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Dealing with Model-Centered Instruction: from Discourse Acquisition to Lesson Plan Design

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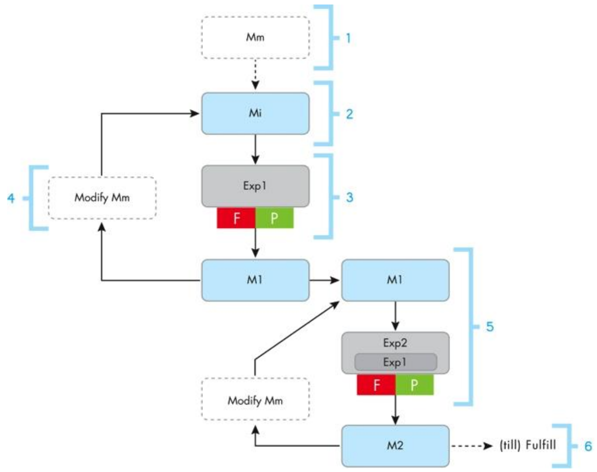
Abstract

This study investigates preservice teachers' difficulties to achieve the required skills to put Model-Centred Instruction (MCI) into practice. To this end, specific MCI for pre-service primary university courses has been designed and performed and various forms of students' productions have been analysed. For the purpose of this paper, we compare initial (prior to instruction) and modified lesson plan designs (performed during and after MCI instruction) and we confront these results with discourse analysis on teaching-learning about science. Results suggest substantial changes in the discourse as well as the incorporation of certain specific pedagogical strategies. However, discourse acquisition is not always fully accompanied by the required skills to put MCI into practice. Thus, specific constrictions for the adequate acquisition of MCI are identified. The paper concludes with different recommendations to improve preservice teacher education.

1. Theoretical framework

International reports on the state of science education indicate the convenience of engaging Kindergarten and Primary students in authentic scientific practices, [e.g. 1] such as scientific modelling. Different studies demonstrate the possibility of implementing this type of practice in primary schools [e.g. 2]. Nevertheless, teaching-learning with and through scientific modelling –here referred as Model-Centred Instruction (MCI)- implies a serious reconceptualization of schooling in which teachers play a crucial role. Unfortunately, preservice teachers have very limited experience in such reform-oriented instructional strategies. Thus, it is a great challenge for them to develop a solid Pedagogical Content Knowledge (PCK) [3] regarding MCI during their preservice training courses [4]. Therefore, understanding how do this teachers learn to engage students in scientific modeling, at the same time as they are learning about scientific modeling themselves, is of crucial relevance.
But, what is a model? We would define a "scientific model" as an abstract representation of objects, systems or phenomena whose central features are highlighted, and which may be used to make explanations or predictions [5]. In science learning, we can find two related ways to use the term model: internal models and expressed models [6]. A mental model refers to the individual's internal representation, or their understanding of a phenomenon. Mental models can be shared and released, becoming expressed models when any symbolic representation system is used to outcome them. Both mental and expressed models are the product of scientific modelling.
Scientific modelling process implies creating, testing, revising and using scientific models (model practices) as well as having metamodelling knowledge (knowledge about scientific models and modelling practices). As schematized in fig. 1 and explained in [7], modelling process establishes a dialogic relationship between model and phenomenon. Different analysis of the phenomenon and/or new evidence obtained make possible to refine the model in relation to its elements, relationships and operations, while indicating its limitations. Anyway, any proposed model must be coherent with the available evidence.
Finally, PCK for MCI implies knowledge of instructional strategies that can promote: a) students' engagement in modelling practices and learning of epistemological metamodelling knowledge; b) deep understanding of the purposes models can serve; c) teachers' knowledge of their students' ideas and challenges, again associated with these practices [4].



1. Mental models
2. Expressed Initial Model
3. Thought/empirical tests
4. Review, modification of Mental models.
5. Use of generated models to new set of tests
6. New cycles until achieve consensus scientific model

Fig. 1 Ideal lesson plan diagram. Paradigmatic schema of a well designed lesson plan showing the dialogic relationship between model and phenomenon. Adapted from [8]. See [7] for an extended explanation.

2. Methodology

2.1 Context of study

Results 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. Study participants were 42 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.

Through different activities and investigations students reflected on the epistemology of science and received instructional support for MCI. They created, used, evaluated, revised models and reflected on the nature of them from the perspectives of both science learners and science teachers. 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.

2.2. Data sources and analysis

For the purposes of this study, we will discuss data from initial and modified lesson plan designs and we will confront these results with discourse analysis on teaching-learning about science. 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. The theme for the lessons was given by instructors as well as specific guidance for lesson plan analysis and reflection in accordance to the model presented in fig. 1.

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 delimitation of activities.
2. Characterization of these actions according to the elements identified by the "Ideal lesson plan diagram" (fig.1) 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.

Questionnaires were also done prior to instruction and submitted to analysis, reflection and modification at the end of the course. For the purpose of this study, we only analyzed responses of two open-ended questions that look for evidence of what preservice teachers' thought about how students learn and how to teach. Data were analyzed via thematic content analysis [9] and themes were identified inductively such that they emerged naturally from the data. Pre- and post- discourse analysis was compared in order to perceive changes in preservice teacher's orientations toward science teaching and learning.

3. Results

Our research on preservice analysis discourse and lesson descriptions allows us to visualize students initial PCK as well as its evolution over time. As shown in fig.2, at the beginning of the course (blue columns), preservice teachers tended to make vague and general statements about science teaching and learning. They put the emphasis on "hands-on" activities used for verification or discovery of concepts without appearing any specific element of science inquiry and modelling practices.

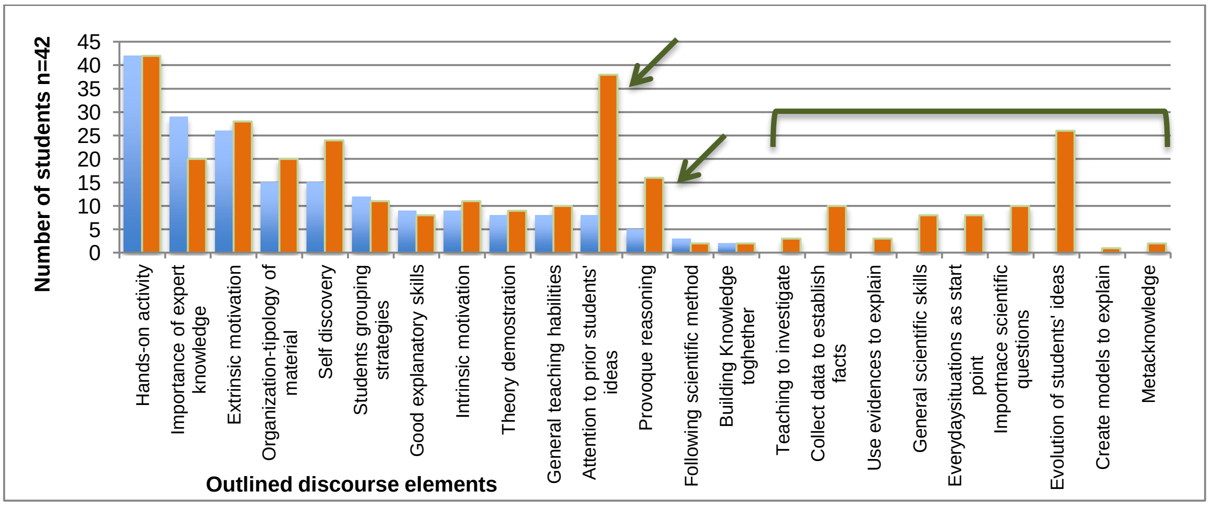


Fig. 2 Analysis discourse prior (blue) and post instruction (orange). Green arrows and brackets highlight most prominent changes.

Initial lesson plans tended to be coherent with this data. Preservice teachers (93%) began the semester designing lessons far from the ideal lesson plan diagram in fig. 1. As shown in fig. 3, these lessons were primarily activity-driven or respond to a classical teaching model of verbal transmission. In general, students did not consider alumni mental models (CASE 1 fig.3; 14%) or, when considered, these prior ideas were explored in an inconsistent way (CASE 2 fig.3; 78%) and they were not considered for further planning.

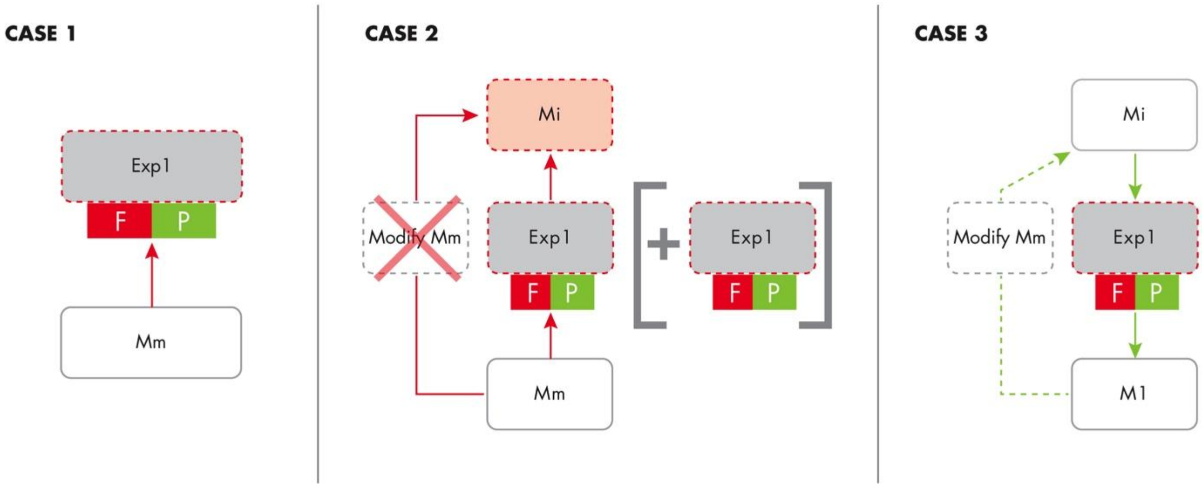


Fig. 3 Diagrams representing major differences found in initial lesson plans, according to their fit to the ideal scheme (fig.1). Mismatches are highlighted in red. Dashed lines show ill defined activities.

Activities described in these lesson plans were far away from real scientific activity (dashed lines in fig.3) and none of them expected students to collect data and evidence to revise prior models

(schematized as lack of feedback to initial model) and construct new ones. Some units also included activities not in accordance with the key ideas to develop (CASE 2, fig.3). Usually, these lesson plans involved students participating in “hands-on” activities used for verification or discovery of concepts or the teacher/expert presenting information. In concordance with results shown in fig.2, lesson plans also put a lot of emphasis in the description of general didactic aspects such as motivation, students grouping strategies, etc.
At the end of the semester, preservice teachers’ discourse showed significant gains regarding MCI. For the sake of clarity, we will focus on those aspects that can be better correlated with diagrams in fig. 4. Many other issues can arise from the analysis of the data, but such exploration goes beyond the scope of this work. As highlighted by green brackets and arrows in fig. 2, the discourse incorporated a cluster of new elements and reinforced two existing items. Interestingly, most of these new/reinforced elements referred to specific elements of science inquiry and modeling practices. In general terms, preservice teachers (90%) stressed the importance of elicit students’ intuitive ideas (mental models) as well as the need to test-review-modify these ideas through inquiry (62%). In some cases, students were also able to fill with meaning what inquiry meant including items such as the importance of questions in research, data collection or giving explanations to fenomena based on data and using models. Finally, it also arised the importance of metamodeling knowledge as well as the promotion of thinking activities.

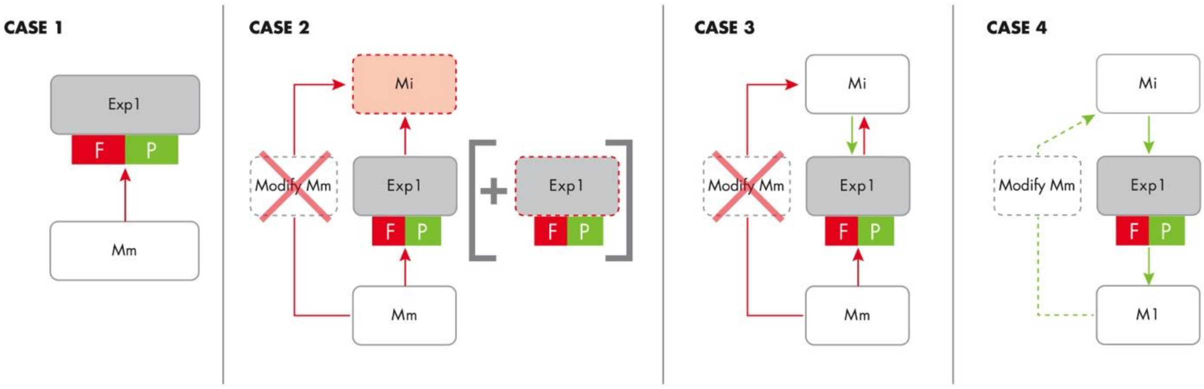


Fig. 4 Diagrams representing major difficulties found in initial lesson plans, according to their fit to the ideal scheme (fig.1). Mismatches are highlighted in red. Dashed lines show ill defined activities.

When confronting these results with lesson plan analysis we realized that language and thought are not always aligned with the practical skills to develop MCI. As can be shown in fig. 4, students easily incorporate changes related to an improvement in data/evidence collection (100%) as well as better design elicitation activities of the initial model (CASES, 3-4; fig 4. 50%). On the contrary, feedback to initial model seems to be the most difficult aspect to incorporate. Furthermore, when incorporated (CASE 4, fig. 4; 43%), it is done in a manner inconsistent with MCI (dashed lines, CASE 4, fig, 4). In general terms, it seems that these final lesson plans were able to engage students with a question and participate in some kind of investigation moving, partially, to a guided-inquiry approach but failing to incorporate models in a consistent way.

4. Conclusion

This study contributes to the literature about MCI in ways that are consistent with others’ findings [e.g. 4]:
a) Initial preservice elementary teachers’ knowledge about MCI is weak at best.
b) MCI appears to be inconsistent with existing presuppositions about learning-teaching science of most preservice teachers and, therefore, requires a great conceptual change for most of them.
c) when given specific and accurate instruction, pre-service teachers can begin to engage in MCI.
This study also provides elements for a deeper understanding of the major challenges for the adequate acquisition of MCI. Our results suggest that preservice students easily recognize the importance of engaging children with elements of MCI. However, preservice teachers may struggle with effective ways of doing so. We suggest major emphasis on understandig the relevance of mental model elicitation as the starting point of the knowledge generation process as well as the importance

of real feedback between the outcome of data analysis and the initial model. The two above pointed difficulties seem to be key ingredients for a real conceptual change.

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