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Delphi technique as a graduate course activity: Elementary science teachers' TPACK competencies

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Abstract. This study aims to explore graduate science education students' views of elementary science teachers' TPACK competencies by employing a Delphi technique. 9 graduate science education students enrolled in a graduate course participated in the study. In the first round, participants were asked to list the competencies of an elementary science teacher with high level of TPACK and a total of 88 competencies were listed. In the second round, all participants investigated these competencies and eliminated the similar ones. In the third round, the number of competencies was narrowed down to 35 and participants rated them on a 7-point Likert type scale. In the fourth round, participants investigated the interquartile range and median values for those competencies, their own previous ratings and rated the competencies again. At the end, a total of 29 competencies were agreed on by all participants. For agreement criteria interquartile range and median values were used.

Keywords: Delphi technique; technological pedagogical content knowledge; science teachers; teaching with technology

1 Introduction

Technology integration into education has been studied widely in recent years since it has a great potential to improve education and facilitate better student learning [7]. During the earlier years of the discussion of technology integration, the focus was on technological skills of teachers ignoring the pedagogy and content area skills; however, then, educators

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realized that knowledge of technology itself does not guarantee promoting students' learning effectively and the focus shifted to meaningful integration of technology into teaching [4]. Based on this idea, Mishra and Koehler [11] proposed the Technological Pedagogical Content Knowledge (TPACK) framework which suggests that good teaching with technology requires an effective combination of three key components: content, pedagogy and technology. TPACK framework argues that teachers need to "develop fluency and cognitive flexibility not just in each of the key domains (T, P, and C), but also in the manner in which these domains and contextual parameters interrelate" [9]. Although TPACK framework has been accepted and studies widely in the educational research community, it has also been criticized for its theoretical background. Graham [3] suggested that, different studies define the TPACK construct and its elements in different ways and there is not a solid theoretical background behind the framework; the term TPACK can be easily replaced with the term technology integration. For this reason, many researchers stated that the need for theoretical studies investigating TPACK. It is suggested that the TPACK construct, its elements and what it means for a teacher to have TPACK should be defined clearly with the help of Delphi studies [1, 12]. Moreover, it is also important to define TPACK specific to the different subject areas since each subject area has its own characteristics, teaching strategies and learning environments.

Inspired by the aforementioned idea, this study aims to explore graduate science education students' views of elementary science teachers' TPACK competencies by employing a Delphi technique. The specific question that was tried to be answered was: "What are the competencies of an elementary science teacher with high level of TPACK?"

2 The study

2.1 Context

The study was conducted within a graduate course named "Technology integration into science education". 9 experts (5 M.S. and 4 Ph.D.) student graduated from science education departments were the Delphi panelists. Moreover, a science education professor had guided the process. Prior to the study, all participants attended the course for four weeks (12 course hours) where TPACK related readings were made, and classroom discussions and activities were held.

2.2 The Delphi technique

Delphi technique is a method where a group of individuals investigate a complex problem by cooperating and communicating each other [10]. The objectives of the Delphi technique were summarized by Delbecq, Van de Ven, and Gustafson (1975) as:

1. To determine or develop a range of possible program alternatives;
2. To explore or expose underlying assumptions or information leading to different judgments;
3. To seek out information which may generate a consensus on the part of the respondent group;
4. To correlate informed judgments on a topic spanning a wide range of disciplines, and;
5. To educate the respondent group as to the diverse and interrelated aspects of the topic (p. 11).

In general, a Delphi technique is composed of three or four rounds [6]. In the present study, four rounds were conducted.

2.2.1 The Delphi Technique – First Round

In the first round, all Delphi panelist were received an open-ended question asking "What are the competencies of an elementary science teacher with high level of TPACK?". They were asked to list all competencies that they think a teacher should possess to have a high level of TPACK. They were given a week to think about this question and list the competencies. At the end of the first round, 88 competencies were listed by 9 experts.

2.2.2 The Delphi Technique – Second Round

In the second round, the researcher listed these 88 competencies, organized them and distributed to the Delphi panelists electronically for review. The experts were asked to comment on all of the items, evaluate their clarity and write their suggestions related to the similar items. Based on the experts reviews' similar items and unclear items were eliminated. At the end of the second round, the number of the competencies was narrowed down to 35.

2.2.3 The Delphi Technique – Third Round

In the third round, each Delphi panelist received a questionnaire composed of the 35 competencies listed and organized by them. They were asked to rate these competencies on a 7-point Likert type scale ranging from strongly disagree (=1) to strongly agree (=7). Moreover, they were also asked to comment on the competencies and write suggestions for the researcher. At the end of the second round, after receiving each panelist's ratings, the interquartile range and median values were calculated.

2.2.4 The Delphi Technique – Fourth Round

In the fourth and last round, each Delphi panelist received a questionnaire including the calculated the interquartile range and median values for each item. This last questionnaire also included their own previous rating. The panelists were told that they can stick with their previous rating or they can revise it after seeing the interquartile range and median values representing the ideas of the majority. They were also asked to explain the reason behind their decision.

At the end of the four Delphi rounds, a total of 29 competencies were agreed on by all participants. For agreement criteria interquartile range and median values were used. Consensus was obtained, if the interquartile range was 1 or below [2]. A full list of theese competencies and eliminated competencies and their interquartile range values can be seen in Appendix 1.

3 Discussion and conclusion

The Delphi technique employed in the present study provides a fruitful discussion environment, increase collaboration between participants and provides a broader perspective. Moreover, it provides a brainstorming environment to reach a consensus on an ill-structured problem. The aim of a Delphi study is not to produce significant results; rather it seeks to identify a group of experts' theoretical and empirical perspectives on a particular issue [8].

In the present study, it was aimed to determine a set of example TPACK competencies that a science teacher should have. The listed competencies revealed that experts generally see technology integration as a transformative process. Teachers should be able to use

technology in a way that changes their regular teaching practices to enhance students learning. As Harris, Lee and Kington [5] stated "the emphasis is not on innovative technology, but innovative practices that involve new or changed roles for teachers and pupils, and in which ICT (information and communication technologies) plays a part". Therefore, it could be said that teachers have the key role in technology integration process. Integration of technology into education requires a change in the way teaching and learning occurs; it should not be only a change in the classroom equipment. Most of the competencies listed were focused on the use of technology for pedagogical purposes. The experts' ideas of TPACK competencies were in accordance with the literature suggesting that technology is just a tool to improve our teaching practices. If technology is not integrated into teaching properly, it will not result in any changes.

Considering the potential improvements that can be obtained by effective technology integration, it is important for our teachers to have required skills. For this reason, the first step is to determine what teachers should know and be able to do for this process. The results of the present study exemplify a minimalist picture of what should be done to be able to define required teacher skills. However, much should be done to be able to identify teacher competencies. After that better teaching training programs can be designed to help our teachers integrate technology effectively into their classroom practices.

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Appendix A. Elementary science teachers' TPACK competencies proposed by Delphi participants

	Q1	Q2	Q3	IR
An elementary science teacher with a high level of TPACK will be able to:				
1. Follow the developments related to digital technologies in science education.	6	6	7	1
2. Adapt to innovations brought by technological advancements.	6	6	6.5	0.5
3. Attend to professional development programs (in-service training, seminar, workshop etc.) related to technology integration into science education.	6	7	7	1
4. Collaborate with other teachers for self-improvement on technology integration into science education.	6	7	7	1
5. Use various different technologies to enhance science teaching.	6.5	7	7	0.5
6. Use technology for designing a student-centered learning environment.	6	7	7	1
7. Use technology to solve classroom management problems.	6	6	7	1
8. Use technology to facilitate students' understanding of science concepts.	7	7	7	0
9. Use technology in a way to improve students' science process skills.	6.5	7	7	0.5
10. Use technology for eliminating science misconceptions	7	7	7	0
11. Use technology in a way to increase students' interest in science topics.	6	7	7	1
12. Use technology effectively during different steps (preparation, implementation, evaluation etc.) of the science teaching process.	7	7	7	0
13. Choose appropriate technologies for different teaching methods.	6.5	7	7	0.5
14. Choose technologies which supports the science content to be taught in the best way.	7	7	7	0
15. Use domain-free technologies in accordance with the objectives of the lesson.	6.5	7	7	0.5
16. Evaluate the strengths and weaknesses of the technologies to be used.	6	7	7	1

17. Be aware of the problems that might arise while using technology in the classroom.	6	6	6.5	0.5
18. Find solutions to problems that arose while using technology in the classroom.	6	7	7	1
19. Take into consideration the technological infrastructure of the classroom/school while integrating technology into science teaching.	6.5	7	7	0.5
20. Take into consideration students' technology use skills while integrating technology into science teaching.	6.5	7	7	0.5
21. Take into consideration students' level of development while choosing technologies to integrate into science teaching.	6.5	7	7	0.5
22. Take into consideration students' individual differences while choosing technologies to integrate into science teaching.	6	7	7	1
23. Evaluate the technologies to be integrated into science teaching in terms of the quality of the science content.	7	7	7	0
24. Differentiate reliable online sources considering the information pollution on the internet.	6.5	7	7	0.5
25. Take into consideration ethical guidelines while integrating technology into science teaching.	6	7	7	1
26. Help students develop a positive attitude towards integrating technology into science teaching.	6.5	7	7	0.5
27. Raise students' awareness about how to follow ethical guidelines on the online platforms.	6	7	7	1
28. Guide students on online learning environments.	6	7	7	1
29. Raise students' awareness about how to evaluate the quality of science content on the internet.	7	7	7	0

A.1. Eliminated competencies in the 3rd and 4th round of Delphi

	Q1	Q2	Q3	IR
1. Use technology to promote inquiry-based learning.	5.5	7	7	1.5
2. Use technology in a way to increase students' participation in the lesson.	5.5	7	7	1.5
3. Test the technology to be used before the lesson.	5.5	6	7	1.5
4. Predict the misconceptions students' might develop while using technology in the classroom.	5	7	7	2
5. Increase the use of technology in the classroom by giving students responsibilities.	4.5	7	7	2.5
6. Help students improve their technology use skills.	4.5	6	6.5	2

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