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Integrating technology pedagogy and content knowledge in Qatar's preparatory and secondary schools: The perceptions and practices of STEM teachers

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Abstract

This paper is part of a project on enhancing STEM teaching through teachers' professional development (TPD). The aim is to explore K-12 science and mathematics teachers' views and practices about implementing STEM through technological pedagogical content knowledge (TPACK) model in Qatar and identify their challenges. The objective is to develop a TPD program using project-based learning pedagogical intervention to support K-12 science and mathematics teachers and to train them on how to implement PBL in their teaching practices. 245 STEM teachers from 16 preparatory and secondary schools, representing an equal number of males and females, responded to a STEM-TPACK survey on perceptions of and practices in teaching STEM subjects. One hundred thirty-seven preparatory (grades 7-9) and 108 secondary school teachers (grades10-11). Generally, there are no significant differences between the different dual groups in understanding STEM, TPACK, and embedding technology, with few exceptions in some aspects. This reflects a high consistency in teaching, pedagogy, and learning environments among these groups (gender, teaching level, and STEM subjects taught). Preparatory school teachers show more variations in all elements of TPACK than secondary school teachers, as reflected by values of standard errors of the mean (SEM). Male teachers show slightly more understanding of elements of TPACK and have somewhat higher means than female teachers. SEM for female teachers is slightly higher, indicating more variation among female teachers than male teachers. However, the difference is also insignificant, as characterized by the small effect sizes ranging from 0.13 to 0.31, small t-test values, and high p-values.

Keywords: pedagogy, project-based learning, STEM, technology integration, TPACK

INTRODUCTION

Unfortunately, the science and mathematics attitudes of Qatari students are not strong as those of students in many other countries. Results generated from our previous projects (El-Emadi et al., 2019; Said, 2016; Said et al., 2016, 2019), together with results from international tests such as PISA (program for international student assessment) and TIMMS (trends in international mathematics and science study) showed only modest progress. In these later tests, the averages and rank remain below the international benchmark (**Figure 1**) (Mullis et al., 2019; OECD, 2019).

From our previous research, we found:

1. A declining interest of Qatari students compared with their counterparts from other nationalities (Arab non-Qatari and non-Arab expatriates). Qatari students' attitudes toward science and their intentions to study science in the future decrease as they approach high school.
2. There is an inconsistency, or a gap, between most students' positive views of science (and its utility) and the lack of interest in enrolment in science programs and the pursuit of science-based careers.

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Contribution to the literature

- The present findings have implications for all education systems that plan to adopt STEM in their science and mathematics teaching.
- Students' science and mathematics achievement relates to their attitudes, enrollment in science and mathematics programs, and pursuit of their–related careers. A decline in students' attitudes toward studying science and mathematics has led to a "swing away from science, mathematics, and engineering." Teachers' attitudes and teaching practices are crucial in reversing students' attitudes and achievements. One among these practices is the use of the STEM approach, specifically the project-based learning pedagogy in teaching STEM.
- This study gains insight into the status of teachers' knowledge and practices of using technology to enhance science and mathematics teaching and recommends addressing the gap in teachers' skills and knowledge. It highlights a procedure for STEM teachers' professional development program that introduces PBL as a pedagogy in delivering STEM classes.

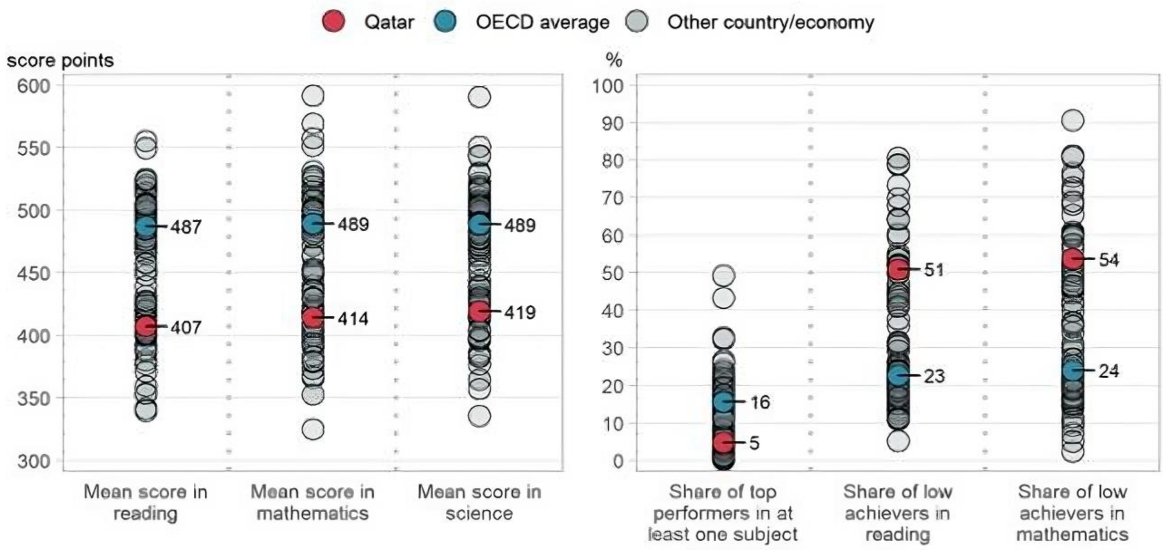

Figure 1. Students' performance in Qatar during the last PISA 2018 test compared to international students (Source: OECD 2019 Table 1.1 & Table 10.1)

3. Female students' attitudes are comparable to those of males, which is uncommon in most countries where males show more interest in taking science courses or working in science-related careers.
4. Non-Qatari Arab students studying in Qatari schools show less interest and a declining attitude compared to Qatari nationals studying in their community schools or international schools.

The above PISA results are alarming and reflect a state of stagnation in teaching practices with a lack of awareness of the need to implement changes required by the new curriculum standards to improve other conditions pertinent to science and mathematics teaching and learning processes.

Research suggests that among educational variables influencing student achievement, the quality of teaching is the most crucial variable. Research also indicates that, on average, the number of high-performing students taught by very qualified teachers is two-three times higher than the number of high-performing students prepared by low-qualified teachers in standardized tests (Darling-Hammond, 2000).

For students to develop mastery of knowledge content, problem-solving, critical thinking, effective communication and collaboration, and self-direction, teachers must employ a variety of pedagogical approaches and teaching strategies. Effective professional development (PD) is the key to improving teachers' learning and delivery skills (Darling-Hammond et al., 2017). This project focuses on improving science and mathematics teachers' quality by training them on effectively delivering practical integrated STEM activities in a life-context environment (to be distinguished from traditional learning style), which includes providing facts and guiding them on practicing the procedures). The program promotes integrating formal and informal science with extensive use of technology, training teachers on delivery skills of STEM activities in alignment with science and mathematics curriculum standards.

Teacher education, generally, focuses on one or two subject matters and pedagogy, and most teachers are not familiar with engineering, which is one essential element of STEM (Fore et al., 2015). Technological pedagogical content knowledge (TPACK) framework, introduced by Mishra and Koehler (2006) of Michigan State University in 2006, is considered the model of teachers' expertise for the 21st century (Al Salami et al., 2017; Chai, 2018). With it, they identified three primary forms of knowledge: content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). In its development, TPACK is a framework that can be used to analyze teacher knowledge related to technology integration (Koehler et al., 2013). In other words, it is a tool to identify teachers' capabilities. Based on OECD's (2019) report from PISA 2018, most science and mathematics teachers in Qatar have sufficient knowledge and technological skills and well-equipped classrooms.

Despite the many challenges in integrating technology into teaching and learning, digital technology offers excellent education opportunities. In many classrooms worldwide, technology supports quality teaching and student engagement through collaborative workspaces, remote and virtual labs, or the many ICT tools that help connect learning to authentic, real-life challenges (OECD, 2016). However, not all teachers use them for instructional purposes. Many studies have indicated that teachers do not use the tools because they have not been effectively trained (Harris & Hofer, 2011).

Nonetheless, the issue is not just teachers' skills but how they can be enacted within the education system. Despite the well-technology-equipped classrooms and moderately equipped laboratories, STEM integration in Qatar and many Arab countries is far from achievable shortly. Several challenges must be addressed, such as the schools' environment, the time constraint to cover extended curricula, and the crowded laboratories. Open and flexible spaces create more effective collaborative activities for teachers and students (OECD, 2016). Modern learning spaces can support inquiry where inquiries are shared, interventions developed collaboratively, and reflections based on self and peer observations, leading to a more robust, continuously improving practice.

STEM learning needs a flexible education policy, a relaxed environment, some free time, lab space, equipped labs, and support from the administration, and parents. Earlier, OECD (2013) stated,

> "Teachers need adequate professional development to meet pedagogical challenges; a common barrier to adopting new teaching models and resources is a lack of formal teacher training, peer learning, and more. Teachers also need time to integrate new technology-enhanced educational models into their pedagogy."

El-Deghaidy and Mansour (2015), based on views from teachers in Saudi Arabia (a similar context to Qatar), believe that a direct dialogue between science teachers, mathematics teachers, scientists, and engineers about STEM applications and activities would be essential for promoting STEM education in schools. Project-based learning (PBL) can provide a vital context for such a dialogue.

International literature has collectively agreed that technology interventions promote academic interest in STEM subjects (Han et al., 2015; Shank & Cotten, 2014). In Qatar, while youngsters have increasing access to diverse computer and media-related technology, their STEM performance is generally poor, as mentioned earlier despite the noticeable improvement in the last decade (OECD, 2019; Said, 2016). Some studies have also suggested that student-centered pedagogy, such as problem and PBL, can be used to support STEM studies by improving student efficacy, interest, attitude, and engagement (Cevik, 2018; Odell et al., 2019; Shank & Cotten, 2014).

PBL has been used during the last decade as a pedagogy to implement STEM; it promotes deeper connections to content and fosters essential inquiry skills through a series of questions and finding ways to find solutions. Real-world problems, the cornerstone of the STEM approach, require intensive questioning and the critical thinking, collaboration, and creative problem-solving needed for success in STEM. Therefore, implementing the PBL approach to STEM learning can help students form deeper connections to content, connect ideas across disciplines, and build the questioning, thinking, and metacognitive skills necessary for success in today's rapidly changing world (Capraro et al., 2013).

Research Problem

We try to answer the following research questions:

1. What are the views and experiences of STEM teachers applying TPACK tool and using the PBL approach in teaching STEM subjects?
2. What are the needed technological and pedagogical skills for teachers to successfully implement PBL in their curriculum delivery of science, mathematics, and integrated STEM?

METHOD

Survey Instrument

TPACK survey is adopted from a self-reported questionnaire developed by Sang et al. (2016). The survey was adapted to fit STEM education in Qatar and the specific objectives of this study. The 5-Likert scale survey consists of 39 items distributed among seven constructs (initially, 42 items).

Table 1. Survey constructs and example items after changes to fit the STEM context

Construct: n	Definition	Example item
CK: Four items	Knowledge of the subject matter.	I have sufficient knowledge about my teaching subject STEM topics.
PK: Eight items	Knowledge of student learning, instructional methods and processes, educational theories, and learning assessment.	I can guide my students to adopt appropriate learning strategies related to STEM-based projects and problems.
PCK: Seven items	Knowledge of adopting pedagogical strategies to make the subject matter more understandable for learners.	I cannot address my students' common learning difficulties in teaching STEM subjects without technology.
TK: Eight items	Knowledge about technology features, capacities, and applications.	I have technical skills to use computers effectively to design learning activities related to STEM.
TPK: Four items	Knowledge of existence & specifications of various technologies to enable teaching approaches.	I can facilitate students' use of technology to find more information related to STEM issues.
TCK: Three items	Knowledge about how to use technology to represent the content in different ways.	I know technologies I can use to research content regarding my teaching subject and STEM topics.
TPCK: Five items	Knowledge of using various technologies to teach and represent the designed subject content.	I can design real-world problems about the content knowledge to engage my students and represent them through computers.

Note. n: Number of items

Table 2. Sample population

Category	n	Number of schools
Gender		
Male	124	8
Female	121	8
Total	**245**	**16**
School level		
Preparatory	137	
Secondary	108	
Total	**245**	**16**

Table 1 shows the seven constructs and example items after changes to fit STEM context. The complete survey is found in **Appendix A**.

Table 2 shows the sample size and population of the respondent STEM teachers distributed among genders and school levels.

However, insufficient scientific knowledge, instructional methods, and conditions may be responsible for the low mastery.

RESULTS AND DISCUSSION

Data were analyzed using IBM SPSS version 28 (IBM SPSS Statistics for Windows, 2021). Very high reliability indicated by Cronbach's alpha coefficient (α) of the seven constructs was observed.

Removing each item from the adapted survey to check the impact did not show a significant change in the values; therefore, no item was removed. Thus, the values are, as follows: **CK** is 0.950, **PK** is 0.982, pedagogical content knowledge (**PCK**) is 0.967, **TK** is 0.960, technological pedagogical knowledge (**TPK**) is 0.971, technological content knowledge (**TCK**) is 0.953, and technical pedagogical content knowledge (**TPCK**) is 0.953.

The high-reliability values indicate a highly satisfactory level of construct validity and internal consistency of the questionnaire, similar to the original survey (Sang et al., 2016) adapted from it. However, the high value of alpha does not indicate uni-dimensionality; because each of (the majority of items) measures a discrete aspect, a high alpha value may suggest that a lot of the variance is due to general respondent-related factors (e.g., intelligence, study diligence, and motivation in the subject).

Consequently, the instrument may not differentiate well between different features of the tested concepts (Taber, 2018). However, statistical tests show high-reliability consistency, with slightly high variances obtained among groups, as will be explained next section.

Descriptive Statistics

Generally, there are no significant differences between the different dual groups in understanding STEM, TPACK, and embedding technology, with few exceptions and minor aspects. This reflects a high consistency in teaching, pedagogy, and learning environments among these groups (gender, teaching level, and STEM subjects taught).

Thus, **Table 3** indicates that preparatory schoolteachers show more variations in all elements of TPACK than secondary school teachers, as reflected by values of standard errors of the mean (SEM) despite the larger sample of preparatory schoolteachers (137 compared with 108 for secondary school teachers). This can be explained because preparatory schoolteachers teach general science subjects with less knowledge, experience, and exposure to a STEM environment.

Table 3. Group descriptive statistics-95% confidence interval comparison based on school level (significant level .05)

Construct	SL	n	Mean	SD	SEM	ES: $d_{(cohen)}$	t-test[a]	P-V: OS
CK	Preparatory	137	21.2701	5.38039	.45968	0.125	0.987	0.162
	Secondary	108	21.8704	4.13576	.39796			
PCK	Preparatory	137	29.1679	7.53674	.64391	0.143	1.083	0.130
	Secondary	108	30.1204	5.69262	54777			
TK	Preparatory	137	28.6788	7.16090	61180	0.116	1.127	0.183
	Secondary	108	29.4630	6.34878	.61091			
TPK	Preparatory	137	19.9708	5.23975	.44766	0.085	0.907	0.255
	Secondary	108	20.3889	4.64000	.44648			
TCK	Preparatory	137	12.0657	3.32814	28434	0.158	0.661	0.107
	Secondary	108	12.5463	2.71852	.26159			
TPCK	Preparatory	137	19.5839	5.07103	.43325	0.028	1.244	0.414
	Secondary	108	19.7222	4.87380	46898			
TPACK	Preparatory	137	160.5036	39.14662	3.34452	0.128	1.0020	0.159
	Secondary	108	165.0278	31.48815	3.02995			

Note. SL: School level; SD: Standard deviation; SEM: Standard error mean; ES: Effect size; & P-V: OS: p-value: One sided

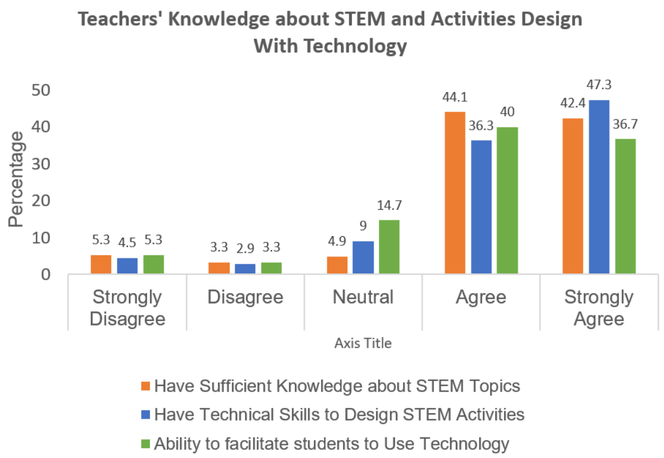

Figure 2. Teachers' knowledge about STEM & activities design with technology (Source: Authors' own elaboration)

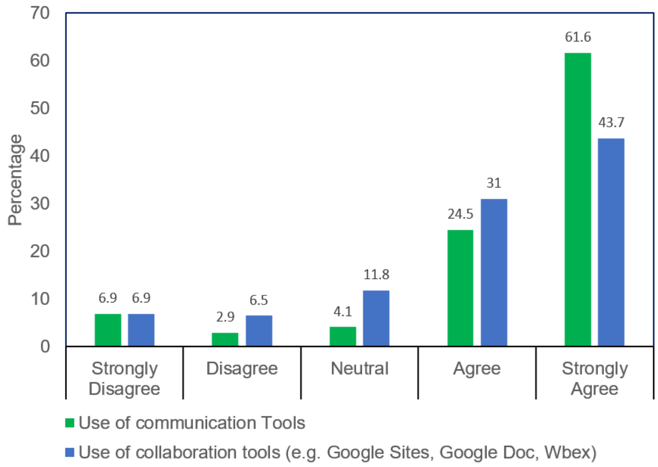

Figure 3. Ability to use technology tools in classroom (Source: Authors' own elaboration)

Male teachers show slightly more understanding of elements of TPACK and have somewhat higher means than female teachers. SEM for female teachers is somewhat higher, indicating more variation among female teachers than male teachers. However, the difference is also insignificant, characterized by the small effect sizes ranging from 0.13 to 0.31, small t-test values, and high p-values (**Table 3**).

About 80%t of STEM teachers show understanding and knowledge of TPACK (**Figure 2**). Secondary school teachers show slightly more sense of all elements of TPACK and have somewhat higher means than preparatory schoolteachers. However, about 30% of teachers reported a lack of knowledge about the design of inquiry-based activities using ICT Tools and insufficient skills (**Figure 2**). 25% cannot solve technical problems. Nevertheless, the differences between preparatory and secondary school teachers are insignificant, as reflected by the small effect sizes.

About 30% of teachers reported a lack of knowledge about the design of inquiry-based activities using ICT Tools and insufficient skills (**Figure 2**). 25% cannot solve technical problems. In addition, nearly 15% of them have insufficient knowledge of communication, and 25% have inadequate skills in collaboration tools such as Google Sites, Google Docs, and WebEx (**Figure 3**), which are necessary tools to design activities on real-world problems that are, also, context of PBL (Holmes et al., (2021). PBL has been introduced recently as one pedagogical approach to the Qatari education system (Al Said et al., 2019). Therefore, teachers' professional development (TPD) training will emphasize these aspects of STEM teaching pedagogy.

Comparing genders using ANOVA test indicates insignificant or very few differences, as reflected in the difference in mean square values, low-test values, and small effect sizes (**Table 3**).

There were significant differences in using Mann-Whitney U test for the influence of the teachers' specialization in education on teachers' views of CK, PK, CPK, TPK, TPCK, and TPACK in favor of holding a certificate in education except in TK (**Table 4**). These results indicate the need for collaboration between teachers teaching different STEM subject disciplines.

Table 4. Group descriptive statistics-95% confidence interval comparison based on gender (significant level .05)

Construct	Gender	n	Group mean	SD	SEM	ES: $d_{(cohen)}$	t-test[a]	P-V: OS
CK	Male	124	22.1452	4.31803	.38777	1.993	0.255	0.086
	Female	121	20.9091	5.32447	.48404			
PCK	Male	124	30.7500	6.53026	.58643	1.075	0.138	0.31
	Female	121	29.7851	7.47129	.67921			
TK	Male	124	30.0161	6.05662	.54390	0.997	0.128	0.075
	Female	121	29.1488	7.46621	.67875			
TPK	Male	124	29.6048	6.36405	.57151	1.350	0.173	0.152
	Female	121	28.4298	7.22130	.65648			
TCK	Male	124	20.8387	4.55925	.40943	2.189	0.280	0.088
	Female	121	19.4545	5.30252	.48205			
TPCK	Male	124	12.6048	2.78153	.24979	1.688	0.216	0.218
	Female	121	11.9421	3.33241	.30295			
TPACK	Male	124	20.4032	4.66943	.41933	2.436	0.312	0.058
	Female	121	18.8678	5.17517	.47047			

Note. SD: Standard deviation; SEM: Standard error mean; ES: Effect size; & P-V: OS: p-value: One sided

Table 5. The influence of teachers' specialization in education on TPACK

Construct	Null hypothesis [a, b]	Significance	Description
CK	The distribution of CK is the same across categories of (Do you hold a certificate in education other than a STEM degree?	<0.001	Rejected
PK	The distribution of PK is the same across categories of (Do you hold a certificate in education other than a STEM degree?	0.002	Rejected
PCK	The distribution of PCK is the same across categories of (Do you hold a certificate in education other than a STEM degree?	0.003	Rejected
TK	The distribution of TK is the same across categories of (Do you hold a certificate in education other than a STEM degree?	0.073	Retained
TPK	The distribution of TPK is the same across categories of (Do you hold a certificate in education other than a STEM degree?	0.002	Rejected
TCK	The distribution of TCK is the same across categories of (Do you hold a certificate in education other than a STEM degree?	0.004	Rejected
TPCK	The distribution of TPCK is the same across categories of (Do you hold a certificate in education other than a STEM degree?	-0.001	Rejected

Note. Test: Independent-samples Mann-Whitney U test; [a]Significant level is 0.05; & [b]Asymptotic significance is displayed

There were significant differences in using Mann-Whitney U test for the influence of the teachers' specialization in education on teachers' views of CK, PK, CPK, TPK, TPCK, and TPACK in favor of holding a certificate in education except in TK (**Table 5**). These results indicate the need for collaboration between teachers teaching different STEM subjects.

STEM learning needs a flexible education policy, a relaxed environment with free time, lab space, equipped labs, and support from the administration, colleagues, and parents. Earlier, OECD (2013) stated,

> "Teachers need adequate professional development to meet pedagogical challenges; a common barrier to adopting new teaching models and resources is a lack of formal teacher training, peer learning, and collaboration. Teachers also need time to integrate new technology-enhanced educational models into their pedagogy."

Teachers' Professional Development Framework

Based on these findings, we developed a framework for TPD in the following sequence currently in progress.

1. TPACK survey is distributed to identify teachers' skills' needs in technological and pedagogical aspects,
2. Enroll mathematics and science teachers in a series of hands-on, collaborative workshops with some contributions from engineering educators,
3. Assigning PBL activities using technological support based on curriculum standards of both science and mathematics subjects,
4. Part of the training is on assessment strategy focusing on formative assessment,
5. Next stage, teachers select projects (two each) and guide students to work in independent groups to carry out the projects,
6. Students' performance is evaluated, and teachers reflect to trainers for final evaluation,

7. Final evaluation is performed by selecting a random sample of students to assess their knowledge and technical skills compared to a similar number who have not performed PBL-STEM training.

CONCLUSIONS

1. Regardless of the school level and gender, teachers have almost the same views and needs of TPACK-PBL in STEM teaching.
2. Specialism in education is very significant and influential for teachers' views of TPACK-PBL in STEM and the context and settings of TPD.
3. Teachers' major specialism and their teaching subjects are significant for views of TPACK-PBL in STEM. This needs to be considered when planning for CPD training and teachers' practices.
4. Teachers' bachelor's degrees influenced teachers' views of TPACK-PBL in STEM.
5. Attention must be given to mathematics, physics, and biology subjects about PBL and STEM.
6. A qualitative study including interviews with teachers and students together with classroom observations is significant for interpreting and understanding these quantitative findings.

Recommendations

1. Strengthen the skills of teachers through training activities based on curriculum standards.
2. Arrange collaborative PBL projects that involve students and STEM teachers from different disciplines.
3. Develop STEM mentoring programs to support STEM teachers and ensure that STEM mentors will be available to teachers.
4. Ensure STEM PD includes real-world applied learning, inquiry-based strategies, and project/problem-based learning.
5. Assess the effectiveness of PD and mentoring programs.
6. Involve principals and schools' leadership in PD of STEM teachers.

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APPENDIX A: STEM TEACHERS' SURVEY ON INTEGRATING TECHNOLOGY PEDAGOGY & CONTENT KNOWLEDGE (TPACK) IN THEIR CLASSES IN PREPARATORY AND SECONDARY SCHOOLS IN QATAR-ENHANCING STEM TEACHING THROUGH TEACHER PROFESSIONAL DEVELOPMENT (TPD)

Table A1. Background information

1. Date	2. Name & school name (optional)					
3. Gender	☐ Male	☐ Female	4. Nationality	☐ Qatari	☐ Non-Qatari Arab	☐ Other (specify)
5. Teaching grade level	☐ 7	☐ 8	☐ 9	☐ 10	☐ 11	☐ 12
6. Your normal load hour per week						…… hrs/week
7. Total years of experience	☐ Less than 1 year	☐ 1-2 years	☐ 3-5 years	☐ 6-10 years	☐ 11-20 years	☐ 21+ years
8. Years of experience in Qatari schools	☐ Less than 1 year	☐ 1-2 years	☐ 3-5 years	☐ 6-10 years	☐ 11-20 years	☐ 21+ years
9. Highest academic degree you hold	☐ Vocational certification	☐ BSc. degree	☐ MSc. degree	☐ PhD	☐ Others	
10. Your major & minor area(s) of study during your education at university or college	Major: ☐ Biology ☐ Chemistry ☐ Computer science ☐ Earth science ☐ Mathematics ☐ Physics	Minor (If applicable): ☐ Biology ☐ Chemistry ☐ Computer science ☐ Earth science ☐ Mathematics ☐ Physics ☐ Others ------------				
11. Subjects you currently teach	☐ Biology ☐ Chemistry ☐ Computer science	☐ Earth science ☐ Mathematics ☐ Physics ☐ Others ------------				
12. Do you hold any education certificates (other than a STEM degree)?	☐ Yes. If yes, please specify:	☐ No				

Select one answer (only) that most describes your agreement/disagreement with each statement in the following questionnaire.

Table A2. Questionnaire (SD: Strongly disagree; D: Disagree; NAD: Neither agree or disagree; A: Agree; & SA: Strongly agree)

	SD	D	NAD	A	SA
CK (content knowledge)					
1. I have sufficient knowledge about my teaching subject.					
2. I can think about the content of my teaching subject like a subject matter expert.					
3. I can gain a deeper understanding of the content of my teaching subject on my own.					
4. I am confident in teaching the subject matter.					
PK (knowledge about teaching methods)					
5. I can guide my students to adopt appropriate learning strategies related to STEM-based projects, including project-based & problem-based learning.					
6. I can adapt my teaching on what students currently understand or do not understand.					
7. I can adapt my teaching style to different learners.					
8. I can assess students' learning in multiple ways.					
9. I am familiar with common students' understandings and misconceptions.					
10. I know how to assess student performance in a classroom.					
11. I can use a wide range of teaching approaches in a classroom setting.					
12. I know how to organize and maintain classroom management.					

Table A2 (Continued). Questionnaire (SD: Strongly disagree; D: Disagree; NAD: Neither agree or disagree; A: Agree; & SA: Strongly agree)

	SD	D	NAD	A	SA
PCK (pedagogical content knowledge) without using technology					
13. I can address the common misconceptions my students have for my teaching subject.					
14. I can help my students to understand the content knowledge of my teaching subject through various ways.					
15. I can address common learning difficulties my students have for my teaching subject.					
16. I can facilitate meaningful discussion about the content students are learning in my teaching subject.					
17. I can engage students in solving real-world problems related to my teaching subject.					
18. I can engage students with hands-on activities to learn content of my teaching subject.					
19. I can support students to manage their learning of content for my teaching subject.					
TK (knowledge in managing technology)					
20. I have the technical skills to use computers effectively to design learning activities related to my STEM subject.					
21. I can easily learn technology.					
22. I know how to solve my own technical problems when using technology.					
23. I keep up with important new technologies.					
24. I am able to use social media (e.g., Blog, Wiki, Facebook, & WhatsApp).					
25. I am able to use communication tools (e.g. ,Yahoo, IM, MSN Messenger, & Skype)					
26. I am able to use collaboration tools (e.g., Google Sites, Google Doc, & Webex).					
TPK (technological pedagogical knowledge) i.e., knowledge about using technology in teaching					
27. I can use technology to introduce my students to real-world scenarios.					
28. I can facilitate students' use of technology to find more information about STEM topics.					
29. I can choose technologies that enhance students' learning for a lesson.					
30. I can facilitate my students' use of technology to plan and monitor their own learning.					
31. I can facilitate my students' to collaborate with each other using technology.					
TCK (knowledge about technology used in my STEM teaching subject)					
32. I know about the technologies that I have to use for the research of content of my teaching subject.					
33. I can use appropriate technologies (e.g., multimedia resources, simulation) to represent the content of my teaching subject.					
34. I can use specialized software to perform inquiry about my teaching subject.					
TPACK (technology pedagogy and content knowledge)-ICT integration knowledge					
35. I can construct real-world problems about the content knowledge and represent them through computers to engage my students.					
36. I can teach lessons that appropriately combine math/science, technologies and teaching approaches.					
37. I can create self-directed learning activities of the content knowledge with appropriate ICT tools (e.g., Blog & Webquest).					
38. I can design inquiry activities to guide students to make sense of the content knowledge with appropriate ICT tools (e.g., simulations & Web-based materials).					
39. I can design lessons that appropriately integrate content, technology, and pedagogy for student-centered learning.					

THANK YOU FOR COMPLETING THIS SURVEY!