

MADEMS: A high school physics teacher master's degree program



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Abstract

This work has to do with a Master degree program for high school teachers: the Maestría en Docencia para la Educación Media Superior (MADEMS). It is oriented to improve teaching professional activities in a balanced treatment of educational issues and the teaching-learning processes of specific disciplines. The program has four main characteristics: (1) a multidisciplinary institutional participation of fourteen academic entities of UNAM; (2) an integrated conception of teaching as a profession that deals with the training and support of pre- and in-service teachers in nine different disciplines, including Physics; (3) a strong fellowship program complemented by a rigorous admission process, and (4) an effective tutorial system including expert professors in the discipline with experience and competences on education. This paper has two sections. Section I contains a general description of the MADEMS Program and some comments on three types of evaluations that have been applied to the program. Section II focus on Physics and the role played by teachers and tutors in connection with the disciplinary subjects of the syllabus and the pedagogical practices of the students as well as their dissertations. We also report on the main effects that the MADEMS-Physics trainees have had in their working schools in connection with the following: changes in the curriculum, production of didactic materials, improvement of the teaching practice, impact on their high school systems in terms of leadership and innovation, and successful participation in national and international meetings on physics education. We obtained previous informations after analyzing a series of questionnaires, interviews and reports concerning the evolution of the MADEMS-Physics Program during 7 years. These instruments of analysis have been applied to students, teachers and dissertation advisors.

Keywords: Teacher training, High school physics teachers, Balanced treatment of educational and disciplinary issues.

Resumen

Este trabajo se refiere a un programa de Maestría para profesores del Bachillerato: la Maestría en Docencia para la Educación Media Superior (MADEMS). El posgrado está orientado a mejorar las actividades profesionales en enseñanza mediante un tratamiento balanceado de los aspectos educativos y los procesos de enseñanza-aprendizaje de disciplinas específicas. El programa tiene cuatro características principales: (1) participación institucional de catorce entidades académicas pertenecientes a la UNAM en donde se cultivan diferentes disciplinas; (2) conceptualización integrada de la enseñanza como una profesión que trata de la formación y el apoyo a maestros en capacitación y en servicio, en nueve diferentes disciplinas, incluyendo la Física; (3) fuerte programa de becas junto con un riguroso proceso de admisión, y (4) un sistema tutorial efectivo que incluye profesores expertos en la disciplina con experiencia y capacidad en cuestiones educativas. Este trabajo comprende dos secciones: la Sección I que contiene una descripción general del programa MADEMS y comentarios acerca de tres tipos de evaluaciones del programa completo y la Sección II que se enfoca a la Física y al papel desempeñado por profesores y tutores en relación con las asignaturas propias de la disciplina, así como con las prácticas docentes y los trabajos de tesis de los estudiantes. También reportamos acerca de los principales efectos que ha tenido la maestría en el trabajo de sus egresados en conexión con lo siguiente: cambios en planes y programas de estudio, producción de material didáctico, mejoría en la docencia, impacto en los planteles respecto de liderazgo e innovación, así como participación exitosa en reuniones nacionales e internacionales relacionadas con la enseñanza de la Física. Hemos obtenido tal información después de analizar una serie de cuestionarios, entrevistas y reportes relativos a la evolución de la MADEMS durante 7 años. Estos instrumentos de análisis se han aplicado a estudiantes, profesores y tutores.

Palabras clave: Formación de profesores, maestros de Física del bachillerato, Tratamiento balanceado de aspectos educativos y disciplinarios.

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I. TRAINING OF HIGH SCHOOL TEACHERS

With rather few exceptions, the main characteristics of teaching high school physics in Mexico are lack of teaching skills and poor understanding of Physics.

Previous situation is made worse by an almost complete ignorance of the results of education research and a great dispersion concerning the treatment of physics content. However, during the last thirty years many courses, conferences, certificates, and training institutes have been organized by individuals and groups of professors belonging to different universities or by academic organizations such as the Sociedad Mexicana de Física (Mexican Physical Society) and the Academia Mexicana de Ciencias. Some of these activities have had the support of the Mexican Ministry of Education, the Latin American Center of Physics, the Inter American Conferences on Physics Education, and the International Commission on Physics Education (ICPE); see for instance the Conference on Cooperative Networks in Physics Education [1].

In one of the first studies concerning physics teacher training at the high school level, Segarra mentioned the following factors that had influenced physics teacher education in Mexico, at the high school level [2]: (1) training corresponded mostly to remedial courses rather than to postgraduate education and in those courses the pedagogy was not integrated with the discipline; (2) results of education research had little impact on the classroom, and (3) the benefits of training were not too much related to the availability of permanent positions nor to promotions in the professional development of the teachers. Up to now, the first factor has been transformed with the creation of a master degree program by UNAM in 2004 [3], but the other two factors remain almost without significant modifications.

A. The MADEMS Program

In what follows, we now describe the main characteristics (C) of MADEMS:

C₁. Multidisciplinary institutional participation: The Program counts with the participation of academic personnel belonging to fourteen academic entities of UNAM: the Center of Teaching of Foreign Studies; the Schools of Chemistry, Sciences, Philosophy and Letters, Political and Social Sciences, and Psychology; the Foreign Multidisciplinary Schools at Acatlán, Cuautitlán, and Iztacala, the Institutes of Mathematics, Research on Philology, and Research on the University and on Education, and the UNAM high school systems Escuela Nacional Colegio de Ciencias y Humanidades and Escuela Nacional Preparatoria.

C₂. An integrated conception of teaching as a profession: The MADEMS program refers to the teaching of either Biology, Chemistry, Classic Studies, History, Mathematics, Physics, Philosophy, Social Sciences or Spanish. All these disciplines are thought in face to face mode (presential mode); however, there are also distance programs in Spanish and Biology. The syllabus contains 15 courses to

be completed in four semesters for full time students or in six semesters for half time students. These courses are distributed in three teaching areas: A₁-*pedagogy for all the disciplines* (History, Society and Education; High School Systems; Adolescents Development; Psycho-Pedagogy of Teaching and Learning, and Ethics in the Teaching Profession); A₂-*teaching of the discipline* (Theoretical and Methodological Foundations; two courses on Specific Didactics, and two courses on Specific Conceptual Developments), and A₃-*integration of pedagogy, the teaching of the discipline and teaching practice* (a workshop on teaching tools, three courses corresponding to the supervised teaching practice during which the students work on their dissertation, and a seminar for graduation work). In the Appendix, more details are given concerning the five courses of the physics teaching specific part (A₂), as well as some examples of the titles of some representative dissertation works.

C₃. A rigorous admission process and a strong fellowship program. The admission process includes three tests referring to: basic knowledge of the discipline, necessary teaching skills shown in the presentation of a lecture sample, as well as written and oral proficiency in Spanish. Students are eligible to three kinds of fellowships: for in-service teachers working at UNAM, for students that just have finished their college and are younger than 28 years old or for any student fulfilling the requirements either of CONACYT or of the General Coordination of Postgraduate Education at UNAM.

C₄. An effective tutorial system with the participation of researchers. To each student an advisory committee of three tutors is assigned. The tutors complement each other by providing knowledge of the discipline and experience in connection with one or more of the following expertise domains: physics content, general pedagogy or specific aim of the dissertation. One member of this committee is the main responsible for leading the dissertation work.

The characteristics C₁ and C₂ were clearly stated in the original structure of the program and nowadays are functioning. However, although the other two characteristics (C₃ and C₄) have been described in the original document creating the program, their practical implementation still requires much more improvement.

B. Evaluations of the MADEMS Program

Up to now, three general analysis of the functioning of the MADEMS Program have been made: the first two concern evaluations made by mexican academic instances: the Dirección General de Evaluación Educativa - DGEE (General Direction of Educational Evaluation) at UNAM [4] and the National Council of Science and Technology (CONACYT) [5] concerning only Physics and Biology, although their recommendations can be applied to the other disciplines studied in the program. The third evaluation refers to an analysis of the structure and functioning of MADEMS when compared to a set of recommendations given to Physics teacher training programs in the United States [6]:

- Evaluation by DGEE: it was based on the analysis of the official document creating the MADEMS master degree program and referred to the leading principles of the program and the following components of its curriculum structure: objectives, profile for entrance and termination of studies, structure of the syllabus and programs of each subject matter, advisory system of tutors, supervision system and flexibility and innovation characteristics. Among other aspects, the recommendations indicated the need for including explicit considerations of competences in different domains, for instance: those competences required at the entrance and at the exit of the studies as well as during each semester, those generic competences concerning the pedagogy and those specific of the teaching of the discipline, and finally, the vertical coordination among the competences associated to subject matters belonging to the same teaching area (see the description in C_2) and the horizontal correspondences among the competences of subject matters studied in the same semester.
- Evaluation by CONACYT: it concerned the criteria required to be satisfied by a postgraduate program in order to be classified as a program of excellence. The recommendations insisted on the need to make explicit reference to competences, knowledge, skills and values that students must satisfy at the entrance and at the exit of the program.
- A comparison of the characteristics of the MADEMS Program with the recommendations made in the Report Synopsis presented by the National Task Force on Teacher Education in USA indicates that the following are the strongest qualities of MADEMS: the integrated approach of the teaching of the discipline, the general discussion of educational issues in the context of professional teaching practice, and the discipline-specific pedagogy that is developed and applied during the preparation of the dissertation. Nevertheless, the Program can be improved by having the support of more researchers working on the teaching of the corresponding disciplines and by creating and maintaining learning communities of prospective and practicing teachers.

II. MAIN RESULTS AND CONSEQUENCES IN MADEMS-FISICA

Up to now, the majority of the student population belongs to the metropolitan area around Mexico City. Since February 2004 until present times, there have been 43 registered students, 40 already finished their courses and 3 are still studying; we had only 4 dropouts. Nearly 90% of the graduates of MADEMS-Física have been physicists or engineers with more than five years of teaching experience; one third of them already had more than 20 years teaching at the high school level. The average of the graduation rate in one year after termination of the courses is around 45%. As a consequence of their training in the MADEMS program, half of the graduate students have been involved

MADEMS: A high school physics teachers master degree program in one or more of the following: (1) changes in the curriculum and in the teaching practice derived from those experiences obtained and reported in their master degree dissertations; (2) impact in terms of leadership and innovation on the high school systems, and (3) successful participation in national and international meetings on physics education.

In order to be more specific, a semi-structured interview was conducted with students who are pursuing the master's degree. Data from these interviews serve to confirm those obtained indirectly and illustrate the observed changes in graduate students. The objective of the interview was to review seven issues related to the perception of the students concerning how the master degree program has influenced them. In what follows, after the title of each educational issue we briefly comment on the most relevant student opinions; however, we do not separate the answers to each one of the previous three questions. Some of the answers concern the learning of the students of the program, while other answers relate to their teaching practice.

ISSUE 1: Cognitive developments concerning teaching practice at the high school level.

MADEMS is a good opportunity to contact other education areas that usually one does not know or take into account, despite the fact that the connection between education and the disciplines lack of a more clear and useful treatment. It is fruitful to see different approaches on education in sciences and humanities.

ISSUE 2: Development of learning and teaching skills and availability for collaboration.

The combination of subjects coming from education as well as from the discipline puts students in contact with different educational cultures, forcing them to think about their own professional training and way of doing within it. During the stay in MADEMS and the development of their dissertation works, most students migrate from a traditional approach to a more student-centered one. Effectiveness concerning collaboration and cooperation depends too much on age and teaching experience; in some cases the results were more positive among students belonging to different disciplines that inside groups of students coming from the same discipline.

ISSUE 3: Conceptual developments concerning understanding Physics.

This is a program for improving the teaching practice not for preparing the teachers on education research neither for updating their knowledge of the discipline. A better conceptual knowledge of the structure and learning problems in Physics is essential; however, the level of understanding must not be limited to the high school syllabus. A common space for reflection and communication is required among students, instructors and dissertation advisors.

ISSUE 4: Strategies for planning, development and evaluation of both teaching sessions and educational projects.

MADEMS has been an opportunity for reflection and learning although the transformation process has been hard but rewarding. There is a generalized feeling of

improvement and broadening of professional horizons; furthermore, the pupils of the MADEMS teacher-students are now aware of that.

ISSUE 5: Efficiency concerning homeworks and tests.

Almost all of the subject matters of the program are thought as seminars and workshops and do not insist too much on teacher talking. Learning and evaluation activities have been stimulating and useful; nevertheless, quite often the way of teaching of the instructors have shown behaviorist realities modulated by constructivist pronouncements

ISSUE 6: Metacognition and self-regulation in connection with teacher education.

Oriented and critical thinking about the teaching practice as well as the learning experiences during the program has been instrumental in improving personal competences in face of social responsibilities. Improvements concerning writing skills and verbal communication abilities have been important consequences of the program.

ISSUE 7: Creation of a better working environment.

Participating in the program has been a fruitful learning experience for all the students and they feel better equipped coming back to their normal teaching duties. The high school teaching environment is strongly inert and change resistant; it is worst due to some negative reactions mostly from those colleagues who have not been in MADEMS.

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APPENDIX

Description of the courses related to the teaching of the discipline (area A₂).

Theoretical and Methodological Foundations: This course considers the context of the initial developments of the three modern mechanics: quantum, statistical and relativity. A triple perspective comprising historical, epistemological and didactic aspects is used to review four crucial phenomena: black body radiation, photoelectric effect, Brownian motion, and Lorentz transformations. Some contributions of historical interest are considered, for instance those famous papers published by Einstein in 1905.

Specific Didactics I and II: These courses provide a framework to organize and interpret the results of the teaching practice that is the didactic scenario for the physics student dissertation work. Several aspects are considered, for instance: teaching methodologies related to lectures, seminars, workshops, practical work, field experiences, tutorial work, and cooperative learning; planning and analyzing teaching situations in connection with problem solving, experiments, computer simulation, and evaluation, and review of some relevant publications on physics education research, not with the purpose of doing research but of using important results in order to be a better professional of physics teaching by improving high school teaching practice. The other purpose in reviewing articles in educational research is to beat down the little impact on the classroom of this research, as pointed out in previous pages.

Specific Conceptual Developments I and II: These courses are focused on the discipline with the purpose of improving the knowledge of a specific topic of general interest such as energy across different branches of physics, entropy, physics in automobiles, experiments in modern physics.... The main purpose is to review conceptual problems and learning difficulties in order to help the high school teachers to understand better the topic under consideration, not just to be more informed about it. Also, to think about new concepts, approaches, and applications, as well as the possibilities to incorporate them into their teaching practice.

Examples of the titles of representative dissertation works in Physics.

- Development of scientific competences: study of the trajectory of a trip to Mars.
- Building a wind tunnel and designing experiments in hydrodynamics.
- Laboratory skills for an introductory physics course.
- Building and using a telescope.
- Conceptual meaning of Maxwell's equations.
- A didactic strategy to teach the atomic structure of matter.
- Waves and light: a teaching project for high school physics.