INSIGHTS INTO PRESERVICE TEACHER KNOWLEDGE APPLICATION: FROM MODEL-CENTERED INSTRUCTION TO LESSON PLAN DESIGN

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RESUMO: The purpose of the present study is to go in depth on the difficulties to translate preservice teachers' understandings into model-centered lesson designs within the context of specific instructional supports. Our findings show that although minor changes related to eliciting students' prior ideas and improving data collection are easily incorporated, it is difficult to produce important shifts in general teaching approaches. Based on these results, areas of focus to improve preservice teacher education in modeling are suggested.

KEY WORDS: teacher education, model-centered instruction, pedagogical content knowledge.

OBJECTIVES

The aim of this study is to insight into preservice teacher knowledge application examining how preservice elementary teachers consider and modify lessons when experiencing modeling centered instruction in a science-teaching course.

THEORETHICAL FRAMEWORK

Current reforms in science education (BOE, 2006; DOGC, 2007) encourage engaging students in authentic scientific practices developing a deep understanding of what science is and how science works. One of the teaching strategies that seems to best engage students in authentic scientific inquiry to promote scientific literacy in classrooms is a model-centered instruction (MCI), which introduces emphasis both in model-based inquiry and metamodeling knowledge (e.g. Schwarz & White, 2005; Windschitl et al., 2007).

Model creation and model-based reasoning are key processes of both human cognition and the development of scientific knowledge (Schwarz & White, 2005; Justi & Gilbert, 2002). Therefore, students should be involved in processes of creating, testing, revising and using scientific models (model practices) as well as having metamodeling knowledge (knowledge about scientific models and modeling practices). Supporting this argument, different studies demonstrate the possibility of implementing this type of practice in primary schools (e. g. Acher et al., 2007; Schwartz et al., 2009).

If teachers are expected to use such reform-oriented practices, it is a challenge for them to develop a solid pedagogical content knowledge –PCK- base regarding these instructional strategies during their preservice training (Shulman, 1986). PCK for scientific modeling implies knowledge of instructional strategies that can promote:

- Students' engagement in modeling practices and learning of epistemological metamodeling knowledge.
- Deep understanding of the purposes models can serve.
- Teachers' knowledge of their students' ideas and challenges, again associated with scientific modeling (Davis et al., 2008).

Likewise, it is also an important target to promote research to understand how teacher educators can promote such understandings which is the main focus of this paper.

Finally, we would like to clarify the use of the terms «scientific model» and «modeling process» for the purposes of this study. A «scientific model» is an abstracted representation of objects, systems or phenomena, whose central features are highlighted, and which may be used to make explanations or predictions (Harrison & Treagust, 2000). Models are produced by the ability of human mind to mentally picture the reality, creating mental models (Johnson-Laird, 1983). Mental models are internal but they can be shared and released becoming expressed models when any symbolic representation system is used to outcome them. On the other hand, «modeling process»establishes a dialogic relationship between model and phenomenon. Different analysis of the phenomenon and/or new evidence obtained, make it possible to refine the model in relation to its elements, relationships, operations and while indicating its limitations. Anyway, any proposed model must be coherent with the available evidence. Taking as a reference the diagram proposed by Justi and Gilbert (2002) shown in fig. 1 we have schematized such dialogic relationship in fig. 2. Such scheme has been used for lesson plan analysis as explaned afterwards.

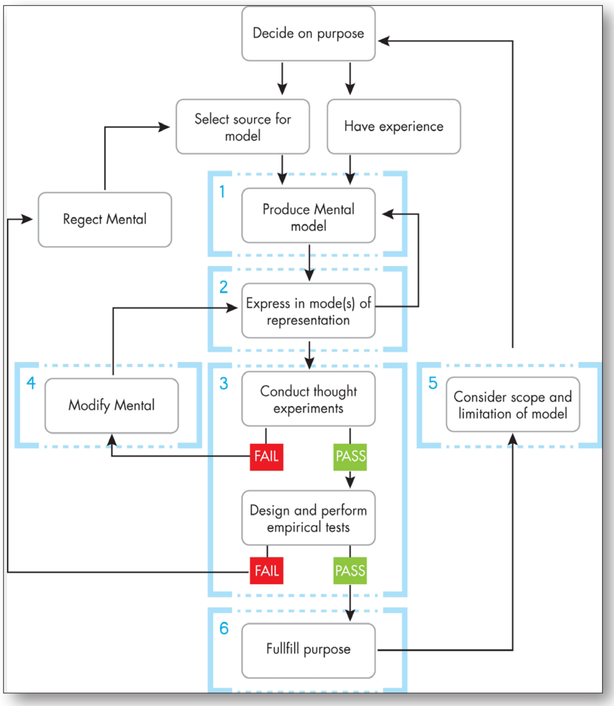

Fig. 1. «Model of modelling» diagram (Justi & Gilbert, 2002). Aspects used to build «Ideal lesson plan» diagram (fig.2) are outlined. Simplification of the scheme responds to best suitability to steps revised by students in their initial lesson plan.

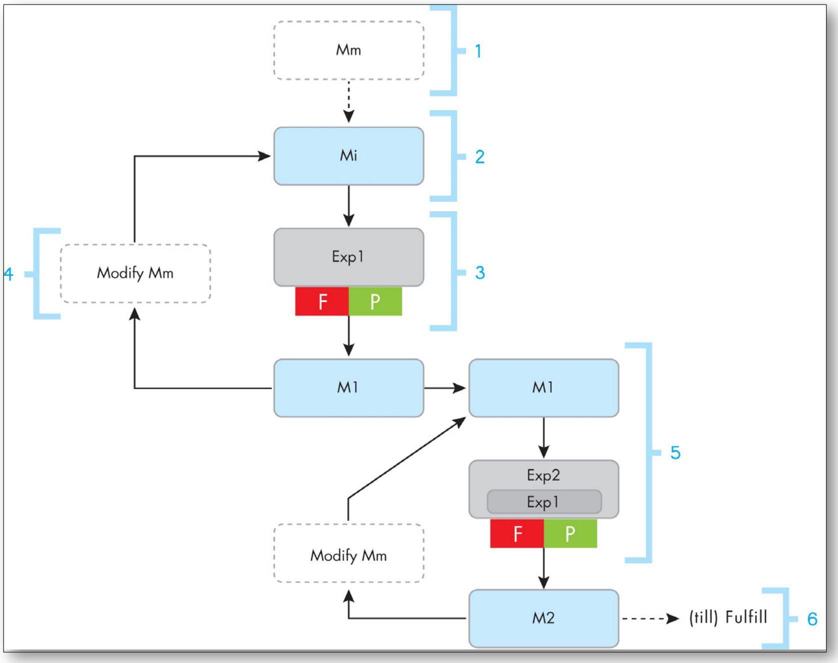

Fig. 2. «Ideal lesson plan diagram». Outlined phases correspond to those in fig.1. Note that 5 is represented as a new merged ideal scheme.

METHODS

The context of this study

Results from the study presented in this paper come from an undergraduate science-teaching course that took place during the 2nd semester of the course 2011-12 at the Universitat de Vic (Barcelona, Spain).

The course met for 2 hours three times a week for 12 weeks. Instruction was led by the first author and has been conceived as an action resarch process. In the course, students experienced MCI in which they used models, created models, evaluated models, and reflected on the nature of models from the perspectives of both science learners and science teachers. Through this activities and investigations students reflected on the epistemology of science and received instructional support for MCI. Furthermore, preservice teachers gained experience in applying MCI through lesson plan analysis, reflection and modification and used a science notebook as an educational tool to support teaching strategies through research.

Study participants were 43 college students in their sixth semester of the Universitat de Vic undergraduate elementary teacher education program. All students but nine were female and most of them were in their early twenties although three were older. Any of the students had taken prior college-level science courses and most of them expressed little or relative interest in science.

Data sources and analysis

For the purposes of this study, we'll discuss data from initial and modified lesson plan designs. Lesson plans were done prior to instruction and were submitted to student analysis, reflection and modification during the course in order to adapt them to the new knowledge acquired through MCI instruction received. To make lesson plans, students had to work into small groups, resulting into 14 different lessons. The theme for the lessons was given by instructors as well as specific instructions for lesson plan analysis and reflection in accordance to the model presented in fig. 2.

Lesson plan analysis was performed following the steps:

1. Identification and delimitation of cognitive or manipulative actions proposed to the pupils beyond the criteria used by students in the delimitacion of activities.
2. Characterization of these actions according to the elements identified by the « Ideal lesson plan diagram»(fig.2) and construction of the logical structure diagram underlying each MCI lesson through confrontation with the ««Ideal lesson plan diagram».
3. Analysis and comparison of diagrams and description of changing trends.

RESULTS

Our research on preservice teachers lesson plan allows us to visualize students initial PCK as well as its evolution over time. A deeper analysis of the diagrams yields also some insight into the constraints to translate preservice teacher's understandings into MCI lesson designs. Results are shown as diagrams in fig. 3-4 and commented below.

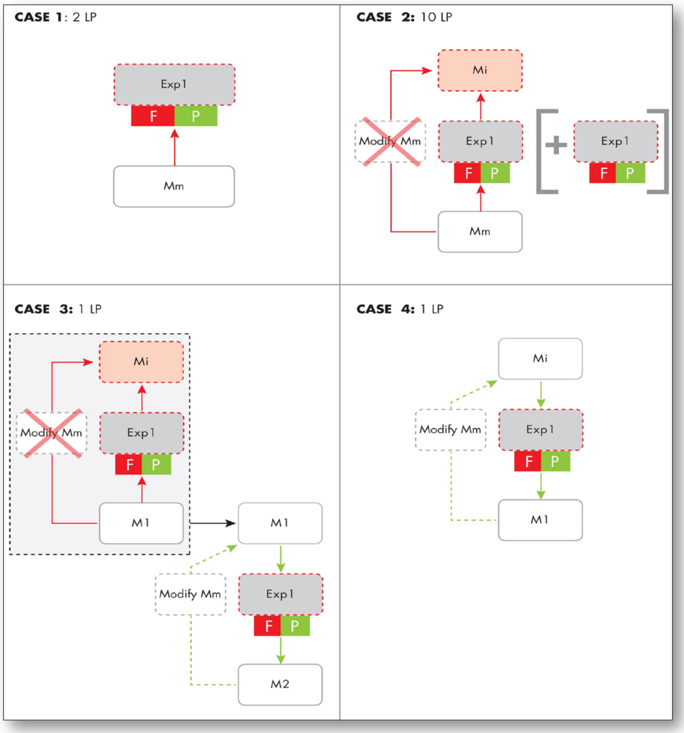

Fig.3. Interpretation of initial lesson plans (LP) according to their fit to the ideal scheme (fig.2). Mismatches are highlighted in red. Dashed lines show ill defined activities.

As shown in fig. 3, at the beginning of the course (cases 1-4), most lesson plans were far distant from the ideal lesson plan diagram in fig. 2 (13 groups of 14, cases 1-3, fig.3). In general, students did not consider alumni mental models in their lesson plans or, when considered, they were explored in a vague way. Moreover, when explored in such a way, mental models were not considered for further planification. Activities outlined in these lesson plans were far removed from real scientific activity and they did not expect students to collect data and evidence to revise prior models (schematized as lack of feddback to initial model) and construct new ones. Some units also included activities not in accordance with the key ideas to develop (shown in case 2 diagram, fig.3). In general terms, these lesson plans respond to either a classical teaching model of verbal transmission or a «hands-on» approach.

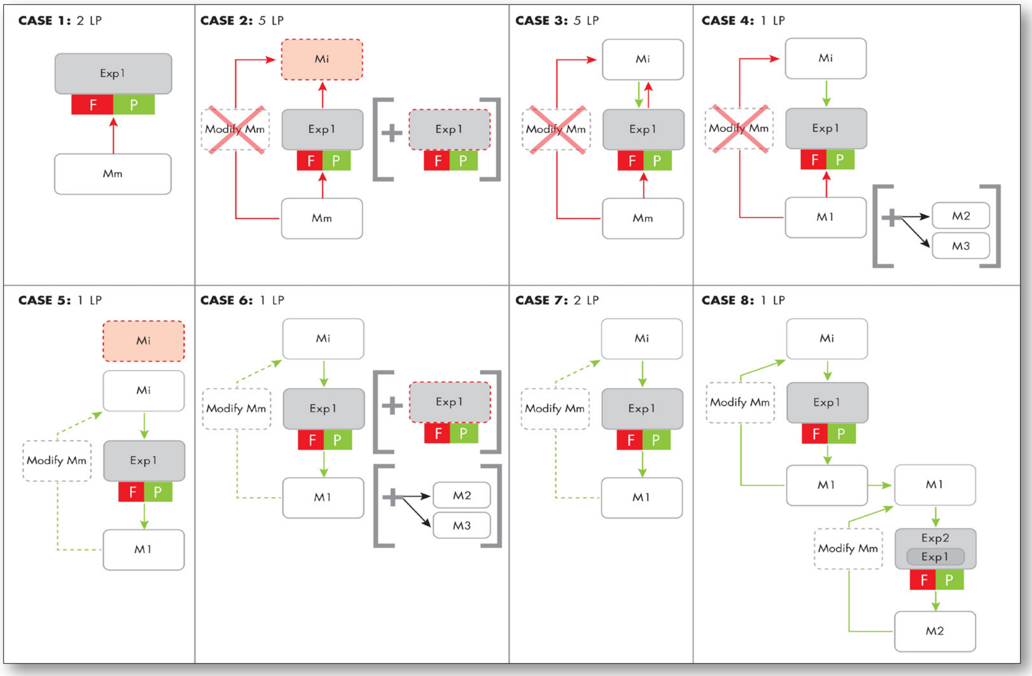

Fig.4 Interpretation of final lesson plans (LP) according to their fit to the ideal scheme (fig.2).

When comparing this initial lesson-plan to revised lesson plans, clear evidences of certain improvements are found in all cases. Even so, just few of them (5 of 14 units –cases 5 to 8, fig.4) get a little closer to MCI. Furthermore lesson plans more distant to the ideal model appear to be the ones with less changes (cases 1 in fig. 3 stayed as cases 1 in fig.4; while 5 units in cases 2 in fig.3 stayed as cases 2 in fig.4) while those closer to ideal model at an initial stage (cases 3 and 4, fig.3) easily incorporate changes in good direction (cases 5 and 7 respectivelly, fig.4).

Interestingly, when there is any change, students easily incorporate changes related to an improvement in data/evidence collection as well as better design elicitation activities of the initial model (cases 3-8, fig. 4). On the contrary, feedback to initial model seems to be the most difficult aspect to incorporate (only in cases 5-8, fig. 4) and, when incorporated, it seems not to be in a really consistent way (cases 5-7, fig. 4). Diagrams 3-4 in final stage (fig.4) represent intermediate models where mental model is elicitated and all or some experimental activities are designed in accordance to it but, when done, theoretical explanations corresponding to a final model are given. Those intermediate diagrams continue representing a «hands-on» approach.

CONCLUSIONS

This study contributes to the literature about preservice teachers and scientific modeling practices in ways that are consistent with others' findings (Schwarz & White, 2005; Windschitl et al., 2008, Nelson & Davis, 2012):

a) Initial preservice elementary teachers' knowledge about MCI is weak at best.
b) MCI appears to be inconsistent with existing beliefs or presuppositions about learning of most preservice teachers and, therefore, requires a great conceptual change for most of them.
c) Engagement in MCI practices during teacher education courses support preservice teacher learning about MCI.

This study provides new elements for a deeper understanding of the key points to contribute to a drift from a classical teaching model of verbal transmission or a «hands-on» approach to MCI. The strongest constrictions we found for the adequate acquisition of MCI appear to be:

a) Understandig the relevance of mental model elicitation as the starting point of the knowledge generation process.
b) Absence of real feedback between the outcome of data analisys and the initial model.

This finding provides new elements for further development of MCI led by teacher educators. More exposition to MCI is necessary for the students to properly integrate it. Special emphasis shoud be providesd on the two above pointed difficulties as they seem to be key ingredients for a real coceptual change.

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