

## The Science Teachers' Pedagogical Contents Knowledge in Teaching Physics and Students' Achievements (Literature Review)

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### Abstract

This study presents a review of the findings of previous studies that were clearly conducted of the science teacher's knowledge of pedagogical content (PCK), and its effect on students' achievement. The current study aims to present a review on the available literature evidence on the effect of the pedagogical knowledge of the science teachers (PCK), and its effect on student achievement. The analysis was limited to studies conducted from 2008 to 2018 in the science subject. To achieve the goal of this study, a qualitative, analytical approach was used; the analysis sample consisted of eleven research studies and work paper. The results showed that there is a weak relationship between science teachers' knowledge of pedagogical content (PCK) in teaching physics subjects and the achievement of their students. The study also showed that a good knowledge for teachers of the pedagogical content is not sufficient to improve student achievement.

**Keywords:** Pedagogical Content Knowledge (PCK), Science teacher, Physics subjects, students' achievement.

## INTRODUCTION

Science teachers face a difficult challenge in the teaching process, as teaching any subject is a complex knowledge activity, and it requires that the teacher employ knowledge from multiple fields as indicated by (Wilson, Shulman & Richerd, 1987). The knowledge was referred by Shulman as the "knowledge of pedagogical content". Thus, the knowledge of pedagogical content for teachers occupied a wide area of interest of researchers and educators since the eighties of the last century from different angles. The extent to which the knowledge of pedagogical content of the teacher has become a criterion for assessing the extent of his success in teaching (Smith & Neal, 1989). The study of knowledge of pedagogical content with science seeks to understand the differences between the methods of teaching teachers (Bindernage, & Eilks, 2009).

Some science teachers perceive that physics topics are very challenging to teach because of its abstract nature. This might be due to the extent to which teachers understand the nature of pedagogical knowledge of the content (PCK) of the subject they are teaching. This type of knowledge falls under the academic subjects in the field of teacher specialization and the methods of representing and formulating these materials facilitate the process of assimilation of students.

Several studies have shown that student's enthusiasm to accept certain subjects, especially physics, are as low (Fortus, 2014; Schiefele, 2009). In general, teaching science subjects must be based on a broad knowledge and combining knowledge of science with knowledge of pedagogical principles (Van Dijkstra, Kattmann, 2007). Verloop et al 2002 defined PCK as the totality of knowledge that the teacher displays at a specific moment, and behind which his behavior lies. The teacher's knowledge relates to the nature of his work, and lies in everything related to his educational activities, inside and outside the classroom.

Shulman 1986 conducted a study on the knowledge of the teacher, in terms of what he knows, what he needs to know, the sources of his knowledge, how to organise it, how he assimilated the scientific subject, the effect of that on his teaching, how to transform that knowledge to be understandable to students, and how he deals with the scientific content? How is that knowledge used in the teaching process? He defined pedagogical content knowledge as the use of similes, metaphors, examples,

And presentations to make the subject understandable to students (Ambosaidi, Al-Hajri, 2013).

Therefore, the teachers play a significant role on students' achievement and are held partially responsible for the low level of their enthusiasm and performance. So, this study came to reveal the relationship between the science teacher's knowledge of pedagogical content in teaching physics topics and the achievement of their students.

## **METHODS**

In this study, a qualitative, analytical approach was used to identify the relationship between the pedagogical knowledge of science teachers in teaching physics topics and the achievement of their students. Available literature that dealt with the pedagogical knowledge of teachers (PCK) and its impact on students' achievement were collected and reviewed. This was limited to studies in science between 2008 and 2018. Inclusion and exclusion criteria are shown on Figure 1.

Due to the large number of studies that dealt with teaching science, the study sample was limited to those specific to physics. The analysis sample consisted of ten research studies and scientific articles.

A search of reported studies was started with the subjects listed under the subject of physics education in PhysPort, which is an online platform containing teaching resources for physics educators community (American Association of Physics Teacher, 2019). As well, search Mendeley reference manager was used on keywords PCK, achievement, and 'science teachers'. Emphasis was placed on studies and scientific articles that concerned the science teacher in teaching physics topics and the achievement of their students.

The studies and scientific articles were studied and analyzed in terms of the methodology used, the study community and its sample, as well as the goals that those studies and scientific articles sought.

The significant findings and recommendations were also analyzed. Inclusion flow chart is shown below:

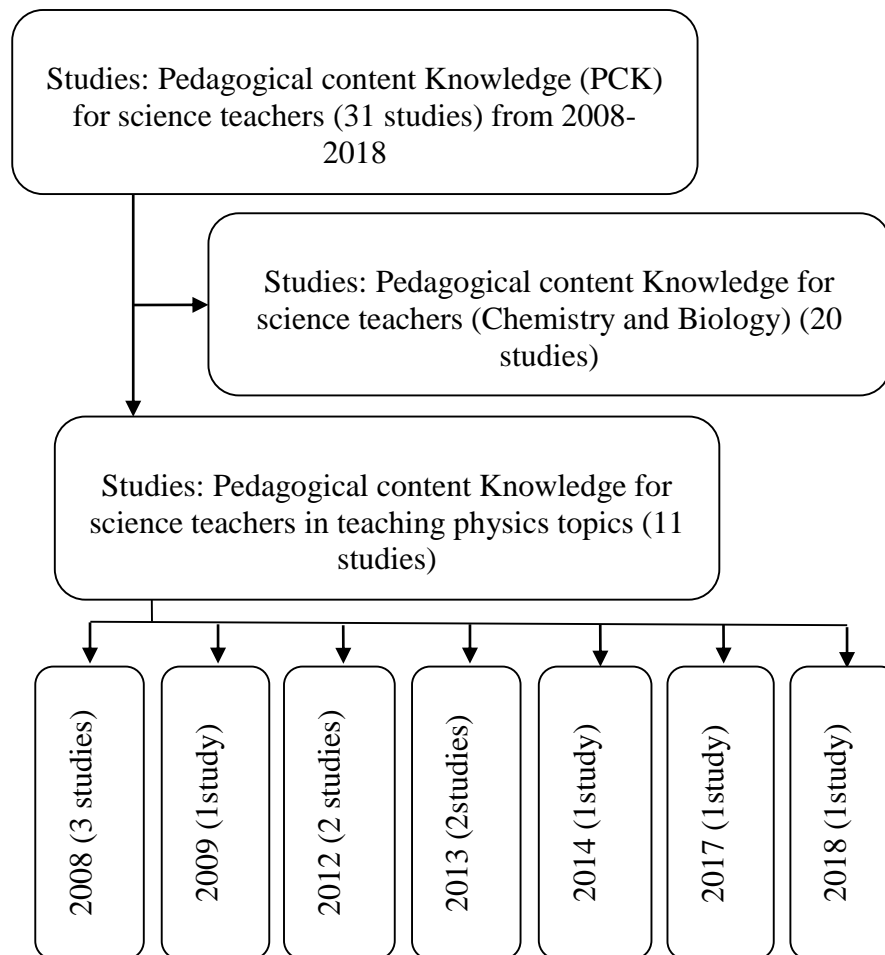


Figure1. Inclusion flow chart

## RESULTS

The study population consisted of science teachers who study physics and their students. Eleven studies that met the inclusion criteria were analysed. Total study sample in all eleven studies consisted of 316 science teachers and 2583 students.

It is clear from the review of previous studies that there is a growing interest in the subject of pedagogical knowledge and knowledge of the content of teachers and its effect on students' achievement.

Previous studies varied in the study population and the sample in terms of type and number, in addition to diversity in study instruments used in identifying pedagogical content knowledge and student achievement.

Some authors, (Angell, Ryder, & Scott, 2005; Karisan, Senay, & Ubuz, 2013; Miqdadi, & Al-Omari, 2014), used questionnaires whereas test was used in Habbas study (2009). Some studies used more than one instrument such as a study by Al-Ramahi & Rawagah (2018), that used questionnaires and tests, and Hamida 2008 that used the questionnaire, individual interviews, and class notes. In addition, some studies used lesson plans and interviews, as it is difficult to measure this knowledge directly. As for the research methodology, some studies were distinguished by using the qualitative method (Karisan, Senay & Ubuz, 2013; Miqdadi & Al-Omari, 2014) or the analytical method such as studying (Becker & Aloe, 2008).

Referring to the results of previous studies, we note that some of them have found that the teacher's knowledge of pedagogical content has an influence on students' achievement. The broader the teacher's knowledge of pedagogical content is the better the students' achievement become. This is found by (Keller; Neumann & Fischer, 2017). The study (Lange, Kleickmann, & Molle, 2012), confirmed a significant correlation between teacher's knowledge of pedagogical content and student achievement.

Also, some studies have shown that there is a strong relationship between the teacher's knowledge of pedagogical content and student achievement, such as the Habbas, 2009 study. On the other hand, some studies showed a weak relationship between the teacher's knowledge of pedagogical content and the achievement of their students, such as study of Becker & Aloe, 2008. Their study also indicated that a good knowledge of the teacher is not sufficient to raise the performance and achievement of students.

A recent study by Al-Ramahi and Rawagah 2018, concluded that there are no statistically significant differences in the relationship between the teacher's knowledge of pedagogical content and student achievement.

## DISCUSSION

The study of the teacher's pedagogical content knowledge is not new. There are several scientific and pedagogical studies conducted in this field in general science subjects. Some of which have been researched in physics teachers such as the study of Keller, Neumann, & Fischer (2017), and Kapucu & Yildirim, 2012, whose results showed a statistically significant difference in knowledge of physical content. Mohlouoa, Rollnick, & Oyoo (2012) study recommended increasing the PCK for teachers. Along this, Angell, Ryder & Scott, 2005 study showed that there is a difference between the novice teacher and the expert in pedagogical knowledge.

This is explained by that the novice teacher is interested in transferring correct content and producing separate elements of knowledge, while the expert teacher places rich links between the elements of his knowledge in different contexts. In the same context, the results also showed that the novice teacher lacks knowledge of the characteristics of student thinking, educational strategies and knowledge of the curriculum. Whereas the study of Magnusson, Broko, Krajcik, & Layman (1992), Which examined the relationship between the nature of teachers' pedagogical knowledge of the nature of content and learners and teaching strategies, showed that experienced teachers had more knowledge than junior teachers.

Some studies have examined PCK, science teachers and physics students and their relationship to various variables, including academic achievement, which this study seeks to discuss. Ozaden, 2008 conducted a study aimed at evaluating the effect of knowledge of scientific content on PCK. Habbas 2009 study, which aimed to examine the relationship between the teacher's knowledge of how to teach students and student's achievements. Study results indicated that teachers have a weakness in how to teach content and student achievement.

Lange, Kleickmann, and Molle, 2012 study also showed that PCK among science teachers is closely related to the achievement of their students. The results of the Carlsen, 1990 study also showed that the teacher tends to innovate in teaching strategies whenever his knowledge of pedagogical content is strong. Table 1 presents extracted information from 11 selected articles about the science teachers' knowledge of pedagogical content PCK in teaching physics subjects.

The articles were categorized to authors, research design, research method, designed product, measured variable (s) and effectiveness.

**Table 1** Studies on the science teachers' PCK in teaching physics subjects

| # | Authors, Years                     | Aims   | Research Design* |   |   |   | Method                  | Findings   | Subject of physics       |
|---|------------------------------------|--|------------------|---|---|---|-------------------------|--|--------------------------|
| 1 | (Al-Ramahi & Rawagah, 2018)        | Examine the PCK of the physics teachers and its relationship to the academic achievement of their students                                       | T<br>√           | Q | I | O | Analytical descriptive  | No statistically significant differences in the relationship between the teacher's knowledge of pedagogical content and student achievement        | Basic concepts of fluids |
| 2 | (Keller; Neumann, & Fischer, 2017) | Examine students' achievement and interest and the extent to which they are predicted by teacher knowledge of pedagogical content and motivation | √                | √ |   |   | A multi-method approach | Partially relationship between teachers' knowledge of pedagogical content (PCK) in teaching physics subjects and the achievement of their students | Electricity              |
| 3 | (Miqdadi, & Al-Omari, 2014)        | Explore the perceptions of science and mathematics teachers of pedagogical knowledge of the content  |                  | √ |   |   | Qualitative approach    | Teachers' perceptions of pedagogical content are weak  | General                  |
| 4 | (Ambosai di, & Al-                 | Investigation the estimation of the  |                  | √ |   |   | Descriptive             | no significant differences in science teachers'  | Rocks, heat, and         |

|   |                                    |  |   |   |   |                      |   |                                    |
|---|------------------------------------|--|---|---|---|----------------------|---|------------------------------------|
|   | Hajri, 2013)                       | importance of pedagogical content knowledge in science.  |   |   |   | analytical method    | estimation of science pedagogical content knowledge   | thermal energy                     |
| 5 | (Karisan, Senay, & Ubuz, 2013)     | Investigation of knowledge of pedagogical content for physics teachers                                       |   | √ |   | Qualitative approach | A lack of pedagogical knowledge of the content of teachers  | Fluids                             |
| 6 | (Lange, Kleickman, & Molle, 2012)  | Explore the relationship between PCK for science teachers and their students' achievement                    | √ |   |   | Qualitative approach | A significant correlation between teacher's knowledge of pedagogical content and student achievement          | States of Matter and their changes |
| 7 | (Mohlouoa, Rollnick, & Oyoo, 2012) | Discuss the effect of physics teachers' knowledge of pedagogical content on student teaching                 |   | √ | √ | Qualitative approach | There is a relationship between the teacher's knowledge of pedagogical content and the teaching of physics    | Radioactivity                      |
| 8 | (Habbas, 2009)                     | Examine the relationship between the teacher's knowledge of how to teach students and student's achievements | √ |   |   | Qualitative approach | A strong correlation between teachers' knowledge of pedagogical content and the achievement of their students | Density                            |
| 9 | (Becker, & Aloe, 2008)             | Examine the relationship between the teacher's knowledge of  |   |   | √ | Analytical method    | A weak relationship between the teacher's knowledge of  | General                            |



|    |                | how to teach students and student's achievements                                     |   |   |   |   |                      | pedagogical content and the achievement of their students                   |                  |
|----|----------------|--|---|---|---|---|----------------------|---|------------------|
| 10 | (Hamida, 2008) | Investigation of science teachers' knowledge of pedagogical knowledge of the content |   | √ | √ | √ | Qualitative approach | A lack of pedagogical knowledge of the content of teachers                  | The waves motion |
| 11 | (Ozaden, 2008) | Evaluating the effect of knowledge of scientific content on PCK                      | √ |   | √ | √ | Qualitative approach | A positive relationship between knowing the content of the material and PCK | States of Matter |

\*T= Test, Q= Questionnaire, I= Interview, O=Observation.

# Studies are presented in order of the latest.

## THE CONCLUSION

Despite the existence of studies in the literature backing up positive correlation between PCK for physics teachers and their student's achievement, other studies showed no correlation at all or substandard relation. Therefore, available evidence shows mixed results that need to be interrupted carefully.

### Recommendations

Current review recommends conducting other studies that seek to know the factors that affect students' academic achievement in physics subjects, and studies that look at the relationship between the pedagogical content (PCK), and other science subject such as: biology and chemistry, and their impact on the students' achievement.

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