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Increasing Teaching Efficacy in Engineering Graduate Students through the Development and Facilitation of Summer Middle and High School STEM Experience

Dr. Jamie R. Gurganus, University of Maryland, Baltimore County

Dr. Jamie Gurganus is a faculty member in the Engineering and Computing Education Program. She is the Associate Director STEMed Research in the College of Engineering and Information Technology (COEIT). She also serves as the Director for the Center for the Integration of Research, Teaching and Learning (CIRTL) in the graduate school. Her research is focused on solving problems relating to educating and developing engineers, teachers (future faculty), and the community at all levels (k12, undergraduate, graduate, post-graduate and internationally). A few of these key areas include engineering identity and mindsets, global competencies, failure culture, first year experiences in engineering, capstone design thinking, integrating service and authentic learning into the engineering classroom, implementing new instructional methodologies, and design optimization using traditional and non-traditional manufacturing. She seeks to identify best practices and develop assessments methods that assist in optimizing computing and engineering learning. Dr. Gurganus was one the inaugural award winners of the Diane M. Lee teaching award in 2021 and received an Exemplary Mentor Award from the Center for Women in Technology in 2022. She earned a virtual mobility Erasmus+ grant in 2023 to continue global engineering work and connection with University of Porto and Universidad Católica Portuguesa where she was invited to serve on their advisory board. This work also expands to Germany where she is creating a Global Engineering Certificate in collaboration with Hochschule Bonn-Rhein-Sieg (H-BRS). She also received the Northern Maryland Technology Council Leader Award in STEM education in 2019. She has written curricula and published a number of works in engineering education in both higher education, P12 and international spaces. She is a co-founder and the Director of Innovation Programs and Operations for the non-profit research group, Advancing Engineering Excellence in P-12 Engineering Education and has launched PROMISE Engineering Institute Global, for international future faculty development. Dr. Gurganus teaches several first and second year Engineering classes along with the Mechanical and Multidisciplinary Engineering Senior Capstone design courses at UMBC. She is also leading and redeveloping a Global Engineering elective. She has also served as this year's Program Chair for the Pre-College division and on the task force for Weaving in students versus weaving them out with the President of ASEE. This year she was elected as a team leader for CRITL national and the Editorial Board for the Engineering Education Review an International Journal.

Michael M. Malschützky, Hochschule Bonn-Rhein-Sieg, Germany

Michael M. Malschützky is a Research Associate at the Centre for Teaching Development and Innovation (ZIEL) as well as Affiliate Faculty at the Department of Management Sciences at Hochschule Bonn-Rhein-Sieg, University of Applied Sciences (H-BRS), Germany. He received his Diplom-Ingenieur (FH) in Mechanical Engineering from H-BRS in 2005. After working as Test & Validation Engineer (TIER-1) and Program Management Engineer (OEM) in the automotive industry, he returned to academia in 2013, receiving his BSc (2017) and MSc (2023) in Business Psychology from H-BRS.

Dr. Neha B. Raikar, University of Maryland, Baltimore County

Dr. Raikar is a Senior Lecturer at the University of Maryland, Baltimore County in the Chemical, Biochemical, and Environmental Engineering department. She has taught both undergraduate and graduate-level courses. Dr. Raikar also has 3 years of industry experience from working at Unilever Research in the Netherlands.

Mrs. Yarazeth Medina, University of Maryland, Baltimore County

Multidisciplinary research interests aimed to diversify and increment access to higher education. Research interests focus on bringing the disparity of availability of information that improves programs that enforce participation in science, engineering, and technology.

Increasing Teaching Efficacy in Engineering Graduate Students through the Development and Facilitation of Summer Middle and High School STEM Experience

1. Introduction

As STEM education progresses, so too should the approach to graduate professional development. It is crucial to define and cultivate students' needs through creative and authentic experiences that offer both personal growth and tangible impact. This means providing unique pathways for professional development.

There is extensive research on the necessity to revamp teaching and learning in undergraduate STEM courses, as well as abundant literature on implementing best practices [1], [2], [3], [4]. However, there remains a persistent need to emphasize the importance and equilibrium of training future faculty in teaching and learning methodologies. Transforming both the classrooms and provide quality professional development to graduate students, necessitates a fundamental shift in instructional approaches, transitioning from a traditional information-dissemination and typical graduate experiences.

Faculty responsibilities encompass research, teaching, and service, but it's crucial to establish connections and involvement with the community and beyond. O'Meara and Jager [5] emphasizes that doctoral and research universities, along with their faculty, bear the duty of upholding public trust and ensuring that research is meaningful and impactful for individuals both within and outside academic circles. The authors stress "becoming engaged in communities is ensuring that institutions, their faculty, and their students are prepared with the skills necessary for their work with the public." This value of community engagement has even been highlighted in many funding agencies. More notably, NSF Faculty Early Career Development Program (CAREER) [6], states three important criteria to include:

> *1) performance of innovative research at the frontiers of science, engineering, and technology that is relevant to the mission of the sponsoring organization or agency,*
>
> *2) community service demonstrated through scientific leadership, education or community outreach, and*
>
> *3) commitment to STEM equity, diversity, accessibility, and/or inclusion.*
>
> *These awards foster innovative developments in science and technology, increase awareness of careers in science and engineering, give recognition to the scientific missions of the participating agencies, enhance connections between fundamental research and national goals, and highlight the importance of science and technology for the Nation's future.*

To enhance the graduate student experience in engineering and development and offer unconventional avenues to prepare for future roles as faculty members in higher education, a collaboration formed between three programs at a minority-serving institution: a middle/high school (MHS) summer experience, the graduate school through University of Maryland, Baltimore County (UMBC), and UMBC's College of Engineering and Information Technology (COEIT). Together, these three groups established an innovative fellowship opportunity focused on advancing scholarly research, teaching, and learning as well as graduate student career preparation. Departing from traditional training methods, this innovative professional development program aims to involve engineering graduate students in crafting evidence-based lesson plans for MHS summer programming. Drawing inspiration from the most effective approaches in both higher education and P12 settings, this initiative also fosters an understanding of how to effectively interact with both the community and their respective academic disciplines. Through this fellowship, graduate students are afforded the exceptional chance to serve as lead instructors for the lesson plans, they themselves have developed.

This research will present a how a unique professional development with graduate students engaging the P12 space increases the teaching self-efficacy. The STEM Graduate Teaching Assistant, Teaching Self-Efficacy Scale (STEM GTA-TSES), a validated tool, was utilized [7].

2. Background

2.1. Need for providing PD in the scholarship of research, teaching and learning

While it is broadly expected for doctoral students to be prepared to join academic environments, college campuses focus more on attaining and advancing content knowledge for graduate students while teaching is disseminating knowledge to students. Graduate students have the opportunity to deliver content to students but don't usually undergo formal training on how students learn or the difficulties they might encounter (learning spectrums, abilities, and limitations).

To train better future faculty, higher education must work to formally provide them with information and training on teaching techniques, how to facilitate an inclusive learning environment, teaching students with different abilities or learning preferences, etc. According to a study done in Purdue University, graduate students who have had opportunities to teach their peers formally are more likely to finish their PhDs promptly and find a position in a higher education institution after graduation [8], [9], [10].

2.2. UMBC's CIRTL and SEA

In pursuit of teaching and innovation excellence, UMBC joined the Center for the Integration of Research, Teaching, and Learning (CIRTL) as a member in 2016. This program, situated within the graduate school, constitutes a key component of the university's future faculty development initiatives.

The Summer Enrichment Academy (SEA), housed in UMBC's Department of Professional Studies, brings exposure to up to 500 or more middle and high school students providing college experiences and opportunities in science, engineering, technology, the arts and humanities, all led by UMBC faculty, industry professionals and graduate students.

This includes:

- *offers unique, fun, challenging and mind-expanding academic summer workshops and camp programs for middle school and high school students that can't be found anywhere else.*
- *Rigorous, engaging, 1 week summer workshops and camp programs are designed to spark our students' deepest passions and interests.*

In 2022, SEA and UMBC CIRTL, partnered to formulate a new program offering graduate students, SEA-CIRTL Fellows, an opportunity to both earn their Associate and Practitioner level certifications through developing a weeklong experience in their respective disciplines. The first cohort was launched in November 2022 lasting until June 2023. Each SEA-CIRTL Fellow facilitated a week-long experience they developed.

2.3. SEA-CIRTL 9-month activity Program Description

Implementation of the Program and Professional Development Activities.

The project's initiation phase involves soliciting course proposals from graduate students, who are encouraged to design a 1-week summer course centered around their field of expertise, aimed at either high school or middle school students. In the first year of this initiative, 7 course ideas were selected for the summer session, from a pool of 55 applicants, with 6 ultimately being developed into full courses. In the second (current) year, 88 applicants applied and 11 course ideas have been selected and scheduled for rollout in the Summer of 2024.

The detailed implementation workflow is outlined below:

Call for Proposals (September):

- Graduate students submit their ideas for a summer course that aligns with their area of expertise, targeting either high school or middle school students.
- The committee reads through each application providing feedback and rating on the feasibility of each of the candidate's ideas and their applications. The committee consists of the Director and Program Coordinator of both SEA and CIRTL, and the Associate Vice Provost and Associate Director for Professional Development Programs

Selection and Finalization (October - December):

- Ideas are selected for development from the submitted proposals. The Program Coordinator of SEA-CIRTL and Director of SEA mentor the students to refine their ideas into finalized courses based on the feedback from the team which are then ready for advertising.

Course Description Development (December- January):

- The selected proposals are developed into detailed course descriptions. These descriptions are crafted to be engaging and informative, aimed at attracting prospective students. They are then published on the Summer Enrichment Academy website https://instituteofextendedlearning.umbc.edu/summer-enrichment-academy/.

Professional Development Activities (January - June):

- As part of the program, participants engage in various professional development activities to enhance their teaching and engagement skills. For the first cohort, these included:
  - Designing effective courses
  - Developing lesson plans
  - Implementing instructional strategies (lectures, discussions, labs, case studies)
  - Engaging students and promoting active learning through FDC workshops
  - Classroom management techniques

Deployment of Summer Enrichment Experience (June-July)

- Graduate students facilitate their developed activities in a weeklong experience in the summer in the months of June and July. Many of them will have an undergraduate assistant throughout the experience to help with setup and coordination throughout the week.

Workshops and Meetings:

- Workshops led by faculty and staff experts provide further training and support. Additionally, regular check-in meetings with the Program Coordinator and the Director of the Summer Academy ensure ongoing guidance and feedback.

Certification:

- Upon completing the program, fellows receive a certificate from a nationally recognized organization, affirming their participation and achievement in this innovative educational initiative.

This structured approach to implementing the project ensures a blend of rigor and engaging content aimed at fostering interest in STEM fields among younger students. Through professional development activities and expert-led workshops, graduate students are equipped to deliver high-quality educational experiences, contributing to the broader goal of promoting STEM education.

2.4. Sample Program Descriptions developed and created by graduate students.

The initial Cohort in 2022-2023 comprised 6 graduate students each from the College of Engineering and Information Technology (COEIT). Below are two course descriptions. Further information can be found here https://gspd.umbc.edu/sea-cirtl-fellows. Samples include one in computing and one in engineering.

Course Detail: ELEC103 - ELECTRICAL ENGINEERING: OPTICAL EFFECTS AROUND US: (High School) IN-PERSON

ELECTRICAL ENGINEERING: OPTICAL EFFECTS AROUND US: Optics in engineering are used every day in grocery stores, airports, cameras, wearable tech, cars, and homes. How does light interact with matter? What is the source of color? What is the difference between coherent and incoherent light? This course will answer these questions and many more. Optical effects from the electrical engineering perspective are rooted in physics, and this class will spark your curiosity and appetite to learn more about the concepts of Optics. The course will be an experiential learning platform, provide insight and offer a practical introduction of how to appreciate the numerous applications of optics around you.

Students will learn and appreciate:

- Some of the optical effects applications around us, like scanners at the shopping mall, airports, homes, and cars
- The difference between coherent and incoherent lights
- Components used in optical experiments, like Laser, amplifiers, mirrors, beam splitters, photodetectors, half-wave plates, Optical spectrum analyzers, IRIS, and many more.
- Day visit to a real optical training lab and observe essential safety measures in operating a laser system
- Hands-on demonstration of some cool optical experiments, e.g. nanostructure behaviors under laser lights
- Opportunity to meet an expert and a legend in optics.

Course Detail: ETHC104 - ETHICAL HACKING: (Middle & High School) IN-PERSON

ETHICAL HACKING: Want to become an Ethical Hacker? Learn to hack like a black hat and secure like a white hat hacker. Ethical hacking is a practice of detecting vulnerabilities in an application, system, or organization's infrastructure and bypassing system security to identify potential data breaches and threats in a network. This beginner-friendly course acts as a launch pad for your cybersecurity career and aims to walk you through the basic concepts of ethical hacking. This 15hr course is specially curated for students to enhance their knowledge of real cyber threats and other vital aspects of hacking, defending themselves in today's advanced Digital World. This course comprises the latest methodologies of ethical hacking and system penetration, giving a hands-on experience to the students on the latest hacking tools, techniques, and real-time case studies, which makes the student feel like a cyber ninja.

Topics covered during this course are:

- Linux fundamentals
- Information gathering and footprinting
- Email Attacks, Phishing, and how to protect yourself
- Basics of Network Security
- Web Application Security
- Wireless Attacks and Security
- Mobile Attacks and Security

3. Methodology

Using the Teaching Self-Efficacy Scale [7], a validated instrument, students from two cohorts were asked to complete the survey via email in January 2024. Cohort 1 participants consisted of individuals who completed the training and facilitated a summer 2023 experience. Cohort 2 participants are graduate students who were selected to participate in the professional development in 2024 and will be facilitating a summer 2024 experience.

As a case study analysis, sending out surveys at the end of cohort 1 and the beginning of cohort 2 allows comparison between both cohorts. Despite a cross-sectional approach, this allows to assess the assumption that cohort 1 shows in mean higher values auf teaching self-efficacy after training and teaching experience compared to cohort 2 which has not been fully trained and performed a teaching experience, yet.

3.1. Description of Teaching Self-Efficacy Scale (STEM GTA-TSES)

The STEM graduate teaching assistants (STEM GTAs) Teaching Self-Efficacy Scale (STEM GTA-TSES, short GTA-TSES) consists of 18 items. Based on the used items' response format (six-point Likert scale with the anchors 1= no confidence to 6= complete confidence), higher scale values imply higher values of self-efficacy. Exploratory and confirmatory factor-analyses showed that these items build two subscales, self-efficacy for instructional strategies and self-efficacy for the learning environment, explaining 45.86 % of the GTA-TSES' variance. The Instructional Self-Efficacy (ISE) dimension relates to activities needed to prepare and teach a class, e.g., "Prepare the teaching materials I will use?". The seven related items show the reliability of Cronbach's $\alpha = .85$. The Learning Self-Efficacy (LSE) dimension covers teaching activities regarding promoting and providing an active, positive, and respectful classroom environment, e.g., "Encourage the students to interact with each other?". The 11 related items show a reliability of Cronbach's $\alpha = .90$. [7]

3.2. Data Analysis

Statistical analyses in this contribution were performed in SPSS [11], jamovi [12] and R [13]. In general, robust approaches of inferential statistical analyses were performed, preventing inflation of type-1-error-rate or loss of test-power, although data might be non-normal distributed or compared groups show unequal variances. According to the hypothesis, statistical tests were performed one-tailed.

3.3. Demographics

A total $N = 16$ UMBC students from College of Engineering and Information Technology (COEIT) and College of Natural and Mathematical Sciences (CNMS) responded to the survey during two different cohorts.

The first cohort, 2022-2023, consists of $n = 5$ respondents of six participants and the second one 2023-2024 of $n = 11$. Details regarding the participants' national background including ethnical affiliation, gender, graduate status, and college affiliation across the two cohorts are shown in Table 1. Multiple two-tailed exact Fisher-tests did not show any structural difference between the two cohorts between gender ($p_F = 1.00$), nationality ($p_F = 1.00$), graduation status ($p_F = 1.00$), or college affiliation ($p_F = .245$).

Table 1
Demographics of participants

		Cohort	
		2022-2023	**2023-2024**
Gender	Male	2 (40 %)	4 (36.4 %)
	Female	3 (60 %)	7 (63.6 %)
Nationality	US citizen	2 (40 %)	6 (54.5 %)
	African/Black American	*2 (100 %)*	*1 (16.7 %)*
	Asian & Pacific American	*0*	*2 (33.3 %)*
	White American	*0*	*3 (50 %)*
	Foreign on student visa	3 (60 %)	5 (45.5 %)
	African/Black American	*0*	*1 (20 %)*
	Asian & Pacific American	*1 (33.3 %)*	*1 (20 %)*
	Indian/Asian	*0*	*1 (20 %)*
	Not specified	*2 (66.7 %)*	*2 (40 %)*
Graduation status	Masters	3 (60 %)	6 (54.5 %)
	PhD	2 (40 %)	5 (45.5 %)
College	COEIT	5 (100 %)	7 (63.6 %)
	CNMS	0	4 (36.4 %)

Note. Values show absolute frequencies. Values in brackets show relative frequencies related to sub-sample size. Italic values in brackets show relative frequencies related to superordinated nationality

4. Results from the study

4.1. Initial Preliminary Results from the Professional Development Cohort 1

To gain more insight into the professional development process and how the students felt after completing the program, the team asked the graduate students to provide feedback on the program from (1= poor to 5= excellent). Out of 6 participants, only 4 responded. They were further asked about the ‘usefulness’ of each development topic (1= not useful, 5= very useful), see Table 2.

Overall, the students expressed high level of satisfaction with various aspects of the program, including the call for participation, the selection process, the program's kickoff, the abstract development process, the professional development sessions, the course delivery, and the overall project management.

Table 2 *The professional development process*

Item	Overall Rating	
	Absolute Score	Percentage
Professional development sessions	(1= poor to 5= excellent)	
Call for participation, selection process, and kickoff	4.5	90 %
Abstract development process	5	100 %
Professional development sessions	5	100 %
Delivery of the SEA-CIRTL course	5	100 %
Overall project management	4.5	90 %
Topics in Session - Usefulness	(1= not useful, 5= very useful)	
Design your course	5	100 %
Lesson Plan Development	5	100 %
Effective instructional strategies (lectures, discussions, labs, studios, case studies	5	100 %
Engaging Students, promoting learning	5	100 %
Classroom Management	4.5	90 %

4.2. STEM GTA-TSES Item analysis to validate survey with new sample

4.2.1. Item-difficulties

The item-difficulty *P(i)* of an item *i* is a numerical value between 0 and 1 that indicates the probability of agreeing or disagreeing with the statement of the item *i*. Therefore, an item-difficulty of *P(i)* = 0.5 shows the highest variability in response behavior. The performance of items with difficulties below 0.2 or above 0.8 is usually not sufficient to differentiate between participants [14], [15]. Table 3 gives an overview across the item-difficulties of the two sub-scale and the whole GTA-TSES.

Table 3
Sub-scale item-difficulties statistics

(Sub-)Scale	Number of items	*Min P(i)*	*Max P(i)*	*M P(i)*	*SD P(i)*	*Md P(i)*
LSE	11	.84	.98	.89	.05	.88
ISE	7	.79	.95	.89	.05	.90
GTA-TSES	18	.79	.98	.89	.05	.89

Note. Min P(i) = minimum of item-difficulty range. *Max P(i)* = maximum of item-difficulty range. *M P(i)* = mean of item-difficulty. *SD P(i)* = standard deviation of item-difficulty. *Md P(i)* = median of item-difficulty.

In result, only one item (V13), with item-difficulty *P*(13) = .79, is in the desired value-range to differentiate between participants. The other items are agreed to unilaterally throughout, meaning that all participants show very high ratings in teaching self-efficacy.

4.2.2. Corrected item-total correlations

The part-whole-corrected item-total correlation *r(i,total-i)* of an item *i* indicates how much the item *i* measures the same psychological construct as the other items combined *(total-i)*. Values between 0.4 and 0.7 are preferred [15]. Table 4 gives an overview of item-total correlations of the 18 items taking the sub-scales and the aggregate scale into account.

Table 4
Corrected item-total correlation for sub-scale and total GTA-TSES value

(Sub-)Scale	***r(i,total-i)* rating: Number of items…** below range	in range	above range	*M*	*SD*	*Min*	*Max*
LSE	0	2	9	.78	.09	.60	.87
ISE	1	2	4	.66	.19	.28	.86
GTA-TSES	1	3	14	.75	.17	.21	.90

Note. r(i,total-i) = part-whole-corrected item-total correlation. *M* = mean of *r(i,total-i)*. *SD* = standard deviation of *r(i,total-i)*. *Min* = minimum of *r(i,total-i)*. *Max* = maximum of *r(i,total-i)*.

Depending on the analyzed (sub-)scale, only 2 to 3 items are in the value range of preferred part-whole-corrected item-total correlation. Most of the items show values above the upper threshold.

4.3. STEM GTA-TSES Scale Assessments

Table 5 shows the results of the scale analyses of the two subscales *Learning Self-Efficacy* (LSE) and *Instructional Self-Efficacy* (ISE) and the resulting total scale (GTA-TSES). The analysis contains the descriptive values of the participants responses across both cohorts, the Pearson's product-moment-correlation between the two subscales as well as the total scale, and the (sub-)scale reliabilities.

Table 5
(Sub-)scales' descriptive values, inter-scale correlations, and reliabilities

(Sub-)Scale	Group	n	M	SD	Md	Min	Max	(1)	(2)	(3)
(1) LSE	Total	16	5.44	0.72	5.73	3.18	6.00	(.94)		
	Cohort 1	5	5.80	0.24	5.91	5.36	5.91			
	Cohort 2	11	5.28	0.82	5.73	3.18	6.00			
(2) ISE	Total	16	5.45	0.63	5.57	3.43	6.00	.95***	(.86)	
	Cohort 1	5	5.66	0.22	5.71	5.43	5.86			
	Cohort 2	11	5.35	0.74	5.57	3.43	6.00			
(3) GTA-TSES	Total	16	5.44	0.68	5.72	3.28	6.00	.99***	.98***	(.96)
	Cohort 1	5	5.74	0.21	5.83	5.39	5.89			
	Cohort 2	11	5.31	0.78	5.56	3.28	6.00			

Note. n = sample size. *M* = mean, *SD* = standard deviation. values in brackets show sub-scales' reliability in Cronbach's Alpha. values below diagonal show Pearson's product moment correlation. * $p < .05$, ** $p < .01$, *** $p < .001$

The descriptive values show unexpected high values of self-efficacy, especially in cohort 1. This is particularly clear from the very high scales' minimum, e.g., GTA-TSES(cohort 1) = 5.39, and median, e.g., GTA-TSES(cohort 1) = 5.83, on the used Likert-scale from 1 to 6.

The correlation analysis of the resulting sub-scales and total scale shows a large association between the two sub-scales [16]. This is matching the reported two-level structure of LSE and ISE as first-order factors, building the total GTA-TSES as a second-order factor. However, the observed correlation of $r = .95$ between the subscales is much higher than the reported one in the tool development report [7].

The reliability of the two-subscales are higher, but comparable to the reported one's in the tool development report [7]. Both sub-scales exceed the desired minimum value of 0.7 [14], [15].

4.4. Analysis of TSES related group differences between cohorts

Based on the small sample size, expected non-normal distribution in the dependent variables, and unequal group-sizes, respectively non-exchangeability between the compared groups, the comparison between cohort 1 and cohort 2 were performed by a Brunner-Munzel test in jamovi [17]. The BM-test were performed with full permutation approach [17], [18] and due to the different point of time of the GTAs' development one-tailed.

Cohort 1 tends to show higher self-efficacy values in the sub-scale *learning environment* ($BM_{fp} = -2.35$, $p = .037$). The probability that a random cohort 1 GTA shows less *Learning Self-Efficacy* than a random cohort 2 GTA is $\hat{p} = 19$ %, splitting ties evenly. Regarding sub-scale *instructional strategies* ($BM_{fp} = -0.55$, p = .288) and the *total GTA-TSES* ($BM_{fp} = -1.60$, $p = .074$) the self-efficacy values of both cohorts were comparable. Splitting ties equally, the probability that a random cohort 1 GTA shows less *Instructional Self-Efficacy* than a random cohort 2 GTA is $\hat{p} = 42$ %, respectively $\hat{p} = 27$ % that a random cohort 1 GTA shows less *total Teaching Self-Efficacy*.

4.5. Preliminary feedback evaluation of middle and high school students who participated in SEA

Although this research did not include a richer investigation of the SEA participants' (summer program middle and high school students) feedback, results from that experience in the summer of 2023 highlighted their positive experiences and high levels of engagement. During summer 2023, in total $N = 281$ pupils participated in UMBC's SEA program, covering 35 different week-long activities. 66.1 % of the pupils visited a high school ($n = 186$), 33.9 % ($n = 95$) a middle school. 26 activities were led by professional instructors, 6 by SEA-CIRTL GTAs, and 3 by untrained GTAs who did not get to participate in the course development exercise, feedback, or professional development sessions. The participants rated their activities' instructor on a single item scale from 1= overall dissatisfaction with instructor to 5= very satisfied with instructor.

An one-factorial ANOVA showed significant differences ($F_{Welch}(2, 7.51) = 34.01$, $p < .001$) in the performance of professional instructors, SEA-CIRTL GTAs and untrained GTAs. Games-Howell post-hoc tests showed that SEA-CRITL GTAs ($M = 4.46$, $SD = 0.17$, $Min = 4.25$, $Max = 4.67$) performed as well ($p_{GH} = .063$) as professional instructors ($M = 4.69$, $SD = 0.27$, $Min = 4.00$, $Max = 5.00$) but significantly better ($p_{GH} = .005$) then untrained GTAs ($M = 4.00$, $SD = 0.11$, $Min = 3.89$, $Max = 4.10$).

Figure 1 shows the performance ratings' differences between the three instructor types indicating the potential benefits of the SEA-CIRTL fellows program.

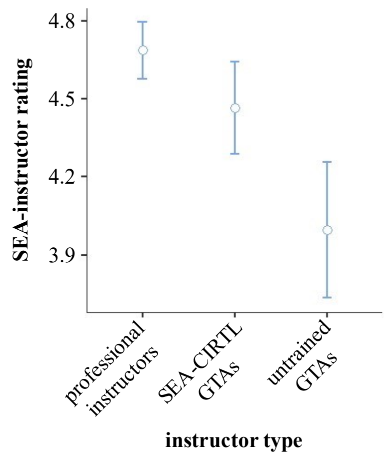

Figure 1. Mean and 95 % CI of SEA-participants' instructor rating by instructor type

5. Discussion and Future work

Although both cohorts showed high confidence their abilities to teach and create curriculum, Cohort 1 demonstrated significantly higher in GTA-TSES values in the Learning Self-Efficacy. Descriptively, they demonstrate higher confidence in their instructional strategies, too. However, the later difference was not statistically significant, which can be caused in the small sample size. Further, SEA participants' feedback showed that cohort 1 GTAs received equal satisfaction values as professional instructors and significant higher ratings than untrained GTAs.

Limitations of this study include the lack of pre-assessment data in Cohort 1. Ongoing collection with Cohort 2 will include a post evaluation to determine growth in their teaching and learning, to improve test-power. Further, Cohort 1 peers are acting as mentors to Cohort 2. Providing learned experiences to their peers and additional help with their curriculum development.

References

[1] L. W. Anderson and D. R. Krathwohl, Eds., *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*, Complete ed. New York: Longman, 2001.

[2] National Research Council (U.S.), S. R. Singer, N. Nielsen, and H. A. Schweingruber, Eds., *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*. Washington, D.C: The National Academies Press, 2012.

[3] Association of American Universities, "Undergraduate STEM Education Initiative." Accessed: Feb. 08, 2024. [Online]. Available: https://stemedhub.org/groups/aau

[4] American Association for the Advancement of Science (AAAS), "Vision and Change in Undergraduate Biology Education a Call to Action." 2009.

[5] K. O’Meara and A. J. Jaeger, “Preparing Future Faculty for Community Engagement: Barriers, Facilitators, Models, and Recommendations,” *J. High. Educ. Outreach Engagem.*, vol. 11, no. 4, pp. 3–26, 2006.

[6] NSF - National Science Foundation, “Faculty Early Career Development Program (CAREER),” Funding at NSF. Accessed: Apr. 01, 2024. [Online]. Available: https://new.nsf.gov/funding/opportunities/faculty-early-career-development-program-career

[7] S. E. DeChenne, L. G. Enochs, and M. Needham, “Science, technology, engineering, and mathematics graduate teaching assistants teaching self-efficacy,” *J. Scholarsh. Teach. Learn.*, vol. 12, no. 4, pp. 102–123, 2012.

[8] M. Richards-Babb, J. H. Penn, and M. Withers, “Results of a Practicum Offering Teaching-Focused Graduate Student Professional Development,” *J. Chem. Educ.*, vol. 91, no. 11, pp. 1867–1873, Nov. 2014, doi: 10.1021/ed500134d.

[9] S. Rizzolo, A. R. DeForest, D. A. DeCino, M. Strear, and S. Landram, “Graduate Student Perceptions and Experiences of Professional Development Activities,” *J. Career Dev.*, vol. 43, no. 3, pp. 195–210, Jun. 2016, doi: 10.1177/0894845315587967.

[10] S. M. Skelly, T. C. Kohlleppel, M. E. Kane, and J. C. Bradley, “Professional Development for Graduate Students,” *NACTA J.*, vol. 46, no. 4, pp. 16–18, 2002.

[11] IBM Corp., “IBM SPSS Statistics for Windows (Version 29.0.0.0).” Armonk, NY, 2022. [Computer Software]. Available: https://www.ibm.com/spss

[12] The jamovi project, “jamovi (Version 2.4.11.0).” 2023. [Computer Software]. Available: https://www.jamovi.org

[13] R Core Team, “R: A Language and Environment for Statistical Computing (Version 4.1).” R Foundation for Statistical Computing, Vienna, Austria, 2022. [Computer Software]. Available: https://www.R-project.org/

[14] P. Kline, *A handbook of test construction: introduction to psychometric design*. in University paperbacks, no. 931. London; New York, NY: Methuen, 1986.

[15] H. Moosbrugger and A. Kelava, Eds., *Testtheorie und Fragebogenkonstruktion*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2020.

[16] J. Cohen, *Statistical power analysis for the behavioral sciences*, 2nd ed. Hillsdale, N.J: L. Erlbaum Associates, 1988.

[17] J. D. Karch, “bmtest: A Jamovi Module for Brunner–Munzel’s Test—A Robust Alternative to Wilcoxon–Mann–Whitney’s Test,” *Psych*, vol. 5, no. 2, pp. 386–395, May 2023, doi: 10.3390/psych5020026.

[18] J. D. Karch, “Psychologists Should Use Brunner-Munzel’s Instead of Mann-Whitney’s U Test as the Default Nonparametric Procedure,” *Adv. Methods Pract. Psychol. Sci.*, vol. 4, no. 2, 2021, doi: 10.1177/2515245921999602.