

From Professional Knowledge to Practice: The Effect of Academic Counseling Model Based on Academic-Teacher Collaboration on Pedagogical Content Knowledge

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ABSTRACT

Collaboration between teachers and academics can have a sustainable impact on teachers' professional development. Accordingly, the aim of the study was to investigate the effect of the academic counseling model (ACM) based on academic-teacher collaboration on the pedagogical content knowledge (PCK) of in-service teachers. The ACM consists of five steps: diagnosis, training, action, gradually decreasing, and evaluation. The seven volunteer science teachers in different seniority levels participated in the research from three secondary schools (urban, suburban, and private schools). A total of six academics, four of whom were in the counseling team and two in the support team, took part as the academic team. We collected the data with an observation form developed according to the three components of PCK. The application period was about 23 weeks. We found statistical differences in all stages of ACM, except for gradually decreasing and evaluation, according to the classroom practices of the participant teachers. Consequently, we determined that ACM significantly improved science teachers' professional skills on PCK. In this study, we focused on teachers' professional development, which is a sub-variable of the school variable of ACM. In future research, more comprehensive studies focusing on other sub-components will be useful to reveal the impact of the model.

KEY WORDS: Academic counseling model; Academic-teacher collaboration; PCK; Professional development; Science teacher

INTRODUCTION

Professional development of teachers is a process that starts with their undergraduate education and continues throughout their professional life. This process is affected by the teacher's individual characteristics (professional experience, attitude, anxiety, belief, perspective, motivation, self-efficacy, etc.), content knowledge and teaching strategies, methods, and approaches, and directly affects students' learning. A country's educational reform, the context of the school, the curriculum, cooperation, etc. are considered integral parts of the professional development process (Sancar et al., 2021). In addition, effective professional development programs for professional development are considered the key component of teacher knowledge (Darling-Hammond et al., 2017). In the literature, there are plenty of suggestions about effective professional development programs and this situation varies according to the perspective of the researcher (Haug and Mork, 2021). Some studies indicate that teachers need support in the professional development process for the implementation of educational reforms (Borko, 2004; Granger et al., 2019). From this point of view, we designed a study for providing professional development within the scope of the academic counseling model (ACM) based on the academic-teacher collaboration proposed by Kala (2017). In this study, we aimed to investigate the effect of this model on

the professional development of teachers we took the concept of pedagogical content knowledge (PCK) as a professional development indicator of a qualified teacher.

PCK is defined as the information that teachers use in the process of transforming the content knowledge of the subject into an understandable form for learners (Grossman, 1990; Shulman, 1987). Kulgemeyer and Riese (2018), on the other hand, explain PCK as a teacher's knowledge that plays a very important role in transferring content knowledge to teaching practice. PCK can be developed with sufficient support, sharing, and classroom practices to be provided to teachers (Hanuscin et al., 2011). For this reason, if it is desired to create a change in teachers' PCKs, it is necessary to provide them with in-class support, long-term training, cooperation, etc. (Appleton, 2008; Borko, 2004).

There are many models that can provide sustainable interaction between teachers and those who support them, each of which includes different methodologies (Eilks and Markic, 2011). These models are Teachers Learning Communities (Putnam and Borko, 2000), Knowledge-creating schools (McIntyre, 2005), and Action Research studies (e.g., Bencze and Hodson, 1999; Eilks and Ralle, 2002; Eilks and Markic, 2011; Feldman, 1996; Parke and Coble, 1997). In this study, we aimed to examine the effect of ACM, which was developed based on the action research proposed by Kala (2017) on teachers' PCKs.

Many PCK models have been developed over time in the context of teacher knowledge (Cochran et al., 1993; Gess-Newsome, 1999; Grossman, 1990; Magnusson et al., 1999; Marks, 1990; Tamir, 1988). We used the PCK model developed by Magnusson et al. (1999) to determine the effect of ACM on the PCKs of teachers. Since the PCK components in this model are also found in many models, we examined three components in this model. These components are knowledge of curriculum, knowledge of student learning difficulties, and knowledge of instructional strategies.

ACM Based on Academic-Teacher Collaboration

The ACM consists of five steps: diagnosis, training, action, gradually decreasing, and evaluation (Kala, 2021). In the model, it is recommended to provide training and counseling in line with teacher needs and to reduce counseling gradually in line with teacher needs. Since the stages of ACM are explained in the method, they will not be explained here. In addition, ACM has three basic variables, which are schematized in Figure 1.

According to ACM, academic-teacher cooperation is expected to have a reflection on the school variable in three sub-variables: teachers' professional development, student achievement, and organizational context. Considering that the change in students' learning outcomes is one of the main goals of professional development programs (Desimone et al., 2013; Guskey, 2002), it is inevitable that one of the sub-variables of this model is student achievement. As Guskey (1994) states, change is both an individual and an organizational process. In some cases, the motivation of the teacher may be quite high, but organizational structures may hinder these improvements and developments. For this reason, it is important that teachers from the same school participate in professional development activities together (Desimone, 2009; Desimone and Garet, 2015). Guskey (1994) mentions that for effective professional development, individuals should work as a team by supporting each other without being isolated. From this point of view, individual and organizational processes are mutual driving

forces of each other. In the model, management, other teachers, and parents are accepted as the basic elements of the organizational context (Kala, 2017).

As shown in Figure 1, another basic variable of ACM is the faculty of education where academics work. In determining this variable, academics are expected to have the chance to update the course contents in pre-service teacher education to address the problems observed in learning environments (school-classroom) and even reflect the experiences gained in this process to the education of pre-service teachers through cooperation with teachers. Another point here is that since the academics will be in schools during the implementation of ACM, the problems that may be encountered in the field also guide academic research. Kala (2017) stated that thanks to the cooperation in ACM, teachers and students' parents can more easily be informed about research and scientific activities in universities, and therefore universities can communicate more easily with society. Another important issue here is the expectation that a better-equipped next generation will grow up from this increase in the professional development of teachers. From this point of view, it is assumed that the application of the model will affect society in two aspects: Social life and future generations.

The academic advising mentioned in ACM is quite different from the concept of mentoring used effectively in many countries.

Academic counseling mentioned in ACM is quite different from the concept of mentoring used effectively in many countries. Although in the limited research on the professional development of teachers, the mentors are academics at the university (Driskell, 2015; Güler and Çelik, 2022), they are generally from the same professional group (Ahn, 2014; Zembytska, 2015). In mentoring, it is very important that the mentor is more experienced than the mentee (Bakioğlu, 2015). In ACM, on the other hand, although there is no comparison of years of experience, it is a prerequisite for the academics

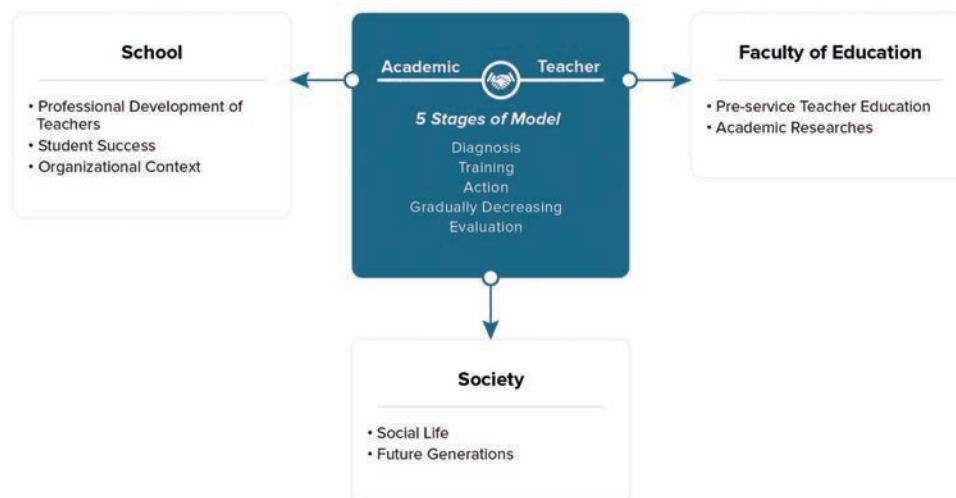


Figure 1: The figure showing the academic counseling model is adapted from Kala (2017; 2021)

to have sufficient experience. The most important difference is that in mentoring, there is cooperation between the mentee and the mentor for the professional development of the mentee. While the professional development of the teacher is still the main goal in the cooperation in ACM, there is also a focus on the development of the academic.

There are many studies on the need for academics to take more roles in the professional development of teachers by being more present in schools (Güler, 2019; Kala et al., 2021; Kala et al., 2019; Kirman-Bilgin et al., 2019). However, for the professional development of teachers, what is more important than the presence of academics in the field is what kind of application should be made. Desimone (2009) mentions that five basic issues are vital in effective teacher education: Content focus, active learning, coherence, duration, and collective participation in meta-analysis research on teacher education. We think that ACM's five-stage application process (Kala, 2021) can be effective for teachers' professional development as it is largely compatible with the issues that Desimone sheds light on. In addition, we think that both teachers and academics can continue to implement it for a long time, as one of the reasons for choosing ACM in this study is that the cooperation between teachers and academics is beneficial to both parties. Another reason we prefer this model is that we want to further develop ACM by making use of the researchers' experience in teacher education and revising the model's failing aspects if any. We expect ACM to be effective both in developing the PCK-based professional competencies of novice teachers and in integrating senior teachers into their learning environments by following up-to-date information. In this context, the aim of the study is to investigate the effect of ACM on the PCKs of in-service teachers. For this purpose, the main research question is as follows;

Is there a significant difference in the PCKs of the participants according to the stages of ACM?

METHODS

Model of the Research

In the study, we chose action research as the best suitable method for our study. Action research is a long-term, multi-stage, and spiral process (Lewin, 1947; Zuber-Skerritt, 1996). Lewin (1947) stated that it consists of: (a) Planning covering the research of the points to be discovered, (b) taking action, and (c) obtaining findings about the results of the action. The main reason for choosing this method in the research is that it provides the opportunity for teachers to identify the problems they encounter in the field, to take action by planning for the solution of the problem, and continue this process cyclically until the problem is concluded by evaluating the results of the action. Because the problems in social sciences are multidimensional and unique, action research is an almost never-ending process, and teachers are researchers (Johnson and Christensen, 2012). In this context, the research was action research for both teachers and researchers in terms of

solving the problems in their classrooms with the support of their counselor and improving their professional skills in this process.

Participants

While selecting the participants for the study, we limited the number of participants because both the application duration and weekly application hours of ACM were long. In the determination of participants, firstly we paid attention to select of at least two teachers from each school, with the thought that the interaction between the teachers in the same branch might have positive reflections on their professional knowledge and skills (Desimone, 2009; Desimone and Garet, 2015). Second, we made an effort to select participants from the popular urban school, suburban schools, and private schools due to the fact that they have children from families of different socio-economic levels. Third, we paid attention to selecting the participants from different seniority groups (0–3 years, 4–9 years, and 10 years and above) with the assumption that teachers of different seniority may have different counseling needs regarding their professional needs. In this direction, we visited almost all the secondary schools in the city center and made presentations to both the administration and teachers in the schools about the aim and content of ACM. However, many teachers did not volunteer to participate in the study because the duration of the study, and there was the concern that if academics entered the classrooms, it might make disturbing some administrators and teachers. As a result, we selected three secondary schools with different organizational contexts, with more than one volunteer participant. The research was carried out with seven volunteer teachers studying in these schools. Table 1 provides information about the participating schools and teachers.

Data Collection Tools

In the research, data were collected by observation form, self-evaluation form, and interview based on vignette technique. Detailed information about the mentioned data collection tools is presented below.

Table 1: Features of the schools where the participants study

Participants	Type of schools	Features of schools
T1 T2	Private school	It is a private school financed by high-income families. There are interactive whiteboards or projectors in the classrooms. There is a science lab.
T3 T7	Suburban school	It is a medium-sized public school. Only two classrooms have interactive whiteboards, other classrooms have projectors, but some do not work. There is a small science laboratory.
T4 T5 T6	Urban school	It is a large public school with around 1500 students. The students of the school generally consist of children from middle- and upper-income families. Although it is a very central secondary school, there are only two projectors used by the whole school. There is no available science laboratory.

Observation Form

We developed the observation form to evaluate classroom practice of the participating teachers in the four stages of the model, except for the training stage. Since two of the participating schools did not have sufficient equipment in terms of instructional technologies, we took into account PCK instead of technological PCK (TPACK) in the evaluation of teachers' classroom practice. In addition, since assessment is not carried out in every lesson, three components of PCK were focused on knowledge of curriculum, knowledge of student learning difficulties, and knowledge of instructional strategies. In the constitution of the items of the observation form, we took as a baseline the General Competencies for Teaching Profession, which the Ministry of National Education (MoNE) in Türkiye wants all teachers to reach regardless of their branches (MoNE, 2017). The main reason for taking this guide as a baseline is that it has been created by taking into account the basic teaching policy texts of many institutions around the world such as OECD, UNESCO, and UNICEF, and the teacher competencies of many countries. While developing the observation form, we took into consideration also studies in the literature (Şahin, 2011). In this direction, we created a total of 10 items, four of which were related to PCK's knowledge of student learning difficulties (item 2, 3, 4, and 6), and three each of which were related to knowledge of curriculum (item 1, 5, and 10) and knowledge of instructional strategies (item 7, 8, and 9). We created the criteria of "observed," "partially observed," and "not observed" for the observation items. In addition, we created the option "not suitable for observation," taking into account the fact that the observed item was not suitable for the learning outcome that the teachers' addressed.

Validity and Reliability of the Observation Form

The observation form was examined by two academics specialized in the field of PCK in terms of content validity and their opinions were noted. We also sought the opinions of academics in the field of science education who would be consulting in the research. We created a draft observation form by making corrections in line with the opinions of the academics in both groups. In line with the suggestions made here, we have added a section called "explanation" where the counselors can explain the reason for the scoring made after each item. In addition, we added the "observer notes" section to the end of the observation form, both for how well the participant could implement the counselor's suggestions in the previous lesson and for new suggestions to be made in the next lesson.

For the reliability of the observation form, 2-h lessons of five different participants were evaluated by two different observer academics using the draft observation form. During the observation process, the observer academics took notes on the issues that were not agreed on the form. After five observations, the observer academics held a final meeting and reviewed the points that were understood differently in the items, and the final form of the observation form was decided. Since it is found medium or high correlation between observers in the

five observations ($r = 0.852, \rho = 0.002$; $r = 0.680, \rho = 0.030$; $r = 0.909, \rho = 0.000$; $r = 0.761, \rho = 0.011$; $r = 0.432, \rho = 0.212$), the form was found to be reliable for use in research.

In the study, besides the observation form, two issues were taken into account for the reliability of the observation. First, to ensure consistency in the observation, each participant was provided with the same counselor throughout the research. Second, all participating teachers were observed during the diagnosis and evaluation stages of ACM by a second counselor using the existing form. This was done because while one performance is sufficient for some academics, it may be partially sufficient for another. According to the observations made here, since there was a high and significant correlation ($r = 0.757, \rho = 0.002$) between the mean scores of the two groups of observers, it was decided that the data obtained from the observations were reliable.

Procedures

First of all, we constituted a team of academics who work in teacher education for this research. Since we selected science teachers as participants, we paid attention to the fact that the academics who would advise them should have a PhD in Science Education or its sub-disciplines and have been conducting research in this field for at least 10 years. In addition, we have included two academics, one of whom has a PhD in Instructional Technologies and the other one has a PhD in Psychological Counseling and Guidance, to conduct the courses during the training stage and to support the counselors in the research meetings. A total of six academics, four of whom were in the counseling team and two in the support team, took part in the academic team. Since the research was carried out according to the stages of ACM, the whole process was presented according to the stages of the model. Table 2 shows both the purpose of the five stages of ACM and the applications made in this process.

As a result, although it varies from teacher to teacher, the entire application period was a maximum of 23 weeks (1.5 semesters), which equates to about 90 course-h per participant. The periods specified in Table 2 show only the observation hours and the counselings were not included in these periods. In the literature, it is stated that the long duration of the training given for the professional development of teachers affects both the professional knowledge of the teachers and the success and attitude of their students in the course (Desimone, 2009; Desimone et al., 2013; Garet et al., 2008; Lie et al., 2019). In the meta-analysis study, Desimone (2009) determined that for teachers' intellectual and pedagogical change, the duration of training should be over 20-course h and its implementation process should be long enough. For this reason, while applying ACM, we paid attention to both that the implementation process should be long (spread over time) so that academics and teachers could cooperate sufficiently, and that the duration should be long to be able to do enough practices. The other point that ACM attaches importance to is that all practices should be done in the teachers' own classrooms.

Table 2: Stages and application process of ACM

Stages and its implementation time	Aims of the stages and application process	
The diagnosis/8–10 course h in 2–3 weeks.	Aim	The aim of this stage is to determine what kind of professional needs teachers have regarding PCK.
	Process	<ul style="list-style-type: none"> • First of all, we held a meeting (dinner) where the participating teachers, school administrators, and academic staff could meet. • In addition, we made sure that the counselor attends the class in the same class at all stages of the model, except for the evaluation. The aim here is to ensure that the counselor is accepted as a member of the class by the students and the teacher in order to be able to observe the class in its routine. • We have created a social media group where teachers can easily reach all academics and the other teachers, exchange ideas, and share all kinds of data easily. • We made preliminary observations and informal interviews to determine teachers' current situation regarding their professional needs in the field of PCK. • Based on preliminary observations and informal interviews, we identified the courses that suitable the professional needs of teachers.
The training/a total of 35 course-h in 4 weeks.	Aim	The aim of the training stage is to provide teachers with a qualified education in line with the needs that arise during the diagnosis stage.
	Process	<ul style="list-style-type: none"> • In line with the needs analysis made at the diagnosis stage, we considered the common needs of the teachers while determining the PCK-based courses to be given to the teachers. We decided to solve the different problems of teachers from the others during the counseling process. • We allocated the courses, taking into account the working areas of the academics. Academics supported the course contents with applied examples in accordance with the Science Curriculum rather than intensive theoretical knowledge. • Some of the courses given at this stage can be listed as follows; <ul style="list-style-type: none"> Use of mobile technologies in science teaching, Science method course, Misconceptions in science teaching.
The action/although it varies from teacher to teacher, 20–32 course h of observation in 5–8 weeks	Aim	The aim of the action stage is to develop PCK-based instructional designs for teachers' classroom practices and to examine their effectiveness. This design may be for the solution of a problem that teachers encounter regarding the teaching process, or it may be suitable for the routine of their course.
	Process	<ul style="list-style-type: none"> • At this stage, the teacher shared his/her ideas about the instructional design he/she will prepare for the next lesson with the counselor. The counselor made suggestions about the instructional design ideas presented to him/her by the teacher, but he/she was not insistent. • Counselors entered the class together with the teachers in the predetermined class and made observations with the observation form. During the observation, the counselor did not interfere with the teacher's practices. • After the lesson -at recess-, the counselor and the teacher made a general evaluation of the lesson together. The counselors paid attention to making soft suggestions at this stage. At the end of this meeting, they discussed the instructional design of the next lesson. • At this stage, the counselors made observations twice a week for a total of 4 lesson h, excluding counseling hours. • The professional development of the teachers and the events in the process were discussed by the academic team by holding meetings every 2 weeks, and a solution was tried to be found. • In line with the opinions of the academic team, if there are serious developments in the professional skills of the teachers, the stage of gradually decreasing was started.
The gradually decreasing/depending on the teacher, 6–10 course h in 3–5 weeks	Aim	The aim of this stage is to guide the teacher as much as he/she needs, and gradually withdraw the support given as the professional skills of the teachers are improved.
	Process	<ul style="list-style-type: none"> • Unlike the action stage, the counseling given to teachers has been gradually reduced. For this purpose, both the counseling hours given to the teachers and the amount of counseling given were reduced, leaving the teachers more free in their teaching processes. For example, four hours of observation and counseling per week were initially reduced to two-course hours, and then to one-course hour.
The Evaluation/8-10 course hours iobservation in 2-3 weeks	Aim	At this stage, we aimed to evaluate the changes in the professional development of teachers. The effectiveness of ACM will also be evaluated through the professional development of teachers.
	Process	<ul style="list-style-type: none"> • The teachers were observed with the observation form as in the other stages of the model. Unlike the action and the gradually decreasing stages, no counseling was given to the teachers here.

ACM: Academic counseling model, PCK: Pedagogical content knowledge

Analysis of Data

The counselor academics filled in each item in the observation form during the observation process. A score of “2” was given if an item was fully observed, “1” was allocated if it was partially observed, and “0” was given if it was not observed. The item 2 of the form was scored reversely due to the nature of the

item. Even though the observed item was not suitable for the learning outcome that the teacher addressed, we marked it “not suitable for observation” and did not take this item into account in scoring that observation. For example, if any item was not suitable for the learning outcome in one of 10 observations, we obtained the average score of the item by dividing the total

score of this item by 9 not 10. We have shown examples of how the academics scored each item in the observation form in the Table 3. To determine whether there is any change in the diagnosis, action, gradually decreasing, and evaluation stages of the ACM according to the items of the observation form, we first calculated the average scores of each item for each participant teacher. We graphed these averages to descriptively examine the change in teachers' professional development (Figures 2-4). Afterward, we performed statistical analysis by calculating the total scores obtained from each observation. We decided to perform the repeated measures test to examine whether the change in the total scores obtained in the four stages of the model was significant. However, we preferred the Friedman Test, which is a non-parametric test, both because the sample was small and the characteristics of the data collection tool (Pallant, 2005). We used the Wilcoxon Signed Ranks Test to determine which ACM stages had significant differences.

RESULTS

In this section, the findings about the participant teachers' reflection of their PCKs in their classroom practices in the four stages of ACM are included. For this purpose, the findings obtained from the observation form developed for the three

components of PCK are presented in order. Figure 2 shows the graphs obtained from the three items in the observation form about PCK's knowledge of curriculum.

Figure 2 shows that all participants, except for T2 and T7-coded teachers, were at a good level at the beginning in item 1 about interpreting the concepts suitable for the learning outcome in accordance with the student level. T2 and T7-coded teachers, on the other hand, made progress according to the diagnosis stage of the model and reached the acceptable range by exceeding 1.5. The teachers had the most difficulty in item 5, which was "associating the learning outcome with other disciplines" regarding the knowledge of curriculum of PCK. In this item, only T4 and T7-coded teachers showed stable progress in the stages of ACM. Since it was not possible to associate all the learning outcomes in the curriculum with other disciplines, this item was left out of observation in some courses. For example, in three out of 23 observations of T1-coded teachers and seven out of 24 observations of T2-coded teachers, this item was not taken into account on the grounds that it was not suitable for observation. In addition, the graph related to item 10 of the observation form shows that all teachers except for T4 and T6-coded teachers had serious problems in choosing teaching materials suitable for the learning outcome during the

Table 3: Examples of scoring the items in the observation form

Criterion	Grade	Subject	The item in the observation form	Observation example
Fully observed	7 th grade	Light	Correcting a scientific mistake in students (Item 3)	A student said that the Moon is the source of white light. The teacher explained that the Moon is not a source of light.
Fully observed	6 th grade	Sound and features	Making a scientific mistake about the focused learning outcome (Item 2)	The teacher incorrectly drew the particulate nature of matter on the board. In the drawing, all liquid particles were ordered (as in solid-state) and spaced between them (as in gaseous-state).
Partially observed	7 th grade	Refraction of light-boundary angle	Organizing the teaching processes by taking into account the development and learning characteristics of the students (Item 6)	The teacher explained the subject well. However, he/she could not sufficiently embody such a complex and abstract subject for this age group. Even the successful students of the class do not look with eyes that fully understand. He/she could do a virtual or real experiment.

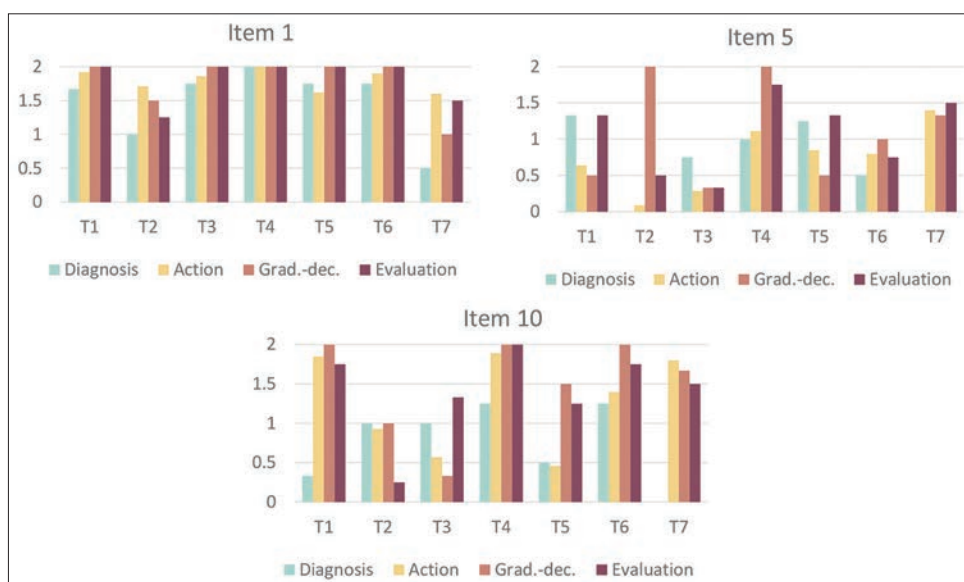


Figure 2: Graphics of pedagogical content knowledges Knowledge of Curriculum

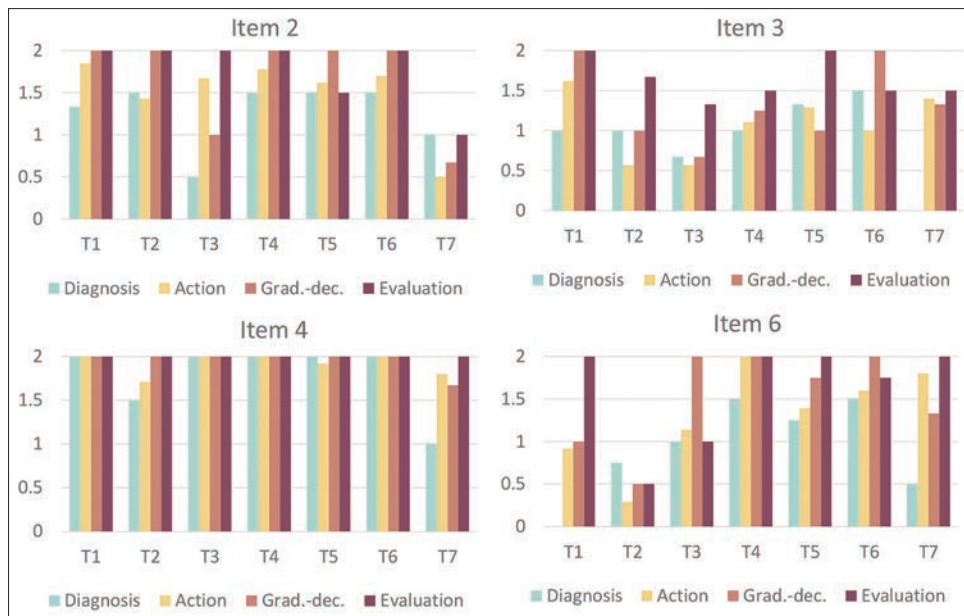


Figure 3: Graphics of pedagogical content knowledges knowledge of student learning difficulties

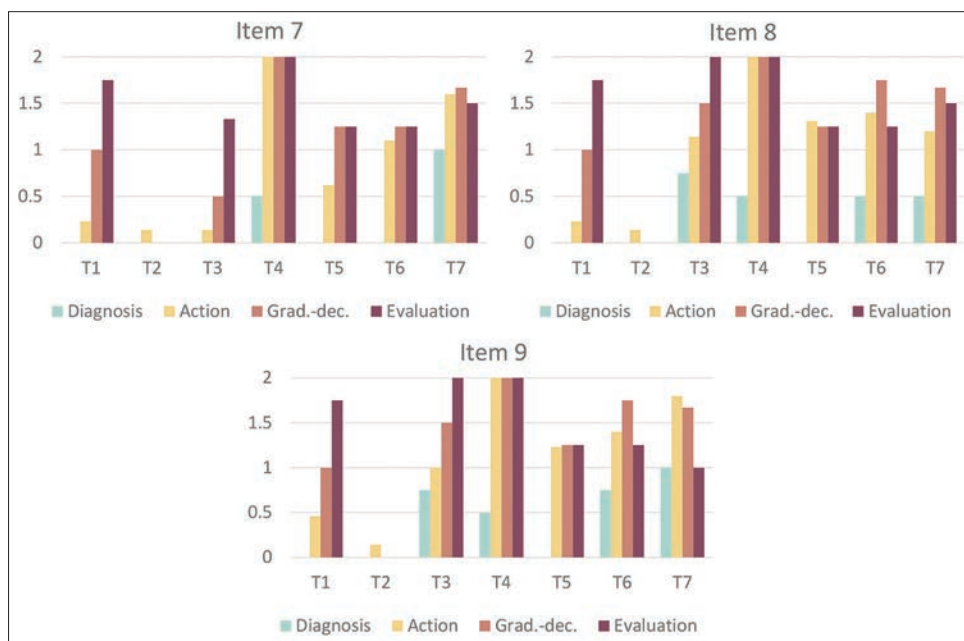


Figure 4: Graphics of pedagogical content knowledges of instructional strategies

diagnosis stage of the model. In the last two stages of ACM, the graph shows that five participants, except for T2 and T3-coded teachers, showed significant improvement. Figure 3 shows the graphs obtained from the four items in the observation form about PCK's knowledge of student learning difficulties.

Figure 3 shows that the participating teachers except for T3 and T7-coded teachers did not make serious scientific mistakes in the classroom practices during the diagnosis stage of ACM, according to item 2. With the implementation of the model, all participants reached the desired level, except for the T7-coded teacher. According to item 3 about the participant teachers'

correcting a scientific mistake in students, the related graph shows that all the participants, except for T5 and T6-coded teachers, had serious problems in the diagnosis stage of ACM. Regarding this component, although all participants showed improvement in the other three stages of the model, T1 and T7-coded teachers showed a high level of improvement compared to the first stage. Item 3 of the observation form was not included in the scoring if the students did not make any scientific mistakes. For example, the students did not make scientific mistakes in 9 of the 25 observations of the T5-coded teacher and in 12 of the 22 observations of the T6-coded teacher.

Figure 3 shows that participating teachers except for T2 and T7 did not have any problems in item 4, which measures the “using of technical terms related to the focused learning outcome”. These teachers solved these problems in the later stages of the model. In addition, T1, T2, T3, and T7-coded teachers had serious problems regarding item 6, which measured the “organizing the teaching processes by taking into account the development and learning characteristics of the students” in the diagnosis stage of ACM. In this item, the figure showed that all teachers, except for T2 and T3-coded teachers, made a steady progress in the later stages of the model.

Figure 4 regards PCK’s knowledge of instructional strategies and shows teachers were the most difficulty in gaining this knowledge in all the stages of the model. In the last two stages of the model, Figure 4 shows that only T1, T4, and T7-coded teachers were able to exceed 1.5 points. Other teachers scored an average of 0.5 point, while T1, T2, and T5-coded teachers were very inadequate, according to items 8 and 9 in the diagnosis stage of the model. Five teachers except for T2 and T5-coded teachers scored above 1.5 points in the last two stages of the model. A significant change was observed in all participating teachers, except for T2-coded teachers according to this component of PCK. A high level of progress especially made for T1, T3, and T4-coded teachers in these two items with the implementation of ACM.

Friedman repeated measures analysis was conducted to determine how the participant teachers showed a statistical change in the three components of the PCK according to the classroom observations made in the four stages of ACM. Table 4 shows the result of the analysis.

Table 4 shows the participating teachers respectively scored an average of 8.81, 12.66, 14.43, and 15.20 points in the diagnosis, action, gradually decreasing, and evaluation stages of the ACM. The scores obtained from the four stages of the model differ significantly according to the Friedman Test ($\chi^2_{(3)} = 16.217, \rho = 0.001$). When we compared the change in the PCKs of the participating teachers according to the four stages of ACM, we found a significant difference between diagnosis and action in favor of action ($Z = 2.366, \rho = 0.018$), in diagnosis and gradually decreasing stages in favor of gradually decreasing ($Z = 2.366, \rho = 0.018$), in the diagnosis and evaluation stages in favor of evaluation ($Z = 2.366,$

$\rho = 0.018$), in action and gradually decreasing in favor of gradually decreasing ($Z = 2.197, \rho = 0.028$), and between action and evaluation in favor of evaluation ($Z = 2.197, \rho = 0.028$). However, no statistically significant difference was found in the PCK scores of the participating teachers in the gradually decreasing and evaluation stages of the model ($Z = 0.734, \rho = 0.463$).

DISCUSSION AND IMPLICATIONS

We designed this research to examine the impact of ACM on the professional skills of Science Teachers. When we examined the effect of ACM on the knowledge of curriculum as a component of PCK, some participants could not show the desired level of development in terms of both associating the learning outcome with other disciplines (item 5) and choosing materials according to the learning outcome (item 10). Similarly, Güler (2019)’s mentoring research aimed at improving the PCKs of novice mathematics teachers did not achieve the desired level of improvement in both in-class association and material selection at the end of the application. First of all, teachers’ awareness of the curriculum should be high to be able to choose materials suitable for the learning outcome and to make extracurricular associations. It is known that teachers encounter some problems because they do not know the curriculum well (Öztürk, 2017; Tekbıyık and Akdeniz, 2008); this situation is true not only for science but also for other courses, and teachers/candidates have limited knowledge of curriculum (Baştürk and Dönmez, 2011). The problems of the teachers about the knowledge of curriculum may be due to the high number of learning outcomes in the curriculum in Turkey. For example; since there are 223 learning outcomes in the Science Curriculum of the 5–8th grade (MoNE, 2018), it may be difficult to associate each learning outcome with other disciplines and to keep in mind the materials suitable suggested by the curriculum for the current learning outcome. As a matter of fact that the number of learning outcome in the curriculum is too high appears as a criticism made by both teachers and researchers in the literature (Boyaç, 2010; Özcan and Koştur, 2019). This result shows that in the future applications of the model, it is absolutely necessary to include courses that increase participant teachers’ awareness of the curriculum.

All of the teachers, except one, reached the expected level with the application of ACM in item 2 regarding the knowledge of student learning difficulties as a component of PCK (Figure 3). Findings show that almost all of the teachers had serious problems in items 3 and 6 but almost all of the participants solved this problem to a large extent in the later stages of the model. In particular, the main reason why teachers made scientific mistakes or did not realize the scientific mistakes in their students may be due to their insufficient content knowledge (Usta, 2018; Uz, 2019). Based on classroom observations, we concluded that ACM was effective in completing the deficiencies of participating teachers in PCK’s knowledge of student learning difficulties.

Table 4: The result of friedman repeated measures analysis of participating teachers according to the four stages of ACM

Stages of the model	n	M	SD	χ^2	df	ρ	Pairwise comparison
Diagnosis (D)	7	8.81	2.30	16.217	3	0.001**	D-A*
Action (A)	7	12.66	3.46				D-GD*
Gradually Decreasing (GD)	7	14.43	3.11				D-E*
Evaluation (E)	7	15.20	3.60				A-GD*
							A-E*

* $\rho < 0.05$, ** $\rho < 0.01$. ACM: Academic counseling model

When participants' knowledge of instructional strategies was examined, almost all participants had very serious problems in the diagnosis stage of the model (Figure 4). In line with this problem, all teachers, except the T2-coded teacher, made significant progress in this component with the lessons given in the training stage and the counseling practices. As a result, we determined that ACM effectively improved teachers' knowledge of instructional strategies as a component of PCK. In the literature, there are some studies stating that the courses given on instructional technologies and strategies, improve the PCK and TPACK of the teachers/candidates (Mouza et al., 2014).

Findings show that ACM has improved in three components of PCK of participating teachers. According to the observations made in the four stages of the model, these improvements in teachers' practice were also statistically significant (Table 4). When we analyzed which stage this difference originated from, we found a significant difference in all stages except for gradually decreasing and evaluation. Considering the structure of the ACM, it is normal that there is no statistically significant difference since no application was made to improve the PCKs of the participating teachers during the evaluation stage. Even partial decreases in the classroom practice of teachers should be considered normal, as the counseling is completely discontinued at this stage, and the participants are expected to present their own designs. However, we found significant increases in some participants compared to a gradually decreasing in the evaluation stage. This apparent increase may be due to teachers' efforts to perform at a higher level because they know they are being evaluated. Similarly, we observed that while most of the participating teachers exhibited their routine teaching designs during the diagnosis stage, some of them acted with performance anxiety (item 10). In future applications of the model, it may be useful to exclude the first observation at the diagnosis stage or to expand this stage.

When we examined the research in general, ACM had significant effects on the professional development skills of teachers. We think that there are two main reasons for this result. The first reason stems from a long-term application covering 1.5 semesters. Because in all research on the professional development of teachers, it emphasizes the importance of both the long application time and the long process (Desimone, 2009; Guskey, 2002). However, as in our research, there are not many studies exceeding 20 weeks. The second reason is that the practices were done in the teachers' own classrooms, that is, in their own routines. Because although teachers want to develop professionally, they may not want to make a great effort, or they may think that the applications made in an artificial environment will not work in their classrooms. We have seen that the model is effective in breaking this prejudice. In addition, the fact that we have not lost participants despite such a long process can be accepted as proof that ACM is not only beneficial but also sustainable. To identify and correct the aspects of ACM that do not work in practice, it is necessary to conduct more extensive research, including different branches.

CONCLUSION

With the application of ACM, we determined a statistically significant improvement in the three components of the participants' PCK according to the repeated measurement analysis. Moreover, we found a significant difference between all stages of the model except gradually decreasing and evaluation, in favor of the next phase of the model. This finding shows that the creation of cooperation between academics and teachers with the ACM is effective on the development of teachers' PCKs. Faikhamta et al., (2009) state that pre-service teachers' cooperation with experienced teachers and expert teacher educators makes significant contributions to the development of PCKs. In summary, based on the results obtained from the research, ACM is an effective model for the professional development of in-service teachers. In this study, we only addressed the professional development of teachers among the seven sub-variables of ACM. In future research, more comprehensive studies focusing on other sub-variables will be useful to reveal the impact of the model.

Limitations of the Study

The number of participants is the most important limitation of this study. Another limitation is that we only focus on the professional development of teachers, although ACM has many variables. The reason for these two limitations is both the long duration of the application and the limited research budget. Conducting more comprehensive studies with larger budgets in the future is vital for the further development of the model. In addition, the knowledge of assessment as a component of PCK was not addressed in the study. The reason for this limitation stems from the fact that assessments were not carried out in every lesson.

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