deliverables) focusing on domain specific, developmentally appropriate content and skills to offer peer-based exercises (activities and experiences) accommodating any experience level. Educator deliverables are viewed in context beyond the STEM instructional program and are published on the GRILL® website for open access to content promoted by standards-based reform curriculum development and instructional design. As opposed to predefined goals and objectives, active experimentation learning facilitates discussion among educators surrounding the comprehensiveness of activities as well as revealing best practices and processes for professional learning needs. Overarching outcomes are related to deepening and expanding opportunities to develop challenge problems and work with domain-specific technology. The underlying philosophy of shared practice and reflective learning reveals a systematic, continuous, collaborative, and reflective model. The student interns in the program work as mentors while overseeing Wright Scholar projects. They are both computer engineering and pre-service educator degree seeking students. The pre-service educators review student logbooks and assist the educators with accessible learning activities. Practicing STEM professionals help tailor activity needs, engage partnerships, and explore learning styles in relationship to technology.

Data were collected throughout the program to establish baselines for the human performance and training goals, to drive future capability improvements, and to evaluate the efficacy of the STEM training and enrichment provided. In light of the training evaluation criterion space, there is value in generating holistic feedback and evaluation data from all involved groups that have contributed to program assessment, development, and refinement in an empirical manner (Erdogan & Stuessy, 2015). The purpose of this research effort has been the documentation of interventions and resources provided by the STEM instructional program as well as quantifying and demonstrating the associated impact on the local community in terms of STEM engagement and outreach in alignment with best practices found in the literature (Constan & Spicer, 2015; Erdogan & Stuessy, 2015; Lynch, Behrend, Burton, & Means, 2013). This paper continues the dynamic conversation about opportunities for innovation and evaluation in STEM learning ecosystems in alignment with the DOD STEM Strategic Plan to ensure competitiveness with the development of world-class STEM talent.

From a programming perspective, identifying specific or relevant dimensions and providing guidance about services, supports and advocacy is essential to generating a STEM pipeline (Dunn, Shannon, McCullough, Jenda, & Qazi, 2018; Lynch et al., 2013). Responding to expressed preferences and illustrating system-level conditions (or person-program fit) through a transparent value-added design is a vital element of science education reform and innovation (Harackiewicz, Canning, Tibbetts, Priniski, & Hyde, 2016). Responding to workforce deficiencies, Reider, Knestis and Malyn-Smith (2016) examined a high-level workforce education model and the kinds of evidence projects should collect to assess the contribution to STEM workforce education. This is consistent with strategic priorities to build a diverse STEM talent pool; the inclusion of workplace partners provides socialization to the task or role for richer data gathering.

In the appraisal process of experimental learning, developing the right combination of dispositions, knowledge, and skills ensures positive changes in key attitudes and behavior related to persistence in STEM (Erdogan & Stuessy, 2015). The core tenants of Professional Learning Communities (PLCs) surround collaborative inquiry-exchange and interpretation of information (Dogan, Tatik, and Yurtseven, 2016). Supportive conditions (i.e., relationships and structures) influence key groups. What is of interest to stakeholders is the accomplishment of objectives, i.e., providing compelling evidence that the STEM instructional program is affording unique experiences, building interest and sustaining motivation of learners for STEM pathways. According to Urais and Gallagher (2012), critical features of a program assessment extend beyond producing quality research and examine assumptions or simplifications from earlier learning based on student feedback and learning outcomes. To better understand the practice of evaluation in more systematic and empirical ways, Lam and Shulha (2015) examined the use of developmental evaluation in the creation of an innovative educational program for pre-service educators. The developmental approach to evaluation takes into account the utility needs of program personnel working in complex arenas; evaluators look for cohesiveness in program strategy and to clarify a potentially broad and scalable impact. From the standpoint of maximizing the utility of STEM education and outreach, transparency of outcomes among stakeholders, is critical to sustain youth and public engagement. Significance in the thinking across perspectives and disciplines, i.e., person-in-context and the cultural context and environment, afford multiple levels or units of analysis.

Evaluating the Training Program

The Kirkpatrick (1979) training evaluation framework delineates four outcome levels that should be considered when assessing instructional programs: Reaction (Level 1), Learning (Level 2), Behavior (Level 3), and Results (Level 4). Level 1 evaluation measures whether learners are satisfied, motivated, and interested in the relevance and applicability of the STEM professional development program; how they feel about the program's success. Did they believe the learning experiences and curriculum were relevant, realistic, and applicable to their academic or career path?

Level 2 focuses on perceived and measurable learning that is attributable to the training program. This level is typically facilitated with surveys and interviews, as well as quantifiable metrics and measures tied to the learning objectives (LOs) of the training. To illustrate, educators develop content consistent with practices vetted through rigorous research; it is inclusive of and describes developmentally relevant learning theories and goals. From the perspective of learning and constructivist theories, learning is a matter of "knowing and doing," and hands-on learning adds to the clarity, correctness, and adequacy of existing knowledge.

Level 3 reflects the degree to which behavior on the job or in the classroom has been influenced by the instructional course or program. In this case, did the STEM-related knowledge and skills transition to the individual's school or career setting? As it relates to "lesson delivery" in the classroom, sources of evidence would come from formal observation and classroom walkthroughs and informal observations. A defining feature of problem-based instruction is the extent to which an ill-defined problem drives students to encounter central concepts and principles (Kokotsaki, Menzies, & Wiggins, 2016). To determine what tangible benefits are received from attendance and participation aside from the contribution of school organizations and their dynamics, stakeholders look for indicators of potential changes in behavior resulting from the intervention or instructional program (Ramos, Silva, Pontes, Fernandez, & Nina, 2014).

Finally, Level 4 involves the results of the training on an organizational, community, state or even national level. This is the stage at which return on investment (ROI) and other higher-order value and performance-based metrics are assessed. Have the STEM initiatives at the GRILL® demonstrated tangible payoffs from effective community practices, such as more robust academic and career opportunities coupled with a strengthened employee pipeline and developed cutting-edge skillsets in Southwest Ohio and the nation? Presented differently, growth toward priorities is

promoted or prevented by a reinforcing feedback process. The effect extends beyond individual behavioral outcomes to include a motivational component whereby learners act to achieve a goal and adjust behavior to minimize barriers and realize desired achievement. The following sections document the research method and obtained results according to Kirkpatrick's Level 1 reactions.

METHOD

The research team utilized a mixed-methods approach to data collection that incorporated surveys, observations, and interviews. To better understand the capacity of the instructional program and contribution to the STEM learning ecosystem, researchers surveyed all program participants to identify their expectations and objectives and whether or not they were met. Additionally, the research team gathered reactions and ratings of training effectiveness and utility. Surveys included items that addressed the following constructs: knowledge and awareness of STEM; engagement and interest; and attitudes, behaviors, and skills in STEM. Informal interviews were conducted to inform community impact through the developmental process and identify how to gain traceability on results from design. Researchers attended to the utility of development-focused stakeholder collaboration, drawing attention to mapping complex identity configurations. Discussions with participants entailed specification of attributes or benchmarks of personal and professional value. This process provided insight into the mechanics of the program and its design to positively impact the growth of learners in STEM. Figure 1 shows a basic illustration of the theoretical structure of the program.

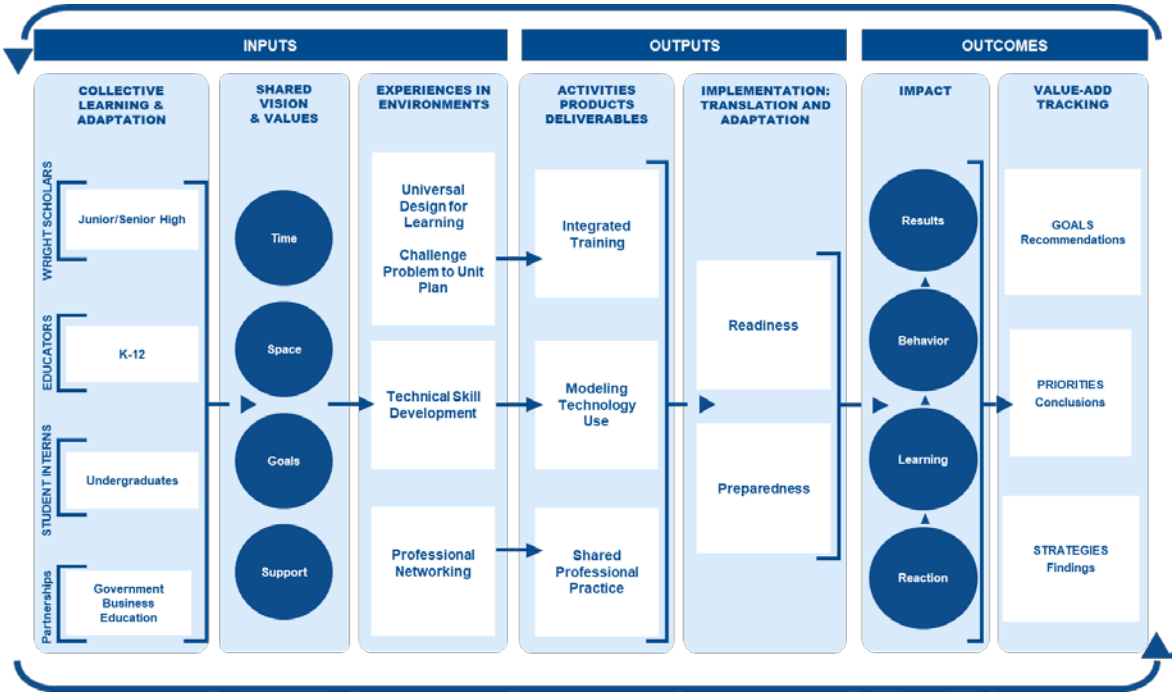

Figure 1. GRILL® STEM Instructional Program Assessment Model

Participants

Ten of the participants were Wright Scholars (two females, eight males, M_{age} = 17.1 years, age range: 16–18 years). Seven students were entering their senior year of high school, and three students were entering their freshman year of college in the fall.

Nine participants represented the educator-professional development program. Of those, six had returned from the previous summer, two were first-time attendees, and one did not return a demographic survey. As a whole, eight of nine participants completed a demographic survey (five females, three males, M_{age} = 43.75 years, age range: 34–64), their average years participating in the professional development program = 2.13 (SD = 2.03). Returning participants represented six school districts, (2/8) of educators reported STEM school designation, (1/8) reported undergoing the STEM designation process, and reported they didn't know or not applicable. All educators reported they worked full-

time as a teacher. They averaged 9.37 years teaching, 6.25 years at their current school, and 5.38 years' experience in STEM. For highest degree earned, (1/8) held a doctorate degree, (6/8) held a master's degree, and one reported "Other-Specialist." Returning educators reported an average of 475 hours in the summer program.

Six of the participants were student-interns (one female, five males, M_{age} = 22.2 years, age range: 18–27 years), (4/6) returned to the summer program or their internships extended throughout the year. In relation to career engagement activities, (1/4) reported they were actively job searching, (3/5) reported they anticipate working for the DoD, (1/4) in nonacademic faculty research, (2/4) for the government and (3/4) in industry. Upon graduation, (2/4) reported "yes" they were interested in pursuing further education in STEM, (1/4) reported "maybe", and (1/4) reported "yes/maybe." The main reasons for selecting the summer program were reported as follows: faculty/reputation (2/4), financial support (2/4), (1/4) program requirements, (4/4) job placement/networking, location/region (3/4), and (1/4) "other" work experience.

Materials and Procedure

A pre-program and post-program survey packet was administered for all learners (see Table 1, Flow of Data Collection [pre] and Table 2, Flow of Data Collection [post]). As a whole, the following surveys included all learner groups: demographics which contains detailed questions about background and experience, and summary of "top 3" and "bottom 3 events" is an open-ended survey that helps identify what events participants thought were most or least beneficial that occurred during the STEM instructional program.

Table 1. Flow of Data Collection for STEM Instructional Program (Pre-Program)

Wright Scholars	Educators	Student-Interns
Demographics	Demographics	Demographics
Expectations & Experiences	Previous Program Follow-up	Expectations & Objectives
Existing STEM Experiences	Expectations & Objectives	Technical Competencies

Table 2. Flow of Data Collection for STEM Instructional Program (Post-Program)

Wright Scholars	Educators	Student-Interns
Expectations & Experiences	Expectations & Objectives	Expectations & Objectives
Top 3 Learning Experiences	Top 3 and Bottom 3 Events	Top 3 and Bottom 3 Events
Top 3 Changes or Updates	Reactions	Reactions
Ratings of Knowledge and Competence	Program Reflection Questionnaire Program Follow-up (3 Month)	Program Reflection Questionnaire

RESULTS

Outcomes for Wright Scholars

One caveat important to present early in the Results section is that while the results are positive, the sample size is admittedly small and results should be interpreted within that context. Therefore, this limits the generalizability of the findings presented below. All ten Wright Scholar participants reported that they planned to or are currently attending college, and that they would all be pursuing a major in a STEM field. Participants rated the overall training quality of the summer program highly on a five-point scale (M = 4.70, ratings range: 4–5), which equates to a "Good to Excellent" rating. A majority of expectations were met 78.57% by the summer program (22/28 met) whereas 21.43% of expectations were not met (6/28). Table 3 contains a subset of open-ended feedback regarding how expectations were met or not met for participants. Participant ratings for the extent to which the summer program improved knowledge and competence ratings can be found in Table 4.

Table 3. Wright Scholar Expectations Responses

Expectation	Feedback	Expectations (Met / Not Met)
Hands-On Projects	Built a laser tag project with my own hands	Met
Hands-On Work	I worked on making PC and electronics parts	Met
Learn Computer Science	I expanded my programming knowledge over the summer	Met
Electrical Engineering	I didn't learn anything new although I already knew quite a bit	Not Met
Mechanical Engineering	We focused mostly on software aspects	Not Met
Robotics	My projects were focused on game development	Not Met

Participants reported that their top three learning experiences of the summer included such activities as: programming in Python, Visual C++, and Unreal Engine; designing, printing, and wiring Printed Circuit Boards (PCBs); working in a team environment; microelectronics design and development; STEM courses hosted by the Air Force Institute of Technology and the University of Cincinnati; troubleshooting hardware and software configurations; technical writing; and developing presentations. Wright Scholars also identified three changes or updates for the summer program. Responses centered around the following: earlier meetings with clients for setting project requirements; additional hands-on demos of projects; more extensive programming lessons; advanced hardware and software concepts; including additional classes beyond engineering and medical content; and grouping of teams based on skill level to avoid potential frustration. Table 5 presents the planned/actual academic majors for Wright Scholars after completing the summer program.

Table 4. Wright Scholar Ratings of Knowledge and Competence Improvements

Competency	*M*	Range
Software Development	3.30	2–5
Game Engine Development	3.10	1–5
3D Modeling and Simulation	3.20	2–5
3D Printing and Prototyping	2.40	1–5
Virtual Reality Technology	3.00	1–5
Augmented Reality Technology	2.20	1–5
Math and Logic	2.80	1–5
Microelectronics	2.80	1–5
Robotics	1.90	1–4
Technology Research and Evaluation	3.40	1–4
Mobile Device Development	1.50	1–4
Teamwork	4.80	4–5
Interpersonal Communication	4.30	3–5
Creating and Delivering a Presentation	4.40	3–5
Technical Writing	2.80	1–5
Time Management	3.30	2–5
Problem Solving	4.30	2–5
Creativity and Innovation	4.20	3–5
Organizational Skills	3.40	2–5
Analytical Skills and Critical Thinking	4.00	3–5

Note. Rating scale reflects magnitude of perceived improvement, from 1 (Not at All) to 5 (Very Large Extent). Item: "Rate the extent experiences improved your knowledge and competence in the following areas."

Table 5. Planned/Actual Academic Majors of Wright Scholars Reported at the Completion of the Summer Program

Academic Major	Frequency of Responses
Aerospace Engineering	2
Computer Engineering	3
Computer Science	1
Computer Science and Engineering	1
Electrical Engineering	1
Electrical Engineering and Astrophysics	1
Mechanical Engineering	1

Outcomes for Educators

All six educators who returned completed a previous program follow-up survey and reported that STEM activities had been institutionalized at their schools as a result of their 2017 participation and curriculum development. Activities included a course in C++ computer programming (high school), a game development course now offered as an elective at the high school, piloted modeling and simulation class and material used in two different classes (middle school), engineering and IT enrichment courses (6th grade), challenge problems integrated in K–12 and after school programs, a rocket unit incorporated in STEM & Physics courses, teaching a robotics course, autonomous rover and other challenges, and referring teachers to the GRILL® website for activities (high school). Educators listed institutional factors that enhance STEM integration efforts, including the utilization of program curriculum content, support from their administration to train and acquire new knowledge and skills in STEM, and available resources that enabled expanded teaching capabilities and more effective instruction for students. Additionally, they reported factors that have traditionally impeded STEM integration efforts in schools, such as educators being initially overwhelmed trying to create a STEM-focused lesson plan, identifying technologies and applications for inclusion in coursework, willingness and availability of mentors to support STEM initiatives at local schools, limited funding for the latest hardware and software, and time for learning integration and assessment of cutting-edge skills and technology. Along the same lines, all educators reported how they personally understood and measured impact and reported levels of student engagement, rubrics, community feedback, and end-of-semester course evaluation.

The program met all educator expectations (15/15 met), while (2/17) of objectives were not met. The top three themes that surfaced for educators included curriculum development, technical skill development, and professional networking. All the top events were in line with educator expectations and objectives. For example, they reported access to STEM professionals and collaboration with other learners provided valuable feedback and peer review relevant to implementation, i.e., how to integrate course material to fit the diverse needs of students. Exposure to unique technology applications prompted discussions as to the preparation required and quality of materials for utilization in the classroom. Perceived benefits were also inclusive of classroom activities and the importance of the professional learning community to exploring new possibilities and new ways of looking at problems that may have been overlooked before participation in the summer program. Educators reported bottom events related to the ability to have separate spaces for teachers and scholars due to the noise of the environment, minimal structure, the amount of work that can be done at home/being allowed to work off site, and follow-up resources.

Both educators and student-interns assessed the value and content of the program. As shown in Table 6, participants indicated their reactions were favorable

Table 6: Overall Educator and Student-Intern Reactions to GRILL® PD Program Average

Reactions Statement	Educator	Student-Interns
The program provided an appropriate level of challenge.	3.60	3.00
I was prepared for the type of experience I received in this program	4.00	3.00
I expected more from the program experience than was delivered.	1.00	1.80
I was given the opportunity to develop a network of STEM professionals.	4.00	3.40
I can routinely get the type of experience I had in this program through my occupational role or educational program.	1.80	1.40
I am satisfied with the level of support I received from the GRILL® community.	3.75	3.40
The GRILL® exposed me to unique applications of technology in the STEM field.	3.60	3.80
I would recommend this program to a colleague.	4.00	3.40
I am satisfied with the quality of the GRILL® summer program.	3.80	3.60

Note. Rating scale ranged from 1 (Strongly Disagree) to 4 (Strongly Agree). Item: "Rate the extent to which you agree or disagree with the statement."

For the program reflection survey, all educators (7/7) rated the 2018 program as "Excellent" on a four-point scale (poor to excellent). They also reported they would participate in the program again. When asked if anything about the experience surprised them, (6/7) said "No" and (1/7) said "Yes- the amount of support from the experts at the in the program and the knowledge shared from colleagues." Although the majority said "No", they still commented they were amazed at what high school students are able to accomplish in nine weeks, they knew what to expect from previous participation, and they knew what they wanted to accomplish. All educators reported they gained new skills as a result of their experience and specifically highlighted they were more adept with microcontrollers and circuitry, virtual reality, coding, robots, new technology like Raspberry Pi, building a computer, augmented reality, electrical engineering, and learning how to program and connect Arduinos to perform different tasks. All educators reported they intend to use a specific technology in future STEM curriculum directly based on their completion of the summer program. Upon completion of the program, all nine educators developed curriculum materials that were published as a result of the summer program. Educators characterized the program as having a positive influence on their teaching style, career, research plans, and that it reinforced their interests in STEM.

For the three-month, follow-up survey, all educators (5/5) reported they had implemented their 2018 project in the classroom. As shown in Table 7, participants used a four-point scale to respond to each item. Additionally, educators were given the opportunity to provide a rationale for their responses. Participants attributed the value of the research required to complete the deliverable and the ability to provide enhanced and differentiated lesson plans as improving their competitive professional profile (see Table 8 for materials developed). As it relates to satisfaction with the quality of the program, one educator reported that a lack of structure and leadership in comparison to previous years (i.e., having defined goals, a lead teacher and accountability) detracted from veteran educator focus and suggested that a return of previous structure may facilitate greater fulfilment. This survey also asked learners to identify what they have done differently as a result of professional development and what follow-up activities would be useful to continue professional growth. They reported the following changes in practice: more confidence to implement problem and challenge-based learning; time to research new technologies and develop content to implement them; access to expertise while trying to accomplish goals; and the ability to use unfamiliar technology. They reported the following desired activities: staying atop of the emerging trends and technologies; time and resources to implement them in the classroom; relationships with teachers; and professional development workshops during the academic year held at the GRILL®.

Table 7: Educator Average Rating 3 Month Program Follow-up

GRILL® PD Program Follow-up Statement	Rating n=5
In my organization, teachers receive adequate on-the-job support to make new practices part of daily practice.	3.00
I have motivated student interest in STEM, in particularly in modeling and simulation.	3.60
I have been able to implement my 2018 project into the classroom.	3.80
I believe the GRILL® Professional Development Program holds value in my competitive professional profile.	4.00
The curriculum I developed at the GRILL® serves a wide variety of student needs.	4.00
I am satisfied with the quality of the GRILL® Professional Development Program.	4.00
The time I've spent at the GRILL® has directly led to a positive change in my confidence integrating STEM into the classroom.	4.00
The GRILL® Professional Development Program met my needs.	4.00
The time I've spent at the GRILL® has had an impact upon the way I teach in the classroom.	4.00
The GRILL® effectively supports educators with implementing new skills and activities.	4.00

Note. Rating scale ranged from 1 (Strongly Disagree) to 4 (Strongly Agree). Item: "Rate the extent to which you agree or disagree with the statement."

Table 8: Educator 2018 Curriculum Materials Developed and Published by GRILL®

Grade Level	**Curriculum Materials Developed and Published by GRILL®**	**New Technology Encountered**	**New Skills Gained**	**Project Implemented 3-Month Follow-up n=5**
Elementary (K–5)	• Informational and opinion essay lessons: 3-5 language arts • Teacher template: Universal design for learning • CoSpaces Edu: virtual reality, 4–8 language arts	**Software** CoSpaces	Virtual Reality	N/A
Middle School (6–8)	• Course syllabus: Introduction to engineering design phase • ePortfolio template: Incorporating an ePortfolio in grade 8 social studies • Capstone project (course syllabus): Block coding and remote-controlled robots challenge	**Automation** Arduinos Ozobots **Software** Alice Python **Modeling** Tinkercad (3D printing)	Coding Robots Circuits Raspberry Pi Augmented Reality	3/9
High School (9–12)	• Implementation guide: Scientific research methods • Challenge problems and resources: Virtual escape room • Course syllabus and accompanying materials: Introduction to Arduino	**Networking** Hardware / software **Software** Tinkercad	Microcontrollers Circuitry Electricity Arduinos	2/9

Outcomes for Student Interns

All student-intern expectations (14/14) and objectives (14/14) were met. The top three themes regarding positive experiences obtained from the program were leadership development, technical skill development, and career development. Learners noted that they gained a better picture and perspective of the STEM discipline in terms of the opportunities available, necessary skill set, and different sub-disciplines within the field. All student interns reported their experiences increased their preparedness and sustained their motivation to pursue STEM. Five participants completed the technical competencies questionnaire (see Table 9. for technical competencies prior to the program). Top events were attributable to the variety of project requirements and goals, the structure of the program, and having access to resources and technology. For "bottom events", participants reported not enough time for projects to make good progress, unstructured time and lack of explicit tasks (reduced freedom to choose and minimal work accomplished), spending time on tutorials, the inability to apply the knowledge to relevant deliverables, disorganization and miscommunication that caused confusion, and the diversity of projects limited the ability of teams working together.

Table 9. Student Interns: Technical Competencies (Pre)

Modeling	Frequency / % (n = 5)
Blender	3 / 60%
SketchUp	1 / 20%
Autodesk Inventor	3 / 60%
SolidWorks	3 / 60%
Unreal Engine	0 / 0%
Unity 3D	0 / 0%
3DS Max	1 / 20%
Fusion 360	1 / 20%
Tinkercad	1 / 20%
AutoCAD	1 / 20%
Hardware	Frequency / % (n = 5)
Motherboards	1 / 20%
Graphics cards	1 / 20%
Hard Drives	1 / 20%
BIOS	1 / 20%
RAM	1 / 20%
Automation	Frequency / % (n = 5)
Raspberry Pi	3 / 60%
Arduino	4 / 80%
Database	Frequency / % (n = 5)
MYSQL	2 / 40%
Oracle	2 / 40%
MSSQL	0 / 0%
SQLite	1 / 20%
Other Tech. Comp.	Frequency / % (n = 5)
MATLAB	1 / 20%
Google	1 / 20%

For the program reflection survey, (4/6) rated the 2018 program as “Excellent” (2/6) rated the program as “Good” on a four-point scale (“Poor- Excellent”). All reported they would participate in the program again, and all interns reported they gained new skills or further developed new ones. Only one participant reported “Yes”, there was something about the experience that surprised them. They commented “How much basic programming the students have coming into the program.” All others (5/6) reported “No – I have past experience at the GRILL®, and I knew about the program from a previous scholar and it is exactly as described.” As a whole, participants reported “Yes” they would return to the program. One commented “I have enjoyed my past 3 summers here, my reasons for not returning would be due to other factors than the program itself.” In their own words, interns characterized program impact as confirming their desire pursue a computer science major, solidifying their interest in STEM, and affording the connections and experiences to set up multiple government service interviews.

Informational interviews surrounded usefulness of key components of the program (e.g., goal setting, choosing a strategy, executing and implementing strategy, using performance feedback, and analyzing and evaluating the use of data). Learners specifically noted the foundational level of exposure to research and technology where the scope of the material is sizeable. They reported that the ability to explore at their own pace makes the program unique. Furthermore, gearing learning toward real-world issues was beneficial as it exposed the sophistication and quality of the interactivity of the group. Pointing out elements of context, participants called out the role interpretation plays in how interventions are problematized as memorable. Altogether, learners believe the design of the program enhanced their ability to affect meaningful change in the context of practice. The integration of the three programs provided valuable insight into on-the-job behavior.

CONCLUSION

The goal of the pilot study was to explore the community impact of the STEM instructional program and gain a better understanding of the degree to which the three training group initiatives influenced engagement and establishing sustainable outcomes for generating a STEM pipeline. Although characteristics of the summer STEM instructional program varied in context depending on the learner group and utilized a fairly small sample size that limits the generalizability of findings, the positive emphasis of participants on the research project and developing leadership skills suggested strong compatibility between targeted participant needs and program goals. As a whole, participants alluded to the satisfaction achieved by enhancement of skill resources and learning opportunities. Specifically, the setup of the program to increase visibility working in and with diverse communities, demonstrated the alignment of resources and efforts necessary to build technical skills and industry acumen. Equally, the general arrangement and choice of material permitted learners to adjust challenges to their abilities and provided fresh insights and authentic practice experiences. As it relates to impact, the findings overall indicate participants appreciated the approach to design and gained significant value conducting their research activities.

All learning projects connected to real-world issues, problems and applications and afforded a broader perspective of theory, practice, and utilization in each group's academic and career field. Exposure to unique applications of technology in the STEM domain was a distinctive characteristic of the learning environment that refined professional practice and increased individuals' awareness, preparedness, and confidence in STEM. Given that the vast majority of participant expectations were met, it would seem that the utility of the program is fairly strong. However, areas of interest that were not met provides insight into activities that will potentially benefit or enhance program performance. Incorporating timelines and measures that will assess the effectiveness of those changes may bring about relevant increases in perceptions of relational and technological support.

Attending to factors lacking agreement or where summaries are inconsistent may reveal aims for a more complete and accurate picture of the experience. For example, where learners interpret system concepts as both connected and ill-defined, i.e., they are guided in part by conditions of self-discovery and a desire to be better informed, the action to enrich the sense of what is credible, suggestive, and applicable (as it relates to decision-making) may provide a better basis for added value. Referencing conditions that promote change, educators particularly noted that a lack of structure and leadership detracted from veteran educator focus. Improving the quality of educator interactions or establishing a model of "process productivity" may prove beneficial across the board. That is, Scholars also suggested that the potential to re-shuffle teams based on skill level and learning goals would avoid frustration. Adding to the dynamic, student interns noted that the diversity of projects limited the ability of teams to work together. With the goal to rationalize career development by clearly defined outcomes measurements, i.e., in reference to standards and appropriate practices, operational practices might require a stronger emphasis, translating values to behaviors. Interestingly, the highest ratings for knowledge and competence gains for the Wright Scholars included such organizational skills such as teamwork, interpersonal communication, creating and delivering a presentation, problem solving, creativity and innovation, and critical thinking. Given that Wright Scholars are typically very motivated and successful students, they may already have access to or have actively sought-out STEM experiences. Moreover, the quality of evidence suggests, opportunity exists to help drive and define students' current and future motivational engagement tendencies through stronger mentoring relationships. To bring about refinement, good mentoring practices will account for connections among particular elements, eventually bearing on successful transition into envisioned careers.

One of the most desirable aspects of the program centered on the opportunity to work in an integrative environment with numerous hands-on STEM experiences and activities. Open-ended feedback indicated that building things with

their own hands with goals and deadlines, competing a project from scratch, and understanding the basics of design, implementation, and troubleshooting were some of the most important components of the program.

All participants reported they interpreted deliverables (projects) as concrete representations of learning and those experiences gained in the program led to a direct sense of achievement. Equally, building a STEM identity was motivating and perceived as beneficial. Striking the right balance between quality and productivity, educators reported that challenge is self-induced; the program allows them to challenge themselves where they see necessary and seeing what others do evoke renewed challenge and enthusiasm. A key lesson to be learned or understood is promoting and developing effective collaboration requires anticipating and creating needs which are also reliable indicators for broadening access to STEM experiences and pathways. To cultivate both a willingness to be vulnerable and a commitment to capture the contribution, will ensure legitimacy in the applied learning approach. Ensuring sustainable solutions, responding to expressed preferences will spotlight opportunities for innovation and required drivers for achievement goal orientations and identity formation styles. In accordance with a definite plan, transparency of role context and situations for respective groups will set the stage to accelerate the transparency of measurable progress in reasonable time.

In closing, researchers examined Kirkpatrick Level 1 reactions, whether participants enjoyed the training and the extent to which they believed it was relevant and useful. This effort also revealed the efficacy of data collection processes, reporting, and tracking procedures. Looking at the successes and improvements needed, many lessons can be learned. For more accurate and insightful data, scaling up the survey suite is essential. To increase effectiveness in evaluating the training program, the aim should be to streamline processes and techniques to select, share, and implement measures. Utilizing and expanding partnerships to craft strategic and meaningful learning progression requires confidence in supportive conditions. Altogether, integrated innovation from the view relationship imparts the strategic payoffs the STEM community desires. Examining the full impact of programming on learners' academic and career paths within STEM fields is an ongoing initiative. A longitudinal study attempting to track Wright Scholar alumni's academic and career paths within the STEM domains is being planned. Identifying additional data streams and constructs of interest for the Wright Scholar, educator and student-intern participant samples over the career continuum is key effort to ensure maximum success of future training and professional development content of the various programs.

REFERENCES

Constan & Spicer (2015). Maximizing future potential in physics and STEM: Evaluating a summer program through a partnership between science outreach and education research. *Journal of Higher Education Outreach and Engagement, 19*(2), 117-136.

Dogan, S. Tatik, R.S. & Yurtseven, N. (2017). Professional learning communities' assessment: Adaptation, internal validity, and multidimensional model testing in turkish context. *Educational sciences: Theory & Practice, 17*(4), 1203–1229.

Dunn, C., Shannon, D., McCullough, Jenda, O., Quazi, M. (2018). An innovative postsecondary education program for students with disabilities in STEM (Practice Brief). *Journal of Postsecondary Education and Disability, 31* (1), 91–101.

Erdogan, N. & Stuessy, C. L. (2015). Modeling successful STEM high schools in the United States: An ecology framework. International Journal of Education in Mathematics, Science and Technology, 3(1), 77-92.

Harackiewicz, J.M., Canning, E.A., Tibbetts, Y., Priniski, S.J., & Hyde, J.S. (2016). Closing Achievement gaps with a utility-value intervention: Disentangling race and social class. *Journal of Personality and Social Psychology, 111*(5), 745–765.

Lam, C., Y., & Shulha, L., M. (2015). Insights on using developmental evaluation for innovating: A case study on the cocreation of an innovative program. *American Journal of Evaluation, 36*(3), 358-374.

Lynch, S. J., Behrend, T., Burton, E. P., & Means, B. (2013, April). Inclusive STEM-focused high schools: STEM education policy and opportunity structures. Paper presented at the annual conference of National Association for Research in Science Teaching (NARST), Rio Grande, Puerto Rico.

Kirkpatrick, D.L. (1979). Techniques for evaluating training programs. *Training and Development Journal*, 78–92.

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. Improving Schools, 19(3), 267–277.

Reider, Knestis, & Malyn-Smith (2016). Workforce education models for K-12 STEM education programs:

Reflections on, and implications for, the NSF ITEST program. Journal of Scientific Education Technology, 25, 847–858.

Urias, D., Gallagher, P., & Wartman, J. (2012). Critical features and value in assessing a research experience for undergraduates: The case of engineering cities. Journal of STEM Education: Innovations & Research, 13(1), 30–42.