Using Seci To Improve Teachers' Pedagogical Content Knowledge

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Abstract: Pedagogical Content Knowledge (PCK) is a form of knowledge that has a big role in determining the success of the teaching and learning process in the classroom. Teachers in one school tend to have different levels of PCK, depending on each teacher's background knowledge and experience. Previous professional teacher development schemes in Indonesia have been held in a way that emphasises the teacher's individual learning aspects, were held separately between different teaching subjects (such as through a Mandatory Regional Teacher Meetings based on subject matters, known as "MGMP" in Indonesia), and has a lack of documented reports about the impact of that training on teaching. This study offers an alternative way to improve teachers' PCK using the knowledge creation approach. This study used the SECI model to design a procedure to facilitate teachers from the same school to share, externalise, combine, and internalise other teachers' PCK for their own teaching practice. The procedures of this study have addressed several problems that are found in previous attempts of using PCK in an educational setting. This study found that one cycle of the SECI model could improve teachers' PCK ($F_{(2, 40)} = 68{,}963$, $p < 0{,}05$) and has the potential to close the gap between teachers' PCK levels. Further research on an iterative SECI model to improve PCK with a longer timeframe and that evaluates factors that might affect the SECI process is needed to explore the potential of creating a shared perspective of PCK among teachers and create a contextual standard for a school as an educational institution. Exploratory research regarding teachers' natural knowledge sharing and knowledge acquisition is also offered.

Keywords: Pedagogical Content Knowledge, Knowledge Creation, SECI, Teacher, quasi-experiment

1. Introduction

The teacher's instruction is one of several important aspects that influence students' learning experience in the classroom. When capable teachers teach, students have a better learning experience and improve their learning achievements (Ballard and Bates, 2008). One of the many ways to improve teacher's teaching practice is by improving teachers' knowledge. After reviewing many formulations of teacher's knowledge, Shulman (1987) proposed that the knowledge that determines the success of teaching is pedagogical content knowledge (PCK).

Shulman initially proposed PCK in the late 1980s as a critique of the way stakeholders saw teachers and education. A teacher's competency was seen either by their pedagogical knowledge or their content knowledge, not both. However, it is argued that more often than not, the combination of both is what determines the success of teaching in the classroom. Shulman (1986; 1987) argued that the factor that determines the success of teaching is the combination of content knowledge and pedagogical knowledge.

Thirty years after its introduction, PCK has been accepted, argued, researched, and developed by other researchers. Research has found that PCK positively affects student's learning (Hayden and Eades Baird, 2018), can be used to create a more holistic way to view teachers' practice (Hanuscin, Lee and Akerson, 2011), and helps to understand and develop teachers' competence (Sperandeo-Mineo, et al., 2010). The acceptance of PCK in the academic field also led to many developments of PCK that often involve several aspects such as knowledge about students, assessments, and curriculum knowledge (Fernandez, 2014; Gess-Newsome, 1999). PCK has also been stated as the only type of teacher knowledge that appears to have an impact on teachers' instruction (Guerriero, 2013).

However, one of the authors of this study has found from his experience in managing a boarding school and training teachers in South Kalimantan, Indonesia, that teacher's PCK still needs improvement. Some teachers do not seem to recognise, respond, or adapt to the students' educational needs in their own classroom. This is aligned with a study conducted by Georgiou (2008), who found that some teachers make assumptions about their students. When teachers are detached from the classroom, teaching becomes ineffective (Käpylä, Heikkinen and Asunta, 2009).

In the author's school, there are many teachers with various levels of knowledge and expertise in teaching, or in short, PCK quality. This is aligned with a report by Sumaryanta, Mardapi, Sugiman and Herawan (2018) about

the quality of teacher's teaching competence in Indonesia. In the context of teaching improvement, there have been several efforts, before this study, that have been implemented in the author's school to develop a shared standard of teaching between teachers, such as through independent group learning, subject-based group sharing (MGMP) and focus group discussion (FGD) among teachers. These were typical of the professional teacher development scheme that is commonly held in schools in Indonesia (Rahman, 2019). Within these activities, evaluations to check the improvement of a teacher's competence were rarely held. There has also been no attempt to document the meeting; when peer-sharing was conducted, there was no structure of sharing being implemented. No one really knows what teachers have learned from the groups, and it is almost impossible for the school to track the progress of the knowledge of teachers. In Rahman's report (2019), one of the principals stated that even the teachers who are often engaged in many professional teacher development schemes do not show any significant teaching improvement. The principal in this report is not the only one who saw this problem. Similar problems occurred in the author's school. The author did not find any significant change, even after two years of actively supporting teachers to engage in professional improvement activities. This lack of improvement of quality and shared teaching quality between teachers' PCK is not good for the students, the school or teachers.

Closing this gap and making sure that everyone improves is imperative. The authors seek an alternative way to solve this problem by looking at the knowledge management field. Although the education world has been exposed to various learning methods, and teachers have adopted various learning activities, very little research involves knowledge management or knowledge creation concepts. Knowledge creation offers a different perspective on acquiring knowledge and is rarely incorporated in the education field. The authors' search in ERIC, the largest education database, yielded 5,624 search results for "Teacher Professional Development", whereas when the search term is altered to "Teacher Professional Development" AND "Knowledge Management" only 11 results were available. This result is alarming because it seems that teacher's professional development rarely considers knowledge management as a way to improve teachers' competence and affirms that teacher development has only been evaluating this problem from a learning perspective (Bredeson, 2002; Rahman, 2019). The authors were interested in considering this problem from a different perspective that reviews not only the teachers' individual learning but also how the organisational setting could help the process of acquiring knowledge from other professionals in the same work setting. This is the different take that knowledge management offers to teachers' improvement.

According to Leibowitz (2005), knowledge management includes sharing and leveraging knowledge, both externally and internally. It is a process of creating value from an organisation's intangible assets, such as employee knowledge. According to Love, Fong and Irani (2005), knowledge management is the process of acquiring, refining, storing, and sharing knowledge within an organisation. Knowledge management has also been defined by different labels. However, the following similarities can be found in most definitions: there must be some knowledge that can be acquired or created, and that knowledge can be shared with others through various media (Haapalainen and Mäkiranta, 2013).

From knowledge management, the breadth of knowledge creation concept emerged. Knowledge creation differs from learning in that knowledge creation refers to a set of social practices that advance the state of knowledge within a community over time (Paavola, Lipponen and Hakkarainen, 2004). The study of knowledge creation that is most influential was by Nonaka, who develop the SECI model. According to Nonaka (1994), knowledge could be created by sharing knowledge within an organisation through a process of socialisation, externalisation, combination, and internalisation, which Nonaka called the SECI model. Knowledge creation in this sense is similar to learning, but it differed in that it emphasised the process of how knowledge is created within an organisation, rather than on one individual. It refers to a set of social practices that advance the state of knowledge within a community over time (Paavola, Lipponen and Hakkarainen, 2004).

As there was a necessity to introduce the concept of PCK to teachers, this study aims to innovate the ways teachers improve their knowledge. PCK is a knowledge that develops as teacher build knowledge and experience in teaching. In a school, teachers are the practitioners of teaching, and they tend to possess different levels of PCK (Chan and Yung, 2018). The SECI model is a knowledge creation model that is the optimal system for organisational knowledge creation, where people generate knowledge from each other. With this setting, the SECI model could be an alternative for teachers to improve their PCK. This study investigated if the SECI model could improve a teacher's PCK. Then, this study designed an instrument which consists of a procedure on how to run the SECI process. And this instrument is the novelty of this study.

In the following literature review section, this article first discusses PCK as the knowledge of teachers that needs to be improved, followed by a discussion on the SECI model and how it has been used (or not used) in the education field.

2. Literature review

2.1 Pedagogical Content Knowledge

PCK is the form of knowledge that teachers use to organise a classroom and to ensure the achievement of teaching goals (Shulman, 1987). When it was introduced by Shulman for the first time, PCK was described as the combination of two forms of knowledge: content knowledge and general pedagogical knowledge. Content knowledge refers to knowledge about the subject matter from an academic perspective. This is the knowledge that is to be taught in the classroom. It includes the teachers' breadth and depth of the knowledge of the teaching subject, regardless of whether it will be taught in the classroom. Meanwhile, pedagogical knowledge refers to general knowledge about teaching, such as how to instruct the class or the teaching model used in class. This also includes the various theories about learning that teachers acquire during teacher training or after teaching for a period of time (Shulman, 1987; Carlsen, 1999; Gess-Newsome, 1999). The combination of both types of knowledge results in PCK: the teacher's mastery of how to decide what is the most representative materials (of a certain topic) to teach and the best way to teach it to students. Teachers' mastery of PCK developed differently depending on their experiences of teaching practice (Sumaryanta, et al., 2018).

Over time, the concept of PCK has become more complex than when it was introduced. For example, Carlsen (1999) made further elaboration on the construct of PCK. He expanded PCK to include not only content knowledge and general pedagogical knowledge but also involve contextual knowledge, knowledge about students, and other forms of knowledge. These forms of knowledge are supposed to be the construct of pedagogical knowledge and content knowledge separately. Similar thoughts have been shared among other researchers who study PCK. Another model was proposed by Morine-Dershimer and Kent (1999), who conceptualised PCK as a more complex interrelation between various forms of knowledge. In their concept, PCK is constructed from various forms of knowledge, as shown below.
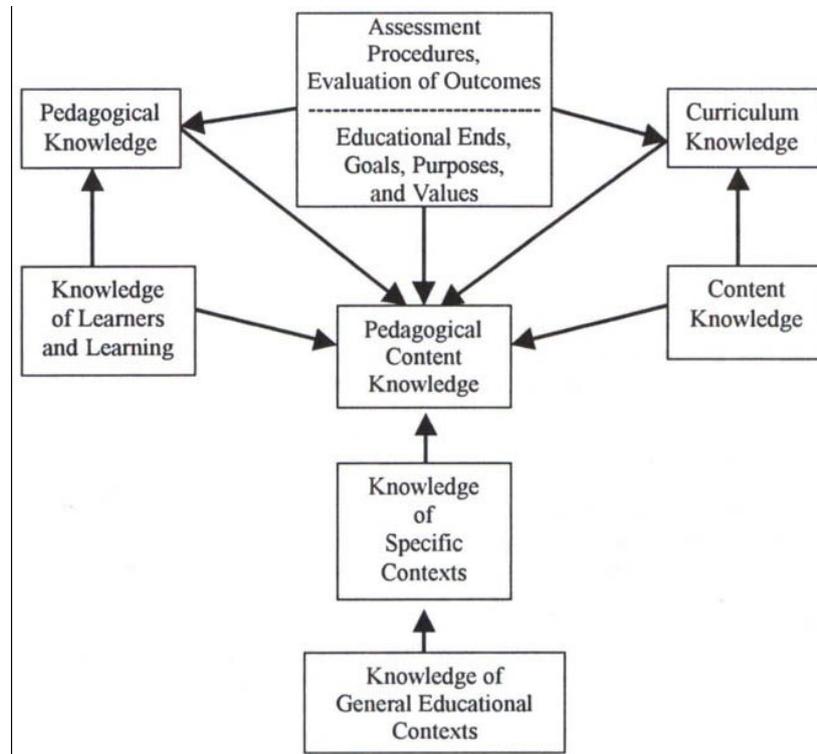
Figure 1: Interpretation of PCK by Morine-Dershimer and Kent (1999)

The above image shows that there are seven aspects that directly or indirectly affect teachers' PCK: pedagogical knowledge; content knowledge; knowledge of learners and learning; curriculum knowledge; assessment procedures; evaluation outcomes — educational ends, goals, purposes and values; knowledge of specific

contexts; and knowledge of general educational contexts. The interconnected knowledge that contributes to pedagogical content knowledge demonstrates the richness of the concept. Some of these aspects are changeable depending on the situation, such as knowledge about learners and learning or curriculum knowledge. Teachers should improve and update their information to ensure that they are aware of recent developments in every aspect of PCK. Teachers are expected to be life-long learners who update their knowledge to keep up with new demands and needs as the education system evolves (Impedovo, 2016).

This recent development is deemed necessary because Morine-Dershimer and Kent found that the concept of PCK has been widely accepted in the education field. This acceptance is an opportunity to expand the construct of PCK further. Morine-Dershimer and Kent (1999) argued that the classroom itself is a complex context that the teacher needs to fully understand before they can adjust their practice accordingly. The aspects of this model can be explained as follows:

- Content knowledge is knowledge about the subject matter that needs to be taught. Teachers should have deep and wide content knowledge, as these are the materials that they teach to students. It enables the teacher to comprehensively teach the subject matter.
- Pedagogical knowledge is knowledge about teaching. This knowledge is developed over time through many teaching experiences and by acquiring declarative knowledge about teachings, such as theories of learning, learning models, and psychology of learning.
- Curriculum knowledge refers to the knowledge that is related to understanding the nature of the current curriculum implemented in the teacher's school— the content and the demand of education as designed in the curriculum. It also includes the teacher's ability to design their own curriculum.
- Knowledge of the learner and learning are the forms of knowledge that correspond closely to one another. Knowledge about the learner focuses on the students' condition, such as their prior knowledge, social upbringing, interests, and learning style. Learning focuses on the various factors that could influence learning, such as learning models and learning styles.
- Knowledge regarding assessments and goals from this model is comprised of assessment procedures, evaluation outcomes, educational ends, goals, purposes, and values. Assessment procedures are comprised of knowledge about the various kinds of assessments in education, such as portfolios and multiple choice. Evaluation outcomes are the knowledge about the way the evaluation results are used. Educational ends, goals, purposes, and values are the knowledge regarding the various aspects that education is expected to contribute, from the classroom scale (e.g. students' understanding of content knowledge) to the national or even worldwide scale (e.g. national education goals).
- Knowledge of specific contexts refers to knowledge about events that happened in the world with which students are familiar that could aid students in making connections between their own experiences and the content knowledge they obtain in learning activities.
- Knowledge of the general educational context is the knowledge of general information that supports and has become the environment in which education takes place. This includes knowledge such as school management, national philosophies and classroom situations (Alimuddin, Tjakraatmadja and Ghazali, 2020)

2.2 SECI Model

Nonaka (1994) proposed his concept of knowledge creation to explain knowledge and its role within organisations (Nonaka, 1991; 1994). This concept was developed as Nonaka acknowledged that each employee must have their own best practice in the company. In this case, professional teachers are no exception. By sharing knowledge with one another, it is expected that teachers will be able to create new knowledge that will help them to improve their PCK.

His formulation of knowledge creation developed into the SECI model. In this model, there are four steps of knowledge conversion that lead to an individual's knowledge creation: socialisation, externalisation, combination, and internalisation (Nonaka, 1994). Each step represents different modes of conversion (Figure 2).
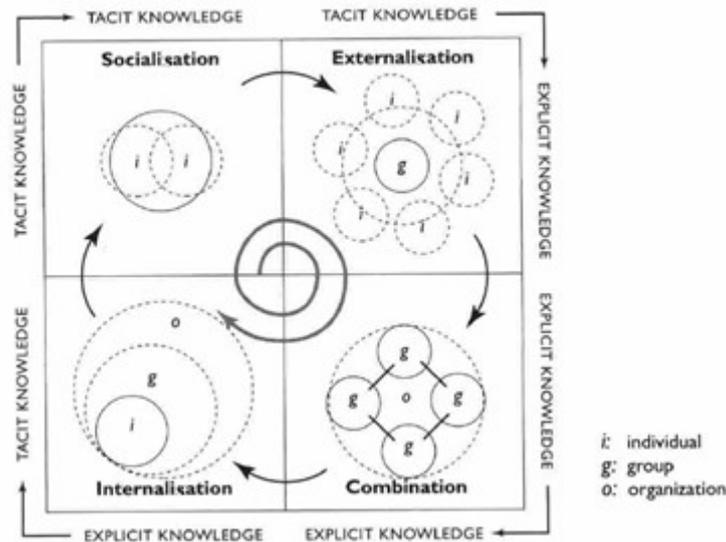
Figure 2: Interaction within the SECI Model. Reprinted from Nonaka & Konno (1998)

- Socialisation: the conversion of tacit knowledge from one person to another through hands-on experience.
- Externalisation: a process where one converts his/her tacit knowledge into explicit knowledge by trying to explicitly explain what they do.
- Combination: the conversion of the explicit knowledge acquired to a more complex and systematic explicit knowledge based on explicit knowledge sharing.
- Internalisation: a process where explicit knowledge from outside is converted to an internal and tacit knowledge.

The SECI model allowed companies to store their employees' knowledge and transfer it between one another. It aims to ensure that most of the knowledge within companies could be acquired by everyone, allowing the company to formulate the best practices from everyone's various knowledge. To do so, tacit knowledge should be converted to explicit knowledge. The conversion occurs through discussions, dialogues, or experience sharing. In the SECI model, this process can be found in the *externalisation* step. This is also the strength of the SECI model. However, when introducing the concept of SECI in his early writing Nonaka did not either provide deep explanation or emphasize the externalization phase (Gourlay, 2006)

In his SECI framework, each step represents how information is used and stored by individuals in the organisation and in the organisation itself. For example, employees externalise their various experiences to share with other employees. The information is then internalised and becomes the knowledge of other employees. Meanwhile, this knowledge could also be compiled in the form of a handbook or written guidance as a reference for future employees. Using Nonaka's SECI model as a framework for knowledge creation in an organisation will facilitate individuals to receive various information for their individual knowledge creation and for the organisation's knowledge creation (Nonaka, 2005).

One important aspect of the SECI model is that it thrives when applied in an organisational setting. When the SECI model is applied within organisations, it can provide a supportive environment where members of the group share their knowledge through any of the knowledge conversion modes. When conversion is conducted continuously in an organisation, it will become a never-ending circular process of knowledge creation for both the individual and the organisation (Nonaka, 1994).

In short, the SECI model departed from the traditional way of knowledge transfer, which has been heavily criticised, and mitigated possible problems that often occur during the learning process. It is structured and provides a clear framework for implementation, giving participants an active role in their learning, which is expected in adult learning (Angelo, 1993).

2.3 Using SECI to Improve Teachers' PCK

The concept of knowledge creation was first introduced in the organisation field. This means that any other form of organisation, including education, could also try to adapt knowledge creation into their field. However, searches in educational databases, such as ERIC, suggest that the implementation of knowledge management in the education field is limited.

An initial search of the term "Knowledge Management" in ERIC, the largest education database, yielded only 2,247 results. The top result was research about an agriculture research institution followed by other results that are less connected with compulsory schooling such as high school or elementary school. This alarming result led the researcher to inspect the descriptor list and choose "Knowledge Management". The descriptor led to a smaller number of articles, only 1,489, showing the same list of articles from the previous search. When the researchers searched for "knowledge management" and "school", it yielded more specific results that are connected to the implementation of knowledge management in formal schools; however, the number of articles became even lower, only 485. The results for "knowledge management" and "teacher" yielded only 440. Table 1 outlines the attempts the researcher conducted to check literature for this study.

Table 1: Search results from 2 different database

No	Search Terms/Keywords	Numbers of article in ERIC (educational database)	Numbers of article in ABI/INFORM (management database)
1	Knowledge Management	2247	Omitted for obvious reason
2	"knowledge management" and "school"	485	35,889
3	"knowledge management" and "teacher"	445	4,479
4	"knowledge creation" and "school"	167	14.064
5	"knowledge creation" and "teacher"	170	2097
6	SECI	15	Omitted for obvious reason
7	"SECI" and "Teacher"	5	146

A contrast could be seen when the search was conducted in the ABI/INFORM database, one of several large databases about the management field. For the same term, ABI/INFORM yielded many results, except for the last keywords, "SECI" and "teacher", where there were significantly fewer results. When compared, the amount of articles from both ERIC and ABI/INFORM search results were still small. Furthermore, when the authors examined all 5 article in ERIC and 146 article in ABI/INFORM search results, there were only a few articles that actually discuss the SECI model in a school setting for teachers' improvement. The authors used Google Scholar to search for relevant articles that were not already indexed in both databases.

From those limited sources, there are a few notable articles that highlighted the use and importance of the SECI model when implemented in an education setting. Some of those studies used the SECI model to facilitate education related to the Virtual Learning Environment (VLE). Hosseini (2011) reported that employing the SECI framework for the VLE could create an integrated and systematised path for knowledge creation. He used SECI's conversion modes as pedagogical steps in the VLE. He reported that the SECI model helps to make teachers' knowledge creation are practical and sequenced. Participants could also be more attentive to each step of knowledge conversion rather than allow it to occur in the background or unconsciously. However, he also reported that not all modes of conversion have been carried out effectively by the participants.

Similar findings could be seen in another VLE related study by Joia (2002). He reported the use of the SECI model as a methodology to implement training for unqualified in-service teachers in Brazil's rural areas. He tried to measure the strengths of all modes of conversion in the SECI model during the training. Similar to Hosseini's findings, the results indicated that the SECI model helped teachers in their practice, but not all modes of conversion were performed well. For example, the socialisation and internalisation processes tended to be more successful compared to combination and externalisation.

Another study that used the SECI framework is by Tee and Lee (2011). They combined problem-based learning (PBL) with the SECI framework to improve teachers' technological pedagogical content knowledge (TPACK). In their study, PBL, combined with the SECI model, improved teachers' TPACK. However, in their study, the program lasted for 12 weeks. This long period gives teachers enough time to shift their problems, from blaming students for lack of participation in class to reviewing their own teaching mistakes.

These previous studies tend to discuss the SECI model in a qualitative manner. While in the Tee and Lee (2011) study, although they used the SECI framework, this was not the only framework they used to improve teachers' PCK. Previous study also found several problems in the implementation of the SECI model for in-service teacher training, such as in Joia (2002). The problem lies with syllabi that are considered to be "too difficult" for teachers and a lack of grounded teaching materials, which make it difficult for teachers to relate with what is being taught in training. Another problem is related to the structure of the training scheme, where the training is held for months, and the need for teachers to visit different classrooms from different schools. Teachers need time outside of their teaching schedule to conduct their visits, and there is a lack of coordination between the teachers and the education department that manages the programme to ensure that visitations run smoothly. In the method section, the authors in this study demonstrate that several of these problems are addressed.

The discussion regarding the SECI model cannot be separated from its root, Polanyi's concept of tacit knowledge. Polanyi (1967) argued that, other than explicit knowledge, which is knowledge that can be delivered through verbal communication and has been linked with know-what, humans also have tacit knowledge. Tacit knowledge is the knowledge that is hard to articulate and has been linked with one's know-how. PCK, as Shulman (1986, 1987) argued, requires teachers to have knowledge about what to teach and how to teach. Even earlier conceptions of PCK argued that those are not the only aspects of PCK (Morine-Dershimer and Kent, 1999). That knowledge is acquired by teachers after their experience of teaching. This is similar to Polanyi's conception of tacit and explicit knowledge. Not only do teachers need to have theoretical knowledge about teaching and what to teach, but they also must be able to deliver it in the classroom. Some teachers might have the same educational background, but their teaching experiences in the years to come may be different depending on their experiential context (Shulman, 1987; Chan and Yung, 2018). This shows that the nature of PCK and the mechanism of knowledge conversion in the SECI model corresponds to one another. This article proposes to use the SECI model as a treatment for teachers to improve their PCK.

This study also adds another novelty to this academic niche. In a later section, the authors elaborate on the process of SECI treatment to improve teachers' PCK. The authors found that there was a lack of a directive process in previous studies to guide other stakeholders in the step-to-step implementation of the SECI model to improve teachers' PCK.

3. Research method

An empirical study on the implementation of the SECI model to improve PCK was conducted. The preparation for the study and the analysis was conducted during 2018 for six months in Indonesia. To test whether the SECI model could improve teachers' PCK, we created a quasi-experimental research design, as shown in the following table.

Table 2: Quasi-Experimental Research Design

Treatment Group	*M*	O	*X*	O
Control Group	*M*	O	*C*	O

M in this design means that the subjects in each group are matched because the subject cannot be randomly assigned to the control and treatment group. O signifies the test that was given to the participants. The treatment group received a test before the treatment (pre-test), treatment (X), and a test after the treatment (post-test). The control group also received pre-test and post-test at the same time with the treatment group, but without receiving any treatments (C).

Two groups of teachers from two different schools were involved in this research. One group was the treatment group and the other was the control group. Each group had a total of 20 teachers each. The grouping was decided based on the teachers' teaching institutions.

Eight open-ended questions were prepared as the pre-test and post-test to measure PCK. The instrument was created in a way that allowed teachers to reflect on how they implemented their PCK in a classroom setting, as seen in Table 3. The instrument was validated by experts.

Table 3: Questions to evaluate teacher's concept of PCK

No	PCK	Question
1	Knowledge of specific context	What is the context that you often use to deliver your subject matter?
2	All PCK components	What are the problems that you usually face during teaching?
3	Educational ends, goals, purposes, values; content knowledge; knowledge of specific contexts	Can you interpret the context that you use in your teaching practice? Explain.
4	All PCK components	What are your considerations when you brought a new perspective on that subject matter?
5	All PCK components	What are the conditions or situations that have helped or impeded you during your teaching practice?
6	All PCK components	What are the instructions that you used to deliver your teaching?
7	Assessments, procedures, and evaluation of outcomes	How do you know whether your teaching practice has been a success or failure?
8	All PCK components	What have been the successes or failures in that teaching practice? Moreover, what did you/would you do when failures occurred/occur?

Source: (Alimuddin, Tjakraatmadja and Ghazali, 2020)

The teachers' answers were evaluated by selected assessors using a rubric and scored. The assessors have experience in teaching as teachers in the same school and grading teacher's performance as assessor teams from the as part of the school's teacher evaluation team. There are five categories within the rubric. Each category was assigned with a score. The scoring system is similar to a Likert scale but with different numerical values. Instead of using the 1–5 or 0–4 range, this research used the 0–1 range with 0.25 intervals. This system was chosen based on the idea that 1 represents a holistic mastery of PCK. Any answer that demonstrates a lack of understanding of PCK would be scored lower than 1, with 0 as the lowest score.

Figure 3: Rubric scoring system

The rubric provides guides for the assessor to determine whether all aspects of PCK that are related to the questions have been considered by the teachers. This is to ensure that the assessor can give an appropriate score (Stevens & Levi, 2005). The benefit of using a rubric is that it can be used to measure the answers created from a complex thinking process (Anderson, 1998; Stevens & Levi, 2005). As demonstrated in the literature review, PCK has a dense structure. Teachers need to have the freedom to externalise it in the form of writing. It is not possible to observe PCK generally if using other forms of assessment, such as multiple-choice tests. In multiple-choice tests, questions tend to encourage rote learning of information, where participants are directed towards a specific context and there is only one right answer. A universal instrument is not an ideal situation to learn about teachers' PCK. Table 4 shows an example of the details that could be captured by a rubric scoring system.

Table 4: Example of a 5-scale rubric

Question	0	0.25	0.5	0.75	1
What is the context that you often use to deliver your subject matter?	The teacher is not able to provide any aspect needed to create a context in teaching (*).	The teacher is able to provide 1 to 2 aspects needed to create a context in teaching (*).	The teacher is able to provide 3 to 4 aspects needed to create a context in teaching (*).	The teacher is able to provide 5 to 6 aspects needed to create a context in teaching (*).	The teacher is able to provide 7 to 8 aspects needed to create a context in teaching (*).

*context in teaching includes, but not limited to: situations, actors, objects, activities, interactions between actors and objects, descriptive aspects (time, place, and distance), changes or consequence (after the

interaction), statement that leads to the connection between necessary aspects that were used to discuss learning concepts

After teachers' pre-tests and post-tests, answers were scored using the rubric. These scores were tabulated and then analysed using ANCOVA in SPSS.

3.1 The SECI Procedure in the Treatment

A session of knowledge creation was conducted in the educational institution that was chosen as the experiment group. The researchers created a systematic and detailed procedure for teachers to engage in the SECI process throughout the session. The session was conducted over four consecutive days. The first day, the teachers were introduced by facilitators to the concept of PCK, knowledge creation, and the SECI model. A demonstration was also carried out by the facilitators to illustrate the implementation of the SECI model on teachers' PCK. This lesson was given as an introductory task before participants used the SECI model to improve PCK the next day

The second day, the teacher was asked to form a group of four people. Each teacher in this group was guided by worksheets to engage in the socialisation and externalisation processes from the SECI model. In the socialisation phase, teachers worked on worksheet 1, and they were asked to watch a video of their teaching practice that had been recorded beforehand and make comments about their practice. After they finished making comments for the improvement of their own practice, the teachers moved on to worksheet 2.

During the externalisation phase, teachers were asked to take their own worksheet 1 and look at worksheet 2. Any comments that they found useful for their own teaching practice from worksheet 2 were to be written down on worksheet 1.

The combination phase and internalisation phase took place on the third day. In the combination phase, the trainers only gave teachers their worksheet 1 that they completed the day before. They each read each other's worksheet 1 that already had teaching two types of comments: the owner's comments and the comments about others' teaching practices that they thought might improve their teaching. Next, they were asked to write down what they learned from each other's notes in worksheet 1 on their own worksheet 1.

The last phase was the internalisation phase. Teachers were given a new worksheet 1. They were asked to re-watch their own video and write their comments on worksheet 1.

Table 5: Question in worksheets for the SECI treatment

Worksheet	Total worksheets/person	Question/Task
Worksheet 1	One worksheet	Watch your teaching video. Take notes and comment on your teaching practice.
Worksheet 2	Three worksheets	Watch other teachers' videos (three teachers). Write down comments, criticisms, and advice on those practices separately.

Researchers in this study expected that after the treatment, the teachers' awareness of what happened in their classroom would increase. This would be indicated by the comparison between their answers on worksheet 1 on the second day and the third day.
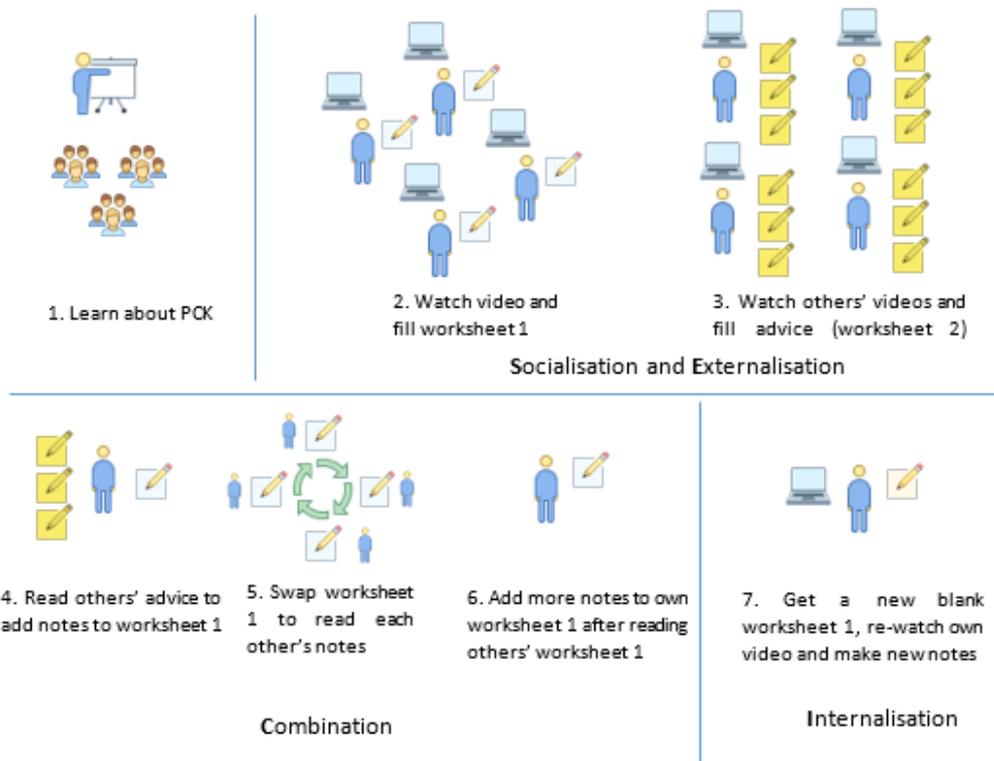
Figure 4: SECI treatment procedure

4. Results

Table 6 presents the means between the treatment group and the control group. There are differences between the control group's average post-test score and the treatment group's average post-test score.

Table 6: Average score for each group

Dependent Variable: Post-test			
Treatment	Mean	Std. Deviation	N
SECI	3.9250	.91443	20
without SECI	1.3250	.48054	20
Total	2.6250	1.50107	40

The data of the teachers' test results also show that all teachers improved their PCK, as seen in Figure 5.
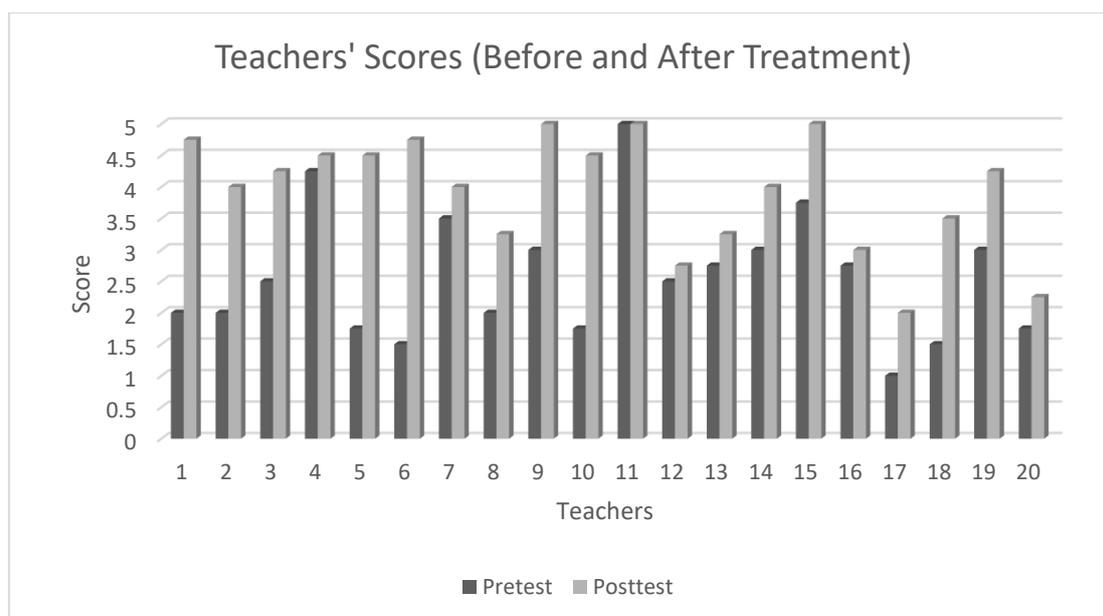
Figure 5: Graph of teachers' scores before and after the SECI treatment

The same data were analysed to check whether any significant difference existed within the data. Table 7 presents the ANCOVA test results. The ANCOVA analysis shows that there was a significant effect of the treatment on the participants' post-test results $[F(2, 40) = 68.963, p < .05]$. The partial eta square for the post-test indicates that the improvement of teachers' PCK, as a result of the SECI model, was as much as 65.1%. However, it could also be seen from Table 7 that 26% of the teachers' PCK improvement was also due to the participants' initial knowledge (pre-test effect on the post-test score has been removed by the ANCOVA analysis).

Table 7: Tests of between-subjects effects

Dependent Variable: Post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	72.882ᵃ	2	36.441	89.926	.000	.829
Intercept	17.122	1	17.122	42.254	.000	.533
Pre-test	5.282	1	5.282	13.033	.001	.260
Treatment	27.946	1	27.946	68.963	.000	.651
Error	14.993	37	.405			
Total	363.500	40				
Corrected Total	87.875	39				

Note: R Squared =.829 (Adjusted R Squared = .820)

This result implies that the SECI model can improve teachers' PCK. However, it is also important to acknowledge that participants' initial knowledge also contributes to a small extent to this improvement.

5. Discussion

This research is aimed at implementing an alternative approach to improve teachers' PCK. This study proposed to approach it from knowledge creation perspective using the SECI model. The researchers equated teachers with employees of a company that have unique skills and contextual knowledge of their practice. There have been few reports on the utilisation of the SECI model for professional teacher development; however, this approach has been successfully implemented to improve employee work in other fields, such as IT (Rodrigues, Gayathri and Rao, 2006), banking (Easa, 2012) and construction (Eliufoo, 2008).

This study found that the SECI model could significantly improve teachers' PCK $[F(2, 40) = 68.963, p < .05]$. This improvement is aligned with previous research conducted by Joia (2002), who found that the SECI model helped teachers in their teaching practice. This research also aligned with findings from Tee and Lee (2011) who

combined PBL with the SECI model to improve teachers' TPACK, and demonstrated that even without combining with PBL, the SECI model could improve teachers' PCK.

Several problems in previous studies, such as Joia (2002), have also been addressed in this study, as demonstrated in the procedures of the SECI treatment. In this study, the teachers did not use a syllabus of teaching theories, but instead, they were asked to look at their own teaching and other teachers' videos. Teachers in the treatment group came from the same school, so the videos they watched had a familiar context and even similar problems. When teachers made notes about other teachers' practices, they shared their PCK in a written form and was expected to notice something that the other teachers did not notice because they were occupied with their teaching perspective. In the combination process, using the worksheets filled with comments and advice, all the teachers reviewed the same problem (the video) through different teachers' perspectives. During the internalisation process, teachers could internalise those new perspectives to their future practice by projecting what they would do differently compared to their previous practice.

The new knowledge and advice from watching other teachers' practice could even be used as a reference for each teacher's future practice if they happened to have the chance to teach the same class and face the same problem. This SECI dynamic is still related to different PCK that teachers have. Different teachers tend to notice different things and have different sensitivities to teaching (Chan and Yung, 2018). This is the tacit knowledge that is transferred during the SECI process. Thus, teachers are not confused with a new context that they are not familiar with, and they are not dragged into problems that they might never face. This latter point also addresses another problem that Joia spotted in his study, where teachers were expected to go to different schools to observe other teachers who teach different classes in different schools.

In this study, since all teachers came from the same school, the SECI process could be conducted in a less time-consuming way. This study's setting made the SECI process more effective because teachers could focus on the problem without needing much time to familiarise themselves with the context. The SECI model is a knowledge creation process that is developed for employees from the same organisation (Nonaka, 1994), and this study mimics that organisation setting well. Teachers also did not have to take extra time to visit other schools to participate in the SECI process.

This study also took a different route than the study by Tee and Lee (2011). It directly asked teachers to reflect on their teaching practice. In PCK, there are eight aspects for which teachers need to have knowledge and awareness. One of those is teachers' knowledge about learning and learners. The procedure bypasses the process of teachers blaming the student (the outcome of the socialisation phase in the few initial weeks of the SECI model in the Tee and Lee study) and asks teachers to directly focus their attention on the actual teaching, such as whether the teacher has a good sense of the students' attention and learning process and whether their teaching strategy corresponds to the problems in the classroom (teaching materials, curriculum needs, etc.). By asking teachers to be aware of other teachers' use of PCK as they teach, the SECI process could be more effective because teachers were focused on a situation that they could change on their own.

Further analysis of the results can be seen in Figure 5, which presents the teachers' PCK scores. This graph shows that it is possible for teachers to improve their PCK and get closer to other teachers' levels of PCK. For example, teacher 8, who initially had a low PCK score, improved his PCK score and had a score closer to those of teachers 7 and 15 from before the treatment. Although it could also be seen that teachers 7 and 15 have also improved their PCK, it should be noted that this study was only conducted in a single cycle of the SECI treatment. Other interesting data could also be seen in teachers 1, 5, and 10, who started with low scores and more than doubled their initial score. This is unlike teacher 20, who showed only a small improvement compared to teacher 2, even though they had roughly the same initial score. Another interesting result could be seen from teachers 16, 17, and 18. Teacher 17 had one of the lowest initial scores and did not improve as much as the other teachers. Meanwhile, teacher 16 had a higher score before the treatment, yet he did not experience a significant change in his post-test score. Teacher 18 had a lower score before the treatment but experienced a larger score increase. These results correspond to the eta square value in table 7, which shows that, although the teachers' initial knowledge (measured by their pre-test score) affected the post-test scores (F= 13,033, p<0,05), the effect of the teachers' initial knowledge was low (26%). Several data, such as that from teachers 12, 13 and 16, who only had a small increase in their PCK score, highlighted the need to investigate further as to whether factors that might pose as barriers to knowledge creation could be found within this setting, such employees unwillingness to

participate in knowledge sharing (due to various reasons as reported by Razi, Karim and Mohamed (2015), Razmerita, Krichner and Nielsen (2016) and Albers et. al. (2018)

6. Conclusion, limitation, and recommendation for further research

Each teacher has different levels of PCK. During their career, they have developed their PCK, but they still need to improve it. At the beginning of this article, the authors addressed that the knowledge management perspective, especially the knowledge creation approach for teachers' professional development, is rarely used in the education setting. This study offered a different perspective by showing that knowledge creation, specifically the SECI model, could be used to improve teachers' PCK. SECI process in this study allows teachers to create a shared perspective about PCK, improve their PCK, and close the knowledge gaps between teachers. If teachers could familiarise themselves with the SECI procedures, they can have a shared PCK, and the school might be able to set certain standards according to its needs. Professional teacher training is no longer an individual pursuit but rather a collaborative effort within the organisation to improve teaching quality. However, further research is needed.

The limitation of this study is that it has not investigated further each SECI mode separately. This study does not show the variety of challenges or difficulties that the participants had during the process. Carried out this way, the study could not provide deeper insights into each SECI knowledge conversion process separately. Since there are four modes of knowledge conversion in SECI, there are still plenty of aspects that need to be explored, especially considering previous research in education indicates that some knowledge conversion steps are not as effective as others (Joia, 2002; Hosseini, 2011). Besides that, further research should also be conducted on the following subjects: First, a further investigation could evaluate whether a continuous PCK cycle (more than one session) is able to result in a bigger impact on teachers' PCK. For example, whether it could close the gap even further if the teachers have become used to the SECI procedure, or in a condition where the teachers are able to do SECI naturally in the work setting. Second, a grounded and longitudinal study could be conducted on certain groups of teachers to assess their natural knowledge sharing process (without the SECI model). This could be followed by a survey study to investigate teachers' habits in acquiring knowledge. Another study could be conducted with the participants of this study to investigate their experiences in using the SECI model as well as their previous experiences in acquiring knowledge (before using the SECI model). These studies are needed to obtain a more holistic understanding of this subject.

Acknowledgement

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