2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #37009

Board 255: Development and Application of Assessment Tools for a Research Experience for Teachers Site

Prof. Weihang Zhu, University of Houston

Dr. Weihang Zhu received his BS and MS in Mechanical and Energy Engineering from Zhejiang University and Ph.D. in Industrial and Systems Engineering from North Carolina State University. Currently he serves as Professor, Program Coordinator, and Graduate Program Coordinator for Mechanical Engineering Technology program in the Department of Engineering Technology, with a joint appointment in the Department of Mechanical Engineering, University of Houston, Houston, Texas. His research expertise areas include design and manufacturing, automation and robotics, machine learning, computational optimization, mariner and offshore safety, and engineering education. He has secured $7.2M ($4.1M as PI; $4.5M since joining UH in fall 2018) funding from NSF, NASEM, USDA, state, local, and foundations. He has received eight engineering education grants from NSF.

Peter Weber

Development and Application of Assessment Tools for a Research Experience for Teachers Site

Abstract

In 2019, University of Houston (UH) at Houston, Texas was awarded an NSF Research Experience for Teachers (RET) site grant titled "RET Site: High School Teacher Experience in Engineering Design and Manufacturing." The goal of the project is to host 12 high school teachers each summer to participate in engineering design and manufacturing research and then convert their experience into high school curriculum. Given the experience from the first year's operation and assessment, it was noted that the extant teacher self-efficacy surveys need to be further improved according to the specific needs of RET site. As such, an updated set of assessment tools was developed to evaluate the impact of RET site on high school teacher participants. In particular, a new teacher self-efficacy survey was created from synthesizing multiple sources including Bandura's Instrument Teacher Self-Efficacy Scale, Collective Teacher Beliefs, and Teachers' Sense of Efficacy Scale (Ohio State Teacher Efficacy Scale). Besides the new self-efficacy survey, more specific questions were added to pre- and post-summer self-reported questionnaires to better understand the teachers' perception and receptance of the summer experience. Interviews were conducted individually instead of using a focus group. This allows the interviewee to be more vocal during the interview, allowing more in-depth understanding of their perception for future improvement. The new assessment tools were applied to the second cohort of 12 teachers in summer 2022. The assessment results show that the assessment tools were able to effectively capture teachers' change in perception and evaluate the affective impact of the RET site. In the future, the tools may be improved and used in similar teacher professional development activities.

1. Introduction

In 2019, University of Houston (UH) at Houston, Texas was awarded an NSF Research Experience for Teachers (RET) site grant titled "RET Site: High School Teacher Experience in Engineering Design and Manufacturing." The goal of the project is to provide opportunities for high school STEM teachers to engage in innovative engineering design and manufacturing research and develop advanced high school STEM curriculum modules. This is a summer research program in which teachers participate in university research for six weeks and also convert their experience into a high school course module. After the summer, they will implement the module in the classroom and submit the module to TeachEngineering.org for approval.

Due to COVID-19, we could not host the RET site in summer 2020. The first cohort of 12 teachers participated in the RET site in summer 2021. Considering the pandemic situation, about 50% of the activities including workshops and curriculum development counseling etc., was arranged to be online. Teachers spend the rest of the week in face-to-face lab research and field

trips to local companies. To evaluate the change of self-efficacy among the teachers through the RET experience, the Teachers' Sense of Efficacy Scale (TSES) survey was used in its original form. During the data analysis, it was found out that the survey as is could not reveal much useful results. This was partially because it does not take the special arrangement and pandemic situation into consideration. Some questions are not applicable. As such, we decided to create a new set of survey questions that can be better at evaluating the teachers' self-efficacy. This is done first through a literature review and select a list of questions from the literature that are most applicable to the RET site scenarios.

The rest of the paper is organized as follows. Section 2 is the literature review on relevant self-efficacy surveys on teachers' self-efficacy. Section 3 explains our self-efficacy survey along with the other evaluation tools used for RET site. Section 4 presents the evaluation results. Section 5 is the conclusion.

2. Literature Review

The concept of self-efficacy derives from Bandura's social-cognitive theory of behavioral change [1]. Self-efficacy refers to an individual's belief in his/her capacity to execute behaviors necessary to produce specific performance attainments [1,2,3]. Teachers' self-efficacy refers to a teacher's belief in his/her ability to cope with tasks, obligations, and challenges relevant to his/her job. Multiple teacher self-efficacy tools have been proposed in the literature. Among them, we select three tools for more detailed review due to their relevancy to our propose.

2.1 Teacher's Sense of Efficacy Scale (Ohio State Teacher Efficacy Scale)

Teachers' Sense of Efficacy Scale (TSES) survey is a set of questionnaires developed by Tschannen-Moran at College of William and Mary and Woolfolk Hoy at the Ohio State University [4]. It is designed to help people gain a better understanding of the kinds of things that create difficulties for teachers in their school activities. Similarly, teachers are asked to indicate the opinion about each question by marking from 1 to 9. There are two forms of this survey. The long form has 24 questions and the short form has 12 questions. These questions measure efficacy in Student Engagement, Instruction Strategies, and Classroom Management. TSES has been used in many teachers' self-efficacy studies.

2.2 Bandura's Instrument Teacher Self-efficacy Scale

Bandura's instrument on teacher self-efficacy scale is a set of questionnaires [5]. It seems to be a variant of TSES introduced above and has better coverage. It is designed to help people gain a better understanding of the kinds of things that create difficulties for teachers in their school activities. It has 30 questions which are classified into 7 categories:

a. Efficacy to Influence Decision Making
b. Efficacy to Influence School Resources
c. Instructional Self-Efficacy
d. Disciplinary Self-Efficacy
e. Efficacy to Enlist Parental Involvement
f. Efficacy to Enlist Community Involvement

g. Efficacy to Create a Positive School Climate

These 30 questions provide a comprehensive coverage of teachers' self-efficacy.

2.3 Collective Teacher Beliefs

The "Collective Teachers Briefs" (CTE) survey is a set of questionnaires [6]. It is designed to help people gain a better understanding of the kinds of things that create challenges for teachers. There are only 12 questions. Teachers are asked to indicate the opinion about each question by marking from (1) "None at all" to (9) "A Great Deal", representing a degree in the continuum. This set of questions seem to focus more on the teacher student interaction in school. It indicates the collective belief of the faculty/staff in their ability to positively affect students.

2.4 Design Requirement: Concise and Pinpoint

We understand a potential issue of having a long survey: teachers (or anyone) tend to become impatient if they have to deal to with a long survey; they have no patience to read each question carefully before answering which leads to unreliable assessment data. For example, the famous "Motivated Strategies for Learning Questionnaire" (MSLQ) survey has 44 items that uses a 7-point Likert scale [7]. While it is comprehensive, it is too long. It is mainly designed for measuring learning strategies and motivation (student self-efficacy), and thus not used for our project purpose.

3. RET Site Teacher Evaluation Tools

As such, we want to keep the number of questions low and seek answers for questions that we care about the most. In fact, all the surveys we referred to have no more than 30 questions in each survey. Based on the literature review, we have selected the following questions with minor modification for evaluating the teachers' self-efficacy as shown in **Table 1**. The questions are categorized into three sections.

A. Instructional self-efficacy: These questions are to find out whether teachers feel they have more knowledge, tools, and confidence to assist themselves in teaching after they participate in the summer program. The teachers' summer research should have loaded them with more tools and capabilities.
B. Community involvement: These questions are to find out whether teachers realize that they have more access to community resources after the summer experience. The teachers' summer activities include field trips to local industries to experience real world engineering, interaction with high school principals and ISD officers, and discussion among teachers that extend their social network.
C. School climate: These questions are to find out whether teachers can use their knowledge learned to improve the overall school climate by helping peers, administrators, and students and acquiring more resources.

Overall, we expect our RET site activities will have a positive impact directly or indirectly on the aspects related to these questions.

Table 1. RET Site Teacher Self-Efficacy Evaluation

A	**Instructional Self-Efficacy**
A1	How much can you do to get through to the most difficult students?
A2	How much can you do to keep students on task on difficult assignments?
A3	How much can you do to increase students' memory/retention of what they have been taught in previous lessons?
A4	How much can you do to get students to work together?
A5	How much can you do to help your students think critically?
A6	How much can you do to help your students value learning?
A7	How much can you do to foster student creativity?
A8	How much can you gauge student comprehension of what you have taught?
A9	How much can you do to adjust your lessons to the proper level for individual students?
A10	Rate from 1 (None / Not at All) to 9 (Greatest) - To what extent can you craft good questions for your students?
A11	Rate from 1 (None / Not at All) to 9 (Greatest) - To what extent can you provide an alternative explanation or example when students are confused?
A12	Rate from 1 (None / Not at All) to 9 (Greatest) - How well can you respond to difficult questions from your students?
A13	Rate from 1 (None / Not at All) to 9 (Greatest) - How well can you implement alternative strategies in your classroom?
A14	Rate from 1 (None / Not at All) to 9 (Greatest) - How well can you provide appropriate challenges for very capable students?
B	**Community Involvement**
B1	Community Involvement - How much can you do to overcome the influence of adverse community conditions on students' learning?
B2	Community Involvement - How much can you do to get community groups involved in working with the schools?
B3	Community Involvement - How much can you do to get local colleges and universities involved in working with the school?
C	**School Climate**
C1	How much can you do to get the instructional materials and equipment you need?
C2	How much can you do to make the school a safe place?
C3	How much can you do to make students enjoy coming to school?
C4	How much can you help other teachers with their teaching skills?
C5	How much can you do to enhance collaboration between teachers and the administration to make the school run effectively?
C6	How much can you do to get students to believe they can do well in schoolwork?

Surveys' Likert scale may have five points, seven points, or nine points, etc. In the literature the teachers' responses, we often see nine points from 1 as "None at all" to 9 as "A great deal". Our RET site survey also adopted nine points Likert scale to allow for finer data comparison of pre-program and post-program results.

4. Evaluation Result and Discussion

4.1 Survey Result and Discussion

The developed RET site survey was used to measure the self-efficacy of teachers in summer 2022. Because each cohort only has 12 teachers which are not sufficient for drawing statistically significant results, we only use descriptive statistics to compare the pre-program and post-program results, as shown in **Table 2**. **Figure 1** illustrates the difference in percentage.

Table 2. Descriptive statistics to compare the pre- and post-program results

Q#	Pre-Program	Post-program	Difference	% difference
A1	7.00	7.67	0.67	9.52%
A2	6.83	7.33	0.50	7.32%
A3	6.18	7.75	1.57	25.37%
A4	7.67	7.92	0.25	3.26%
A5	6.82	7.75	0.93	13.67%
A6	6.50	7.67	1.17	17.95%
A7	7.25	8.17	0.92	12.64%
A8	7.00	7.75	0.75	10.71%
A9	7.50	8.25	0.75	10.00%
A10	6.91	7.33	0.42	6.14%
A11	7.18	8.17	0.98	13.71%
A12	7.08	8.08	1.00	14.12%
A13	7.09	7.92	0.83	11.65%
A14	7.50	8.17	0.67	8.89%
B1	6.08	7.08	1.00	16.44%
B2	5.83	6.75	0.92	15.71%
B3	6.00	6.42	0.42	6.94%
C1	6.08	7.25	1.17	19.18%
C2	6.09	6.92	0.83	13.56%
C3	6.67	7.75	1.08	16.25%
C4	6.91	7.33	0.42	6.14%
C5	6.42	7.17	0.75	11.69%
C6	7.08	7.58	0.50	7.06%

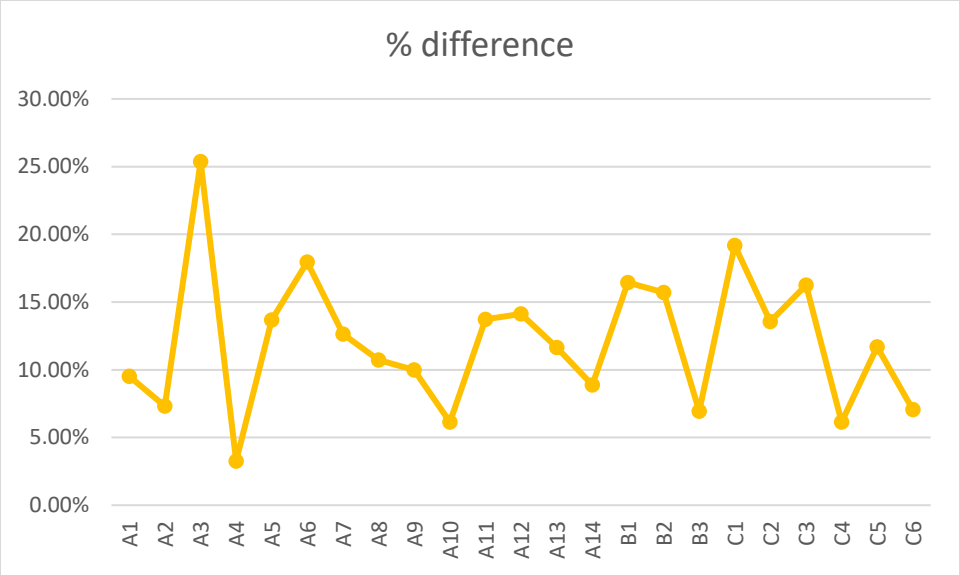

Figure 1. The different between the pre- and post-program results in percentage

From the results, it can be seen that all the scores are changing in a positive direction. Out of 23 questions, 15 questions had more than a 10% increase in score and 6 questions had more than a 15% increase. Interestingly, each category has 2 questions with more than a 15% increase. They are listed and discussed in **Table 3**.

Table 3. Comparison and discussion of the results with the larger difference

Q#	Question	% Difference	Discussion
A3	How much can you do to increase students' memory/retention of what they have been taught in previous lessons?	25.37%	This implies that teachers have learned a variety of knowledge and techniques to use in the future.
A6	How much can you do to help your students value learning?	17.95%	This implies that teachers felt they can explain better with more in-depth understanding of the STEM subject.
B1	Community Involvement - How much can you do to overcome the influence of adverse community conditions on students' learning?	16.44%	Harsh environments have negative impact on student learning. This implies that teachers are more confident in finding more ways to counter the adverse community influence.
B2	Community Involvement - How much can you do to get community groups involved in working with the schools?	15.71%	We visited four local companies to see real world engineering. Teachers think about bringing their students to visit the companies, too.
C1	How much can you do to get the instructional materials and equipment you need?	19.18%	Teachers participated in lab research, took workshops, visited companies, and discussed curriculum development. All these contribute to future materials and equipment acquisition.

C3	How much can you do to make students enjoy coming to school?	16.25%	This implies that teachers can think of more ways to attract and retain students' attention with the knowledge learned from the summer program.

However, while results from all questions have a positive trend, we noticed that some questions did not receive higher positive answers as expected. These point us to the opportunities for improvement. For examples,

- Question A4 asked about helping with students' teamwork and teachers seem to be unsure about how they help students. We can provide more pedagogical discussion and guidance in the course module development counseling sessions.
- Question B3 asked about the university involvement with high school and teachers seem to be unsure about how that works. In the future cohort, we can provide more explanation to help teachers understand how to collaborate with universities.
- Question C4 asked about RET teachers helping other teachers. In the future cohort, we can provide more discussion about teamwork and how peer teaching can help each other in the course module development counseling.

4.2 Interview Results

The teachers were randomly sampled, and four teachers were selected for individual interview with the Director of Assessment in the College of Technology, University of Houston. The following are excerpts that echo the positive survey results and reveal more details in these aspects including:

A. Instructional self-efficacy
    a. "This is a good opportunity because now I came up with several ideas that I could develop, not only for TeachEngineering lessons, but also in the classroom."
    b. "At the end of the day it has to be able to [be] reproduced in the classroom without expensive equipment. … That's the way this program impacted me. More hands-on activities helped [me] translate it to that – cool ideas."
    c. The RET program is "…definitely going to have a positive impact on my relationship with my colleagues as well as what's going to happen in my classroom."
    d. "That gives me a better perspective for my students."
    e. "I definitely want to bring that to my lesson activities overall for everything that I'm doing in my classroom, because I've struggled with that coming into education from industry."
    f. "That made me feel part of the process and not just the observer. I truly like the fact that I have this research going in… This actually made me feel more vested and it gave me perspective."

g. “Being able to do something like this allows me to refresh those [engineering] skills, those thought processes, see what is still out there so I can bring back relevant information or application to my students.”
h. “Doing the labs helped me understand that even if I make a mistake you can learn from it.”

From these quotes, we can see that the teachers became more confident after being loaded with more tools and knowledge to improve their future teaching, and they are eager to apply what they have learned to their own classrooms.

B. Community involvement
   a. “I know many of my colleagues are still actively working on the projects because they've become vested in the research topics.”
   b. “The field trips were wonderful. I might link some of the companies to my [school] counselors.”
   c. One student commented that the field trips were a favorite part “because that’s real-life application of what we’re learning inside the classroom and that’s something I can brag to my students, that if they’re not university material after high school they can earn a lot by going to a technical school or junior college. There is opportunity there for them.”
   d. “It was interesting hearing different aspects [and] different perspectives.” (re: course development)

From these quotes, we can see that the field trips to local companies and the opportunities to interact with industry and researchers helped teachers to find more community resources to support their future teaching and motivate their students.

C. School climate
   a. “I think I’ll do more labs than before because I think that’s how they learn better.”
   b. “I really like it. So that’s why I stayed, it’s the best program for a teacher – certainly as a science teacher.”

From these quotes, we can see that the teachers became more confident in helping the school and peers after being loaded with more tools and knowledge from the summer program.

5. Conclusion

Considering the pandemic issues and special requirements from the RET site, we have developed a set of questionnaires that are suitable for evaluating the impact of RET site on high school STEM teachers. The set of questionnaires has 23 question and is classified into three categories, namely Instructional Self-efficacy, Community Involvement, and School Climate.

The developed survey was used to assess the impact of the RET site on teachers’ self-efficacy at the end of summer 2022. Twelve teachers in the cohort completed the survey. The results

showed positive impacts with all the questions. The positive results show the positive impact on the teachers' knowledge gained through the summer program makes them more confident in future teaching, getting new teaching resources, leveraging community support, and helping their schools to achieve the education goals. The individual interview can provide more insights and details about the impact on teachers' self-efficacy. The developed survey will be further improved for the cohort in summer 2023. This survey can be used by educators in similar teacher professional development programs nationwide.

Acknowledgment

This project is sponsored by the National Science Foundation grant #1855147, #1955036, #2141674, and #2220683. The support is greatly appreciated.

References

[1] A. Bandura, "Self-efficacy: Toward a unifying theory of behavioral change," *Psychological Review*, vol. 84, no. 2, pp. 191-215, 1977.

[2] A. Bandura, *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall, 1986.

[3] A. Bandura, *Self-Efficacy: The exercise of control*. New York, NY: W. H. Freeman, 1997.

[4] M. Tschannen-Moran and Hoy A. Woolfolk, "Teacher efficacy: Capturing an elusive construct.," *Teaching and Teacher Education*, no. 17, pp. 783-805, 2001.

[5] Bandura. (2014) wpmucdn.com. [Online]. https://cpb-us-w2.wpmucdn.com/u.osu.edu/dist/2/5604/files/2014/09/Bandura-Instr-1sdm5sg.pdf

[6] J. Hattie, "Mindframes and Maximizers," in *Third Visible Learning Annual Conference*, Washington, DC, 2016.

[7] P.R. Pintrich and E.V. de Groot, "Motivational and self-regulated learning components of classroom academic performance," *Journal of Educational Psychology*, vol. 82, no. 1, pp. 33-40, 1990. [Online]. https://doi.org/10.1037/0022-0663.82.1.33