Change in teachers' practice through the elaboration and testing of an informed teaching proposal

Pilar Segarra[1], **María de los Ángeles Ortíz**[1], **Virgen Huerta**[2]
[1]*Departamento de Física, Facultad de Ciencias, Universidad Nacional Autónoma de México.*
[2]*Escuela Nacional Preparatoria 7, Universidad Nacional Autónoma de México.*

E-mail: psegarra@ciencias.unam.mx

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Abstract

Educational research indicates that it is very difficult for experienced teachers, to modify their teaching approach, even after several disciplinary or educational courses. It is known that they, generally continue with the familiar methods used for years, remaining as the central figure that transmits knowledge, without fully considering the ideas, interests or knowledge of their students. We ask ourselves if a group of experienced teachers improve their pedagogical content knowledge (PCK) after attending an interdisciplinary training program, in which the elaborated teaching proposal is tested in the classroom. In order to investigate this, a questionnaire was applied to master degree graduates with such characteristics of co-construction and application of a teaching proposal. Contrary to the results of short courses, we have found that all the surveyed teachers had significant advance in their PCK.

Keywords: Teachers' training, Pedagogical content knowledge, High school Physics teaching.

Resumen

La investigación educativa indica que es muy difícil para los profesores con experiencia para modificar su método de enseñanza, incluso después de varios cursos disciplinarios o educativos. Se sabe que por lo general continúan con los métodos habituales utilizados por años, manteniéndose como la figura central que transmite el conocimiento, sin examinar a fondo las ideas, los intereses o los conocimientos de sus alumnos. Nos preguntamos si un grupo de profesores con experiencia mejorarían su conocimiento del contenido pedagógico (PCK) después de asistir a un programa de entrenamiento interdisciplinario, en el que la propuesta didáctica elaborada se prueba en el aula. Para investigar esto, se aplicó un cuestionario a los graduados de maestría con características tales como co-construcción y aplicación de una propuesta de enseñanza. Contrariamente a los resultados de cursos de corta duración, se ha encontrado que todos los profesores encuestados tuvieron avance significativo en su PCK.

Palabras clave: Formación del profesorado, Conocimiento didáctico del contenido, Enseñanza de la Física en bachillerato.

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I. INTRODUCTION

The greater population access to education has increased the concern of governments to improve its quality. It is now acknowledged that the teacher is the main key to the qualitative improvement of an educational system and determines the success or failure of whatever curricular reform or innovation it is intend to be implemented [1]. The European Commission EACEA states "high quality teaching is a prerequisite for high quality education and training" [2].

In many countries, high school teachers have a university education, but usually no attention is paid to training students in teaching at universities, since the common conception has been that teaching is "easy" and that to teach it is enough to have knowledge of the subject, common sense and innate personal qualities [3]. When university graduates have no previous specific teaching training, they use their intuition and try to copy the teaching techniques of their good teachers, which often place the teacher as the central figure, and base their schooling on the transmission of conceptual knowledge and textbooks [4, 5, 6].

Most high school teachers over the world are subject specialists and they are required to have a university degree in the specialist subject. The initial teacher education for this level follows the consecutive model i.e. it is completed after the degree and it is done from short courses in theory and practice of teaching, to a postgraduate degree. In the European countries, teacher education programs for upper secondary level lasts between four to five years, but the compulsory minimum proportion of professional training only exceeds 30% in 6 countries. In the U.K., Ireland and

Spain a one year intensive education programme follows the degree in the teaching subject [7, 8, 2]

In order to enhance high school education, academic institutions over the world have promoted intensive pedagogical and disciplinary courses for in-service teachers, generally lasting one or two weeks and coached by a specialist. A lot of them are often structured as a summer workshop, with little attention to how the content may be used more successfully with students. Many times professional knowledge is placed in opposition to disciplinary knowledge, both domains of knowledge are considered separately and, yet, expected to converge in teacher behavior [9]. Teacher legends suggests that traditional in-service programs consist of outside experts with little knowledge of local conditions who present irrelevant, sometimes amusing, often boring information. It is argued that these experiences are irrelevant and teach teachers little, or at least little of worth [10].

As it may be seen in literature, these courses are not useful because teachers find it difficult to change. It is known that short programs do not really transform the way that science is taught. Teachers go on teaching in the way they are accustomed to do [11]. It is also recognized that individuals and organizations possess a natural tendency to maintain a steady state, so any changes that disrupt this status quo are viewed with caution and are only accepted when the perceived outcome adds value to the individuals and their organizations [12]. On the other hand, Gil *et al*. [3] claims that the personal pedagogical conceptions of teachers' own school experiences acquired naturally and not in a reflexive way, are an obstacle to training and teacher educational change. All these contribute to the poor effectiveness of the proposals transmitted by experts to the teachers [13].

As a rule, educational research rejects training models based on the overlapping of disciplinary knowledge of science and general psycho-pedagogical knowledge [14] but this is the usual way that high school teacher education is done. In summary "standard teacher preparation and in-service teaching experience is not sufficient to develop a high level of teaching expertise" [15]. Another aspect of the problem is the disciplinary knowledge of teachers. Some researchers have found serious problems with subject matter knowledge of preservice teachers, even of those who have completed majors in academic disciplines. Wilson, Floden, & Ferrini-Mundi [16], exemplify that in mathematics, preservice teachers' knowledge of procedures and rules may be sound, but their reasoning skills and knowledge of concepts is often weak. De Jong *et al*. [17] claim that "most of the studies reviewed show that teachers' subject matter knowledge needs improvement, not only because of deficiencies but also because of views deviate from scientific one". Cochran and Jones state [18] "students completing baccalaureate degrees show, at least to some extent, unorganized, superficial and inaccurate knowledge of subject matter areas". Research suggests that changes in teachers' subject matter preparation may be needed, and that the solution is more complicated than simply requiring a major or more subject matter courses [16].

Although teachers' knowledge can be influenced and improved by receptive learning, the most powerful changes result from experiences in practice. The process of change in teacher's practice has been the subject of many studies in educational research. In order to make any modification to the constructed knowledge, the learner must be able to apply the changed idea to new situations, receive feedback about the validity of the construct from other sources, and establish further connections to other elements in the new one [19].

According to Mellado [20] the training skills more able to be set into practice are the ones that are not "for" or "on" teachers, but those made "for" and "with" teachers in interdisciplinary teams between levels. There, the teacher is not a consumer of external knowledge, but a co-producer and an agent of change in the issues that really concern them in their classes. So, if we want to improve education we must begin to work together with high school teachers [21]. If teachers are engaged in a research project involving reflection on their practice and attend courses to support their project, then both contribute to the development of teachers' knowledge [22]. Evidence indicates that such in-service work is more effective when it is planned over 3, or more sequential years [23].

From the previous paragraphs, it can be seen that the initial and on-service high school teacher education problem exists long ago and may be considered an unresolved issue. There have been different ideas around the world but there is not yet a solution that can be applied anywhere.

In this work, we ask whether an integral and interdisciplinary teachers' training program can transform positively teachers' work. For this research we surveyed a sample of experienced teachers graduated from a Master in Teaching for High School Education (MADEMS) at Mexico City.

II. REVIEW OF RELEVANT LITERATURE

Our approach to understand and study the process of change in teachers' practice is the theoretical construct "pedagogical content knowledge" (PCK) introduced by Shulman in 1986. PCK is a way of describing the particular form of content knowledge that exemplifies the aspects of content most relevant to its teaching abilities and that includes the ways of representing and formulating the subject that make it intelligible to others [24]. PCK is teachers' knowledge used to transform subject matter content into forms more comprehensible to students. Shulman [24] states, that it is important to be proficient on the core content and to comprehend general pedagogy, but when you sum up the two, you do not get a teacher.

It is teachers' understanding and performing the key to help a group of students interpret a specific subject matter using multiple instructional strategies, representations and assessments, while working within the contextual, cultural, and social limitations in the learning environment [25, 26].
Initially, Shulman [24] considered the three components of teacher knowledge as: content knowledge, PCK and curricular knowledge. PCK is the teacher knowing, the teacher doing and the reasons for the teacher's actions. It

incorporates both teachers' understanding and its transformation of subject matter knowledge for teaching [25]. PCK can provide a useful conceptual framework to understanding the teacher progress.

Many researchers in the area of teacher education have already recognized PCK as a critical component of the professional status of teachers [27, 28, 29]. While it is generally accepted that PCK is an essential knowledge base for science teachers, educational researchers are not clear on how it develops but have suggested that classroom practice may play a significant role [30, 31, 32].

Shulman [33] affirms that the development of PCK involves a dramatic shift in teachers' understanding. This goes from being able to comprehend themselves subject matter, become able to clarify subject matter in new ways, reorganize and partition it, grasp it in activities and emotions, in metaphors and exercises, and in examples and demonstrations, so students can grip it.

According to this author, the difference between novice teachers and expert ones is the capacity of a teacher to transform the content knowledge that he or she possesses into forms that are pedagogically powerful and yet adapted to the variations, the abilities and the backgrounds presented by students. This means that teacher educators should work with them in the development of this transformation capacity, helping teachers in acquiring the underlying theoretical elements, and accompanying them on the continuous reflection needed to improve their teaching. PCK development incorporates knowledge acquisition and knowledge use. It is unlikely that teachers acquire PCK first, and then apply it. Rather, knowledge acquisition and knowledge use are interwoven within the context of instructional practices. Although teachers' knowledge can be influenced and improved by receptive learning, the most powerful changes result from experiences in practice. Teachers are knowledge producers, not knowledge receivers.

This characteristic is essential to recognize teachers as true professionals [25, 34] Student-teachers need opportunities to reflect on, and develop their understanding of the structure of science knowledge, as well as opportunities to apply these understanding in classroom practice [35].

As noted by Day [36] change is a matter of brains and at the same time a matter of heart. It hardly develops if it does not make up emotionally, and helps provide more personal satisfaction at work and a sense of achievement. Change is to recognize that something can be done better than before, and to feel empowered to make such modifications. Therefore, allowing the teachers to propose themselves the adjustments they are willing to do, or to try new strategies, ensures a long-lasting transformation [21].

To what extent do science teachers' theories correspond to their practices? There is still a lot of debate on whether pedagogical knowledge and views influence actions, or these ones affect pedagogical interpretations [37, 38, 39]. Hanley *et al.* [12] states that a variety of research evidence has shown that teachers' beliefs about teaching and science learning impact their teaching practices. Instead of one clearly preceding the other, changing teachers' beliefs and changing their classroom practice is more of a cycle, where each one reinforces and provides impetus for the other. Developers thus need to consider how to create, or co-construct, such cycles as part of a continuous professional development (CPD) process.

Mansour [39] brings up that teachers' pedagogical views are significant indicators of the behaviors that will be present in the classroom. Of course, they are restricted by teachers' knowledge of the subject matter and his view of the same, which have also been found to influence the day-to-day decisions about what to teach, what to skip, and how much class time needs to be assigned to a particular topic.

However, based on other research, the same author points out that teacher performance is not always consistent with their beliefs, and indicates that the relationship between teachers' theories and their practices are not very strong.

III. METHODOLOGY

This research was developed with 14 high school teachers in Mexico City, who have graduated in the last six years of MADEMS-Physics (Master in Teaching for High School Education), over a population of 32. The participants were seven males and seven females. The ages of this sample ranged from 35 to 48.

This Master in Teaching was designed for future and in service high school teachers in three learning areas:

a) Socio-Ethical-Education, which aims to train students fully in the spirit and practice of social and education purposes of high school education, so that they can understand and use educational models and projects, as well as plans and programs of study to contextualize their educational practices;.
b) Psychopedagogic-Education, its purpose is to familiarize future teachers with the characteristics of the psychological development of young high school students (cognitive, social, emotional, moral and sexual) and to analyze the various theoretical concepts underlying the processes of teaching and learning.
c) Disciplinary; it allows advanced understanding of the contents in a field of knowledge and its teaching, so that subject matter knowledge may be presented into a suitable form for use with pupils [40]. The incorporation of the three areas is done both in teaching practices and in the development of the thesis. The degree seeks that the students use and apply what is learned in the three areas.

The intention of this Master's degree is that each high school teacher finds its own way into classroom work, based on the three knowledge areas. They must design a teaching proposal in a specific physics topic. The proof of the teaching proposal takes place over some weeks, for three consecutive semesters with regular high school groups in Mexico City, allowing teachers to improve and adjust teaching and learning strategies. There are four semesters of courses and an additional semester to prepare the dissertation.

The survey was done using a written questionnaire (annex) with 7 open questions that allows us to know how

they currently work in their classroom. All the interviewed teachers entered their degree studies motivated primarily by a desire for self-development, namely: improving their skills, picking up new ideas and gaining an opportunity to reflect on their practice. They wanted physics to be more useful and applicable to students.

According to Park & Oliver [25] assessment of PCK requires a combination of approaches that can collect information about what teachers know, what they believe, what they do, and the reasons for their actions. We know that a single instrument cannot capture the complexity of teachers' knowledge, but the questionnaire is a good start to detect if the results point to changes [41].

In the analysis we use Fox's [42] suggestions about the way in which teachers answer. If the surveyed uses terms like 'imparting knowledge', 'conveying information', 'giving the facts', or' putting over ideas' he/she is considering in the transmition mode. If teachers made a vivid description of their actions in the classroom, it is consider that their PCK had changed to be more student-centered. Besides, if they simply repeated the knowledge, we considered that they have not change [37, 43] since Waggett [44] stresses that verbalization of best practice does not guarantee that teacher will do as they say".

IV. RESULTS

In all surveyed teachers, the development of their pedagogical knowledge is evident. All of them report transformations, most in the disciplinary aspect, some in learning about teenagers, ways of assessment and development of practical activities. Those who graduated early reflect a greater integration of the elements of PCK, as mentioned by Park *et al.* [25] and Peme–Aranega *et al.* [34] that the most powerful change results from experiences in practice.

Considering the questionnaire, the most significant change is that if teachers focus on students, then they have to change the form of assessment, teaching and learning strategies, experimental activities, use of Information and Communication Technologies (ICT), etc.

Teachers showed awareness that they needed to develop their subject matter knowledge into a suitable form for use with pupils. All the teachers showed evidence that their general pedagogical knowledge (GPK) was developing as they reflected on pedagogical approaches which they had tried and adapted.

There are five main changes that can be deduced from the questionnaires and are illustrated with a few phrases of teachers:

1. The educational process is no longer centered on the teacher; they now consider the interests and knowledge of students. Judged by their answers, they have more educational and discipline elements to plan. In some cases they enjoy the new way of working. Now they have taken the students into account understanding that students are teenagers. Teachers foster deeper knowledge, being aware that students do not just repeat information without understanding.

   "I now consider what interests the students and their previous ideas".

   "I am more sensitive to high school students, understanding that they are teenagers, so I am more tolerant. I stopped being the main actor; I use more tools, such as rubrics, videos and science projects. As I have more elements, I plan better classes and became more organized".

   "I search the activities thinking in the usefulness of each one and in the possible application of them. Students work in groups, both in theory and in the laboratory and develop their own research projects".

   "The best way for students to learn is that they work by themselves, discuss and draw conclusions from the problems and experiments proposed by the teacher".

2. Teachers' recognized solid knowledge of the content as essential. They can now change from using only textbook, to now employing a variety of teaching and learning strategies.

   "To be able to modify the classes, I need a change of view and ask myself what I really want students to learn. After MADEMS I believe that students should ask themselves questions and raise their own challenges".

   "I previously used a text book as a guide, now I use several sources of information, different ways of teaching".

   "Before, I thought of the topics of the day for 10 minutes and began to teach. Now, I invest more time, not only thinking of the topics in more detail but also in how to involve the whole class, the appropriate activities to be implemented. I also want to see the applicability of physics in life".

   "Now I seek greater participation of students in class: talking, solving exercises, writing, communicating among themselves, in order to develop skills that will be useful not only in physics, but for life".

   "Classes were prepared with few materials and I gave little importance to pedagogical issues".

   "Now, learning activities are quite varied, and done by the students and me; the class is interactive".

   "Before I simply developed a list of topics and thought in the most consistent way to lecture on them, so that students may solve numerical exercises from the end of the chapter. Now, I think in the students' skills, their interests and how the specific topics may be related with daily life to develop the lesson plan".

3. Assessment is in accordance with the strategies employed, to evaluate what is taught and what is learned.

   "Before MADEMS, I usually explained and at the end of the class asked if there were questions. Now during the session I ask students questions, give them time to think and answer; I use some of their ideas to explain further. As students' ideas are taken into account, their participation increases".

   "I promote the evaluation beyond traditional examinations, looking at assessment methods that promote more analysis of physical situation than of solving exercises".

   "I have adopted the use of portfolio in order to facilitate peer assessment and self-assessment".

"I am starting to explore learning experiences where students can look at their answers and those of their peers. Then I request them to amend any errors in dialogue with their classmates. This is a form of self-assessment".

"At the moment I am satisfied that students may apply the new learning, but I would like that they are capable of analyzing them."

4. The importance of practical work in and out of the laboratory is acknowledged.

   "I became more aware of the importance of practical work to achieve meaningful learning. I applied this to my teaching practice, which was at least 50% based on experiments conducted by students. I got very good results."

   "I strive that students recognize that physics is applied in daily life, and its knowledge is useful. Several experiments were performed to surprises and trap students."

   "Now some experimental activities are conducted in the classroom with accessible materials taken by the students. Some experiments are also performed outside the laboratory. As students like these activities, they work better."

   "I give students small experimental challenges and encourage them to answer certain related questions and that they try to explain the phenomena".

5. Surveyed teachers are in a process, they are aware of their change and recognize the need to change more. Sometimes they come back to what was done before, but know they should continue trying new strategies to get better learnings.

   "I am still in a conflict because I have not developed specific assessments when I am teaching. I have been implementing some, but I still need to continue with this work. I felt many times in traditional evaluation".

In MADEMS, teachers change to improve their classes and to achieve that their students learn effectively. In the answers to the survey, all teachers demonstrate change in the assessment and in the activities performed in the classroom, as in the disciplinary aspect. Change takes place within a nonlinear process with ups and downs. Teachers are clear that it is not enough to repeat what they did in their thesis, but that they need to advance and apply the proposal to different themes with the groups they are attending now.

The main changes found by us are consistent with descriptions in the literature of the evolution in teachers' PCK. In the answers to the questionnaire we found that teachers were able to transform the subject matter knowledge, to subject matter in new ways so that it can be grasped by students. Findlay & Bryce [43] in 2012, studied the development of 6 teachers' PCK, from the beginning of their training one-year professional development graduate diploma till four and a half years later. The most significant change found by them was the teachers' change of focus from teaching the discipline to teaching children. Teachers showed evidence that their general pedagogic knowledge was developing as they reflect and tried different pedagogical approaches, considered the impact of their teaching on their pupils and were conscious that the pupils understood what was being taught. Our results have a high relationship with these findings. On the other hand, Park *et al.* [25] found that PCK was developed mainly through the action reflection cycle within instructional contexts. They proposed 5 components1 of PCK and supposed that the development of each component may simultaneously encourage the development of the others and that the development of a single component may not be sufficient to stimulate change in practice.

In addition to the questionnaire, we have information of the professional activity of several MADEMS-Physics teachers. Most of them are involved in their improvement and understand that this is a long live process; they recognize that the work during the master degree was only the beginning of their transformation. Some of them are collaborating in programs' modification or developing educational materials for students. Their products are presented in national and international conferences on physics education. Some are also subject coordinators at high school; one of them is the academic leader in a K-12 school.

The most relevant result is that three of the surveyed teachers are now participating as teachers in this master's program on teachers' education, where they enrich the courses with their experience as active high school teachers, more near to high school classroom reality.

V. DISCUSSION AND CONCLUSIONS

In this work we investigated whether a graduate program of two and a half years, which includes a design and implementation of a teaching proposal to work in the classroom, has a positive impact on teachers' work.

Obtained results are very encouraging. It is still missing to document the actual students' learning; nevertheless teachers' opinions are enthusiastic.

It is considered that the positive results obtained in this survey may be due that all participants in the degree program enrolled in it with a very high initial motivation to become better teachers. Change begins when teachers have to raise a teaching proposal that takes into account the age and interests of students, as well as the different forms of learning that implies a use of varied teaching strategies. The degree studies provided them with the space to reflect on the work in their classrooms and gave them the interdisciplinary tools to pose the teaching project. The proposal is tested over three consecutive semesters, with the advice of an experienced teacher. Changes in the project are suggested in the evaluations of each cycle: reflection-action–reflection.

When graduate teachers apply the new way of work and see the results, they really begin to appropriate this new teaching approach; it is recognized that the work based on teaching practice is absolutely essential.

Derived from this study we think that in order to improve teachers' PCK they need:

1. To increase knowledge of the taught subjects. Many studies point out that there are difficulties in discipline knowledge.

2. To be aware of the interests of their students and have the elements to plan appropriate classes for them.
3. The necessary tools to modify teaching and learning strategies in the specific discipline.
4. A space where they can reflect on their teaching, propose changes and prove them.
5. Awareness of the need for continuing professional development.

It is likely that this action reflection cycle continues working throughout the professional teachers' career, if they have the support of a professional association or learning group, so that the work is not done alone. Effective science teaching is more than knowing science content and some teaching strategies.

Note:

1. (a) Orientations to science teaching, b) knowledge of students' understanding in science, (c) knowledge of science curriculum, (d) knowledge of instructional strategies and representations for teaching science, and (e) knowledge of assessments of science learning [25].

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APPENDIX

Questionnaire applied to teachers

We request support to accomplish a research on the impact of MADEMS in the way of teaching of graduates. Please answer the following questions briefly.

1. Mention the three or four main areas in which you have modified your teaching practice after MADEMS
2. Do you think that the knowledge gained in the three axes influences your current practice? If so, please explain why.
3. How did you prepare your classes before and how do you prepare them now?
4. Has the dynamics and development of your classes changed after MADEMS? If so, please justify.
5. Do you use different strategies in your courses now? Which are those and how do you use them now?
6. Did your assessment method changed after MADEMS? Which type of learning do you promote with it?
7. Explain how you motivate your students.