International Journal of Engineering Education Vol. 38, No. 2, pp. 505–511, 2022
Printed in Great Britain

0949-149X/91 $3.00+0.00

Elementary Teachers' Perceptions of Engineering Education: A Survey Study in Taiwan*

PAO-NAN CHOU
Graduate Institute of Technological and Vocational Education, National Pingtung University of Science and Technology, Pingtung, Taiwan. E-mail: pnchou@g4e.npust.edu.tw

WEI-FAN CHEN
Department of Information Sciences and Technology, Wilkes-Barre Campus, The Pennsylvania State University, PA, USA.
E-mail: weifan@psu.edu

This study investigated elementary teachers' perceptions of engineering education using a self-developed assessment tool (Science Teachers' Views on Engineering in Elementary School Questionnaire). Prior to the study, exploratory factor analysis and reliability testing involving 117 elementary teachers were performed to evaluate the validity and reliability of the questionnaire. Through snowball sampling, 202 certified elementary science teachers completed the survey. The results indicated a medium level of overall understanding among elementary science teachers regarding engineering education. Teachers perceived a lack of engineering expertise and had little experience in teaching engineering. Although schools did not actively support teachers' engineering teaching or STEM education activities, teachers had high expectations of higher education institutions to provide engineering education training and of education authorities to offer a specific framework for engineering teaching in the science curriculum. Moreover, teachers' college majors influenced their perspectives on engineering expertise and engineering teaching as well as their overall understanding of engineering education.

Keywords: engineering in elementary school; K–5 science curriculum; engineering instruction

1. Introduction and Literature Review

After an extensive review of prominent international engineering education journals, our research team determined that research topics on engineering diversity and inclusivity, particularly for K–12 education, have been insufficiently discussed [1]. In 2017, to close this literature gap, we provided an overview of high-quality research papers published in a special issue on K–12 engineering education in the *International Journal of Engineering Education* [2]. However, among those studies, few investigated the integration of engineering into elementary schools. Hammack and Ivey [3] also reported this literature gap and further identified engineering education in elementary schools as a new field of study.

Some studies have identified learning benefits for students when engineering is incorporated into the elementary school curriculum. For example, Cunningham [4] specified that engineering in elementary school enabled students to improve their (a) understanding of the world, (b) problem-solving skills, (c) math and science achievement, and (d) access to future STEM careers. In an experimental study by Chou et al. [5], math instruction combined with engineering principles increased fifth graders' awareness of the value of spatial reasoning skills in mechanical engineering.

In the United States, the Next Generation Science Standards (NGSS) emphasize the need for engineering practices to be integrated into the K–12 science curriculum [6]. At the elementary level, engineering design principles are outlined in science inquiry activities. Unlike the approach of the NGSS, Taiwan's Curriculum Guidelines for 12-year Basic Education require engineering domain knowledge to be covered in the technology curriculum at the 6-year high school level (grades 7 through 12)[7]. However, at the elementary level, the science curriculum includes only a few engineering-related units [8]. Thus, engineering design instruction is not necessary for Taiwanese elementary teachers.

By implementing the draw-an-engineer test [9], we previously indicated that elementary schoolers in Taiwan were lacking engineering knowledge. Students' engineering epistemology presented a pattern of misconceptions in which children often perceived low-level engineering design jobs (e.g., mechanics) as true engineering jobs. In that study, science teachers responsible for administering the test had not integrated engineering activities into the science curriculum, and they had little engineering expertise. However, because teachers' engineering knowledge and skills directly influence the engineering cognition of students [10], teachers' perceptions of engineering education should be examined to promote engineering in elementary schools.

Prior to the study, the research team had several

* Accepted 7 November 2021.

personal communications with elementary science teachers who attempted to promote engineering education at school. Those enthusiastic teachers not only expressed their concerns on the limited engineering knowledge in the current science curriculum, but also suggested a curriculum reform for introducing engineering design at the elementary level. Overall, the teachers stressed that there is a need to systematically cultivate engineering talents from the elementary level, especially since Taiwan is well-known for engineering-based industries. Based on the personal experiences and evidence in literature review, the study serves as an exploratory study to investigate elementary science teachers' conceptions of general engineering education.

Studies have tended to employ two approaches in investigating elementary teachers' perceptions of engineering education. The first is the analysis of elementary school teachers' engineering integration experience. For example, Sun and Strobel [11] interviewed several elementary school science teachers to construct an elementary engineering education adoption and expertise development framework. Wendell [12] used discourse analysis to examine preservice elementary teachers' design thinking behaviours in engineering projects. Moreover, Lottero-Perdue and Parry [13] explored elementary teachers' perspectives on use of the word "failure" during engineering teaching. Those studies have mostly used qualitative methods.

The second research approach is the quantitative surveying of elementary teachers' attitudes and opinions toward teaching engineering in the science curriculum. Under such a research paradigm, Yasar et al. [14] developed the first measurement instrument (design, engineering, and technology, DET) to assess K–12 teachers' perceived familiarity with engineering. In the study, one portion of the participants were elementary teachers. Subsequently, Hsu et al. [15] and Hammack and Ivey [3] have used DET as a research instrument focused on elementary teachers. However, the findings of these studies are reflected only in teachers' views in Western countries. Whether cultural factors influence teachers' perceptions of engineering education [16] deserves further discussion.

The current study was conducted using the second, quantitative research approach. However, unlike related studies, out of consideration for cultural differences, the current study aimed to develop a reliable assessment tool for measuring teachers' perceptions of engineering education through exploratory factor analysis. The research instrument was specifically used for Taiwanese in-service science teachers in elementary schools. In particular, this study sought to answer the following two research questions:

1. What are teachers' perceptions of engineering education in elementary school?
2. What type of background information influences elementary teachers' perceptions of engineering?

2. Survey Constructs

Prior to the study, a focus group interview was conducted with 10 elementary science teachers who actively promoted engineering education at school to discuss the findings of the literature review. During this the interview, six survey constructs were proposed for further factor analysis:

1. Characteristics of engineers: Yasar [14] claimed that people often have inadequate information about engineering, particularly those who are unfamiliar with the topic . For example, people often refer to educational technology as technology education (pre-engineering education). The current study adapted survey items from two constructs (stereotypical characteristics of engineers and characteristics of engineering) in the DET measurement.
2. Women in engineering: Teachers' personal ideologies may directly influence their curriculum design [17]. For example, teachers' gender stereotypes may influence students' perspectives on their future careers. In the current study, because gender equity in engineering is a prevalent research topic [18], several elementary science teachers expressed that the inclusion of women in engineering must be a survey construct.
3. Engineering expertise: Teachers with adequate engineering expertise may purposefully integrate engineering into the science curriculum [10]. Teachers' expertise may be a result of their personal educational background or professional development in workshops outside school. Unlike the DET measurement, the assessment developed in the current study included engineering expertise as a new survey construct to account for the importance of skill and expertise development.
4. Engineering teaching: In the DET assessment [14], teachers are instructed to indicate the barriers to their engineering teaching, such as a lack of time or training. In the study of Hammack and Ivey [3], in addition to DET, qualitative data revealed specific barriers to the integration of engineering into curricula, such as a lack of teaching strategies. However, because the current study focused only on teachers' experience in engineering teaching, the factors affecting their attitudes were not measured in survey items.

5. School support: In addition to teachers' intrinsic motivation, school support plays a crucial role in innovative instruction. For example, Hew and Brush [19] indicated that incentives offered by school administrations can increase teachers' willingness to integrate technology into curricula. Similarly, Chen et al. [20] indicated that school administrative support encourages teacher contributions to digital teaching and learning. Therefore, the current study added school support as a survey construct, which is not on the DET measurement.
6. Education policy: In the United States, the NGSS serves as an instructional framework which guides elementary teachers to teach engineering in science classes [6]. By contrast, no specific framework proposed by the Taiwan government can be used as a teaching reference. Elementary teachers in the focus group expressed concerns regarding this educational policy. In addition, some elementary teachers might perceive that centres for teacher education at colleges should be responsible for offering engineering education courses or related training workshops [21].

3. Research Methods

3.1 Research Design

The present study adopted a survey methodology to answer the research questions. Elementary teachers' perceptions of engineering education (in terms of the characteristics of engineers, women in engineering, engineering expertise, engineering teaching, school support, and education policy) were the major dependent variables. Teacher background was an independent variable comprising sex, college major, age, and science teaching experience. The survey design is summarised in Table 1.

3.2 Research Participants

Potential participants were full-time certified science teachers at elementary schools in Taiwan. The study employed snowball sampling [22] to recruit participants. Ten elementary science teachers were invited to be research campaigners, and they used their social connections to encourage other teachers to complete the survey. After the 1-month campaign, 202 valid questionnaires were analyzed. Table 2 presents the demographic characteristics of the research participants.

Table 1. Survey Design

Structure	Items	Variables
Part one (Background information)	4	1. Sex 2. College major 3. Age 4. Science teaching experiences
Part two (Perceptions of engineering education)	20	1. Characteristics of engineers 2. Women in engineering 3. Engineering expertise 4. Engineering teaching 5. School support 6. Education policy

3.3 Research Instrument

A questionnaire entitled 'Science Teachers' Views on Engineering in Elementary School' was developed to assess elementary science teachers' perceptions of engineering education. This research instrument consisted of two parts with 24 survey items rated on a 5-point Likert scale. The first part contained four questions, which were used to collect teachers' background information. The second part had 20 questions aimed at obtaining teachers' viewpoints on the six major constructs (characteristics of engineers, women in engineering, engineering expertise, engineering teaching, school support, and education policy). Higher scores on the questionnaire represented a superior understanding of engineering education in elementary schools.

The questionnaire was developed in four stages. First, a draft of 30 survey items was produced after a discussion of the survey constructs. Second, the researchers' colleagues were invited to modify inappropriate and ambiguous survey items. Third, a revised survey with 25 items was administered to 117 elementary science teachers to determine the validity and reliability of the survey. Finally, through the use of exploratory factor analysis (eigenvalues and variance), the number of survey items was reduced to 20. Reliability analysis also indicated that the reliability coefficient for each survey construct exceeded 0.6. Table 3 summarises the results of the validity and reliability tests.

3.4 Data Analysis

Descriptive and inferential statistics were used to analyze the collected data. The descriptive statistics

Table 2. Research Participant Demographics (N = 202)

Type	Number
1. Gender	
A. Male	96
B. Female	106
2. Major	
A. Science-related	92
B. Social Science-related	110
3. Age	
A. Below 30	37
B. 31~40	61
C. 41~50	50
D. Above 50	24
4. Science teaching experiences	
A. 1~10	57
B. 11~20	62
C. 21~30	48
D. Above 30	35

Table 3. Reliability and Validity Test Results (N = 117)

Survey Construct	Question Items	Reliability Coefficient	Eigenvalue	% of Variance
1. Characteristics of Engineers	5	0.64	1.83	46.57
2. Women in Engineering	3	0.75	1.67	55.60
3. Engineering Expertise	3	0.78	2.09	69.49
4. Engineering Teaching	3	0.76	2.05	68.38
5. School Support	3	0.77	1.37	45.74
6. Education Policy	3	0.67	1.85	61.75

Table 4. Mean Scores for Survey Constructs (N = 202)

Survey Construct	Mean	S.D.
1. Characteristics of Engineers	3.83	0.95
2. Women in Engineering	3.89	0.45
3. Engineering Expertise	2.96	0.90
4. Engineering Teaching	3.03	0.90
5. School Support	2.67	0.74
6. Education Policy	3.62	0.73
Total	3.33	0.41

were used to examine the means and standard deviations of the survey item scores. Inferential statistics (the Kruskal–Wallis test) were used to confirm the effect of the teachers' backgrounds on their perceptions of engineering education.

4. Results

4.1 Perceptions of Engineering Education

Table 4 reports the mean score in each survey construct. Overall, the teachers' perceptions of engineering education indicated a medium level of understanding (M = 3.33). The lowest mean score was for school support (M = 2.67), whereas the highest score was for women in engineering (M = 3.89). In addition, teachers exhibited an adequate understanding of the characteristics of engineers (M = 3.83) and expressed concern regarding engineering education policy (M = 3.62). However, the teachers perceived that they lacked engineering expertise (M = 2.96) and they positioned themselves at a neutral standpoint for engineering teaching (M = 3.03).

Table 5 summarizes the details of the survey items. In construct 1 (characteristics of engineers), a strong educational background in math (M = 4.44) and science (M = 4.21) were what the teachers perceived to be the strongest characteristics of engineers. Teachers placed the least emphasis on engineers' salary (M = 3.26). In construct 2 (women in engineering), although teachers perceived that women can excel in engineering (M = 4.24) and be excellent engineers (M = 4.30), they indicated that female engineers might encounter difficulties in male-dominated workplaces (M = 3.13). In construct 3 (engineering expertise), teachers had low confidence in their engineering expertise (M = 3.03), completed few engineering-related courses in college (M = 2.53), and did not participate in professional development activities regarding engineering (M = 3.34). In construct 4 (engineering teaching), teachers were unwilling to integrate more engineering knowledge (M = 2.85) or introduce the role of

Table 5. Statistical Details of Survey Items (N = 202)

Survey Item	Mean	Standard Deviation
1-1 A typical engineer has good verbal skills	3.82	0.87
1-2 A typical engineer does well in science	4.21	0.73
1-3 A typical engineer has good math skills	4.44	0.59
1-4 A typical engineer earns good money	3.26	0.89
1-5 A typical engineer work wells with people	3.41	0.92
2-1 I feel that women can be good engineers	4.30	0.58
2-2 I feel that women do well in engineering	4.24	0.60
2-3 I feel that female engineers can perform well in a male-dominated workplace	3.13	1.06
3-1 I have basic engineering expertise	3.03	1.06
3-2 I took some engineering-related courses in college	2.53	1.14
3-3 I have attempted to gain engineering knowledge by using different sources (e.g., reading or workshops)	3.34	1.06
4-1 I have integrated engineering knowledge into my science class	2.85	1.03
4-2 I have imparted the role of an engineer in my science class	3.09	1.12
4-3 I have introduced well-known Taiwanese technology companies (e.g., TSMC) that have skilled engineers to students in my science class	3.15	1.22
5-1 My school supports STEM education activities	2.65	0.91
5-2 My school encourages teachers to develop engineering learning activities	2.50	0.98
5-3 My school encourages teachers to participate in STEM education activities outside of school	2.86	0.88
6-1 I feel that the current science curriculum structure should cover more engineering units	3.35	0.71
6-2 I feel that centres for teacher education at colleges must offer engineering education courses for in-service or preservice science teachers	3.72	0.74
6-3 I feel that education authorities should provide a specific framework for engineering teaching in the science curriculum	3.79	0.61

Table 6. Kruskal–Wallis Test Results by Sex (N = 202)

Survey Construct	χ^2	***p***
1. Characteristics of Engineers	1.80	0.18
2. Women in Engineering	0.03	0.85
3. Engineering Expertise	0.27	0.60
4. Engineering Teaching	0.20	0.66
5. School Support	0.71	0.40
6. Education Policy	2.06	0.15
Total	0.01	0.95

engineers in science curricula (M = 3.09). In construct 5 (school support), the teachers seemed to receive little encouragement or support from their schools for developing engineering learning activities (M = 2.50) or STEM education (M = 2.65). In construct 6 (education policy), teachers expected centres of teacher education at colleges to offer engineering education courses (M = 3.72) and education authorities to provide a specific framework for engineering teaching (M = 3.79).

4.2 Effect of Background Information

The Kruskal–Wallis test results for the participants' background information (sex, major, age, and teaching experience) are summarised in Tables 6–9. Sex, age, and teaching experience did not influence teachers' views on any survey construct ($p > 0.05$). Only teachers' majors in college directly affected their perspectives on engineering expertise ($\chi^2 = 12.62$, $p < 0.01$), engineering teaching ($\chi^2 = 5.05$, $p < 0.05$), and overall perceptions of engineering education ($\chi^2 = 8.56$, $p < 0.01$). In other words, teachers who majored in science at university had more engineering expertise, engineering teaching experience, and understanding of engineering education than did those who majored in social science.

5. Discussion

In this study, survey construct 1 (characteristics of engineers) was based on two constructs in the DET measurement. The current results indicate that teachers had a medium to high level of understanding of the characteristics of engineers. This finding is consistent with those of Yasar [14] and Hsu [15], who used DET as a research instrument. The responses to items measuring survey construct 1 revealed that elementary science teachers still have a traditional perspective that typical engineers should be equipped with strong math and science skills. In addition, elementary science teachers emphasized verbal skills, possibly due to their belief that engineers must engage in teamwork activities during project development [23].

Unlike previous related studies, the current study included women in engineering as a novel survey construct. The findings indicate that elementary science teachers understood gender equality in engineering. However, on the item regarding women in the workplace, the teachers seemed to have a neutral opinion regarding women's involvement in engineering. This finding might be attributable to teachers' regular observation of the difficulties that female engineers encounter as a minority in male-dominated workplaces. For example, media reports on minorities in engineering may contribute to elementary teachers' impressions of how female engineers survive in the workplace [9].

School support and educational policy were two other new survey constructs in the present study. Among the survey constructs, the score for school support was the lowest. That is, schools did not provide sufficient practical help for elementary

Table 7. Kruskal–Wallis Test Results by Major (N = 202)

Survey Construct	χ^2	***p***	**Post-hoc**
1. Characteristics of Engineers	0.08	0.77	
2. Women in Engineering	1.52	0.22	
3. Engineering Expertise	12.62	0.00**	S > SS
4. Engineering Teaching	5.05	0.03*	S > SS
5. School Support	1.54	0.22	
6. Education Policy	2.19	0.14	
Total	8.56	0.00**	S > SS

*$p < 0.05$. **$p < 0.01$. S: Science-related majors. SS: Social science majors.

Table 8. Kruskal–Wallis Test Results by Age (N = 202)

Survey Construct	χ^2	***p*** 1.
Characteristics of Engineers	0.73	0.87
2. Women in Engineering	7.49	0.06
3. Engineering Expertise	1.72	0.63
4. Engineering Teaching	4.18	0.24
5. School Support	3.99	0.26
6. Education Policy	0.73	0.87
Total	2.13	0.55

Table 9. Kruskal–Wallis Test Results by Teaching Experience (N = 202)

Survey Construct	χ^2	***p*** 1.
Characteristics of Engineers	2.68	0.44
2. Women in Engineering	0.62	0.89
3. Engineering Expertise	6.88	0.08
4. Engineering Teaching	3.42	0.33
5. School Support	0.85	0.84
6. Education Policy	4.39	0.22
Total	1.57	0.67

science teachers to develop engineering learning or STEM education activities. Consequently, a lack of school support is likely a barrier to teachers implementing engineering teaching at elementary schools [3]. However, regarding educational policy, teachers had high expectations that centres for teacher education at colleges should offer training on engineering teaching and educational authorities should provide specific teaching references for engineering in elementary school. Thus, support from external sources may increase opportunities for elementary science teachers to teach engineering [3].

Similar to previous research on Western populations [3, 14, 15], the results of the present study reveal that elementary science teachers in Taiwan lack adequate engineering expertise and have limited experience with teaching engineering in the science curriculum. Teachers' low confidence in their engineering expertise might be attributable to their educational background of limited experience in engineering-related courses in college or inadequate time to gain engineering knowledge after school. Even though the scientific curriculum already includes limited engineering-related learning units, teachers were unwilling to integrate more engineering knowledge, introduce the role of an engineer, or highlight well-known technology companies that employ skilled engineers in their science classes.

The study collected four categories of background information from the elementary teachers for inferential statistical analysis. Among the potential factors, only college majors influenced teachers' perceptions of their engineering expertise and engineering teaching. Teachers who majored in science-related disciplines exhibited more engineering expertise, more engineering teaching experience, and a superior understanding of engineering education compared with those who majored in social science. A potential explanation for this finding is that teachers who majored in science-related disciplines were involved in several engineering-related activities in college. Such a strong educational background in science might have resulted in teachers acquiring engineering knowledge that they then can integrate into their science classes. Because previous related studies did not use college major for further analysis [14, 15], no information can be compared with the findings in this study.

Because of the research design, the results of this study have limited generalizability, particularly to elementary teachers of other cultural backgrounds or in other countries. However, some research implications can be used to promote the development of engineering teaching in elementary schools. First, educational authorities might modify the structure of science education, and propose a specific framework for engineering teaching in the science curriculum. Second, teacher education at colleges could provide engineering training courses for teachers who attempt to integrate engineering knowledge into science classes. Third, elementary school administrations might propose incentive plans to support science teachers who are willing to adopt engineering instruction. Finally, education authorities may collaborate with mass media to promote the concept of gender equality in the engineering field.

The limitations of this study are as follows: First, the time limitation on snowball sampling in the present study limited the sample size. Future studies may increase the sample size to investigate the same research questions. Second, the types of background information collected in the present study influenced teachers' perceptions of engineering education. Future studies may collect different teacher information, such as school type or overall teaching experience. Third, the study served as exploratory research for investigating general concepts of engineering education for science elementary teachers. Future studies may develop more specific question items in different types of engineering domains (i.e., mechanical engineering or electrical engineering). Finally, only exploratory factor analysis was used to determine the questionnaire items. Future studies may re-examine the survey items to establish additional constructs through confirmatory factor analysis.

6. Conclusion

The present study surveyed elementary science teachers' perceptions of engineering education by using a reliable and valid questionnaire. The findings indicated that these teachers hold a neutral view on the concept of engineering education. Teachers demonstrated high understanding of the characteristics of engineers and women in engineering, but lacked the engineering expertise and engineering teaching experience. Although the teachers' schools (internal sources) did not actively support engineering learning or STEM education activities, teachers expected higher education institutions and education authorities (external sources) to offer engineering training or curriculum development support. In addition, teachers who majored in science-related disciplines in college exhibited more engineering expertise, more experience in teaching engineering, and a higher overall understanding of engineering education than did those who majored in social science.

Acknowledgements – This manuscript was edited by Wallace Academic Editing. The study was supported by Research Grant (MOST 108-2511-H-020 -003 -MY3) from Ministry of Science and Technology in Taiwan.

References

1. [1] P.-N. Chou and W.-F. Chen, Global resources in engineering education: A content analysis of worldwide engineering education journals, *International Journal of Engineering Education*, **30**(3), pp. 701–710, 2014.
2. W.-F. Chen and P.-N. Chou, Guest editorial: Current trends of K-12 engineering education, *International Journal of Engineering Education*, **33**(1B), pp. 285–286, 2017.
3. R. Hammack and T. Ivey, Elementary teachers' perceptions of K–5 engineering education and perceived barriers to implementation, *Journal of Engineering Education*, **108**(4), pp. 503–522, 2019.
4. C. C. Cunningham, *Engineering in elementary STEM education: Curriculum design, instruction, learning, and assessment*, Teachers College Press, New York, pp. 9–19, 2018.
5. P.-N. Chou, W.-F. Chen, C.-Y. Wu and C. Robert, Utilizing 3D open source software to facilitate student learning of fundamental engineering knowledge: A quasi-experimental study, *International Journal of Engineering Education*, **33**(1B), pp. 382–388, 2017.
6. NGSS Lead States, *Next generation science standards: For states, by states*, The National Academy Press, Washington, DC, 2013.
7. C.-J. Ku and K.-Y. Lin, Technology teacher education in Taiwan. In L.-S. Lee & Y.-F. Lee (Eds.), *International Technology Teacher Education in the Asia-Pacific Region*, Central Taiwan University of Science and Technology, Taichung, Taiwan, pp. 263–304, 2020.
8. P.-N. Chou and W.-F. Chen, Enhancing Student Learning Experience by Implementing an Electronic Voting System: A Quasi-experimental Approach. In P. Resta & S. Smith (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference*, Association for the Advancement of Computing in Education, Austin, TX, United States, pp. 1479–1483, 2017.
9. P.-N. Chou and W.-F. Chen, Elementary school students' conceptions of engineers: A drawing analysis study in Taiwan, *International Journal of Engineering Education*, **33**(1B), pp. 476–488, 2017.
10. C. M. Cunningham and W. S. Carlsen, Teaching engineering practices, *Journal of Science Teacher Education*, **25**, pp. 197–210, 2014.
11. Y. Sun and J. Strobel, Elementary engineering education adoption and expertise development framework: An inductive and deductive study, *Journal of Pre-College Engineering Education Research*, **3**(1), pp. 32–52, 2013.
12. K. B. Wendell, Design practices of preservice elementary teachers in an integrated engineering and literature experience, *Journal of Pre-College Engineering Education Research*, **4**(2), pp. 29–46, 2014.
13. P. S. Lottero-Perdue and E. A. Parry, Perspectives on failure in the classroom by elementary teachers new to teaching engineering, *Journal of Pre-College Engineering Education Research*, **7**(1), pp. 47–67, 2017.
14. S. Yasar, D. Baker, S. Robinson-Kurpius, S. Krause and C. Roberts, Development of a survey to assess K–12 teachers' perceptions of engineers and familiarity with teaching design, engineering, and technology, *Journal of Engineering Education*, **95**(3), 205–216, 2006.
15. M.-C. Hsu, S. Purzer and M. E. Cardella, Elementary teachers' views about teaching design, engineering, and technology, *Journal of Pre-College Engineering Education Research*, **1**(2), pp. 31–39, 2011.
16. T. Hong, S. Purzer and M. E. Cardella, A psychometric re-evaluation of the design, engineering and technology (DET) survey, *Journal of Engineering Education*, **100**(4), pp. 800–818, 2011.
17. P.-N. Chou and W.-F. Chen, Epistemological beliefs of electrical engineering students: A case study, *International Journal of Engineering Education*, **32**(5A), pp. 1935–1941, 2016.
18. P.-N. Chou and W.-F. Chen, Female engineering students' perceptions of college learning experiences: A qualitative case study in Taiwan, *International Journal of Engineering Education*, **31**(1), pp. 2–11, 2015.
19. K. F. Hew and T. Brush, Integrating technology into K–12 teaching and learning: Current knowledge gaps and recommendations for future research, *Educational Technology Research and Development*, **55**, pp. 223–252, 2006.
20. W.-F. Chen, P.-N. Chou, Y.-N. Su and H.-Y. Chen, Electrical engineering faculty's perspectives toward integrating technologies into teaching and learning, *International Journal of Engineering Education*, **34**(2A), pp. 381–387, 2018.
21. R. Hammack and T. Ivey, Elementary teachers' perceptions of engineering and engineering design, *Journal of Research in STEM Education*, **3**(1), pp. 48–68, 2017.
22. M. D. Gall, J. P. Gall and W. R. Borg, *Educational research: An introduction (8th Ed.)*, Allyn & Bacon, Boston, MA, pp. 165–191, 2007.
23. P.-N. Chou and C.- C. Chang, Small or large? The effect of group size on engineering students' learning satisfaction in project design courses, *EURASIA Journal of Mathematics, Science and Technology Education*, **14**(10), pp. 1–9, 2018.

Pao-Nan Chou is an Associate Professor of Technological and Vocational Education and a Director of Smart Media Research Center at National Pingtung University of Science and Technology, Taiwan. He received his BS in Electronic Engineering and MEd in Technological & Vocational Education from National Taipei University of Technology, Taiwan. He also received his MEd and PhD in Learning Design and Technology from The Pennsylvania State University, USA. Dr. Chou's research interests include emerging technologies in STEM education and maker education.

Wei-Fan Chen is an Associate Professor of Information Sciences and Technology at The Pennsylvania State University, USA. He received his BS in Information and Computer Engineering in 1993, from Chung Yuan Christian University, Taiwan. He received his MEd and PhD in Instructional Systems in 1999 and 2002, respectively, both from The Pennsylvania State University, USA. Dr. Chen's research and teaching interests include cognitive and information sciences and technology as related to learning.