Tracking the Comprehension of Model Centred Instruction through Preservice Teachers' Science Notebooks

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Abstract

This article explores how science notebooks used in science undergraduate courses can be used to visualize and foster preservice teachers' understanding on models and modeling practices. To that aim, and for the last three courses, student science notebooks have been introduced as an integral part of the undergraduate science courses of the University of Vic (Barcelona, Spain). As students, preservice teachers are encouraged to use science notebooks during inquiry lessons reporting experimental data, models, explanations, questions, hypothesis and predictions, such as scientists do. These notebooks have been collected and scanned as a primary data source. Students' spontaneous elements of modeling practice have been analysed regarding learning progressions on modeling practices. Preliminary results show some of the aspects of this complex practice that can be made accessible through the use of science notebooks. Suggestions for their use in teacher education are also outlined.

1. Theoretical framework

Science instruction focused around models and modeling practices (also known as Model Centered Instruction) helps learners to better integrate their conceptual knowledge, to enhance their inquiry skills, and to develop accurate epistemologies of science [1]. However, and despite its importance, research studies reveal the unfamiliarity of inservice and peservice teachers with these reform-oriented practices and, consequently, the persistence of traditional views of science teaching in classrooms [2].

Well-designed, reform-based instruction and materials for undergraduate and inservice teachers appear to be key components of efforts to support teacher change towards MCI [3]. Nevertheless, it is still a challenge for research to understand the way teachers appropriate instruction and translate it into significant and worthwhile classroom changes [4]. In this paper, preservice science teachers' notebooks are proposed as a non-interfering method to explore some aspects of the development of pedagogical content knowledge for MCI.

Scholar science notebooks suppose a compilation of entries that record the instructional experiences a student has had for a certain period of time [5]. They may be defined as individual paper notebooks where students are encouraged to formulate questions, make predictions and hypothesis, record data, analyze results and propose explanations. They are used before, during and after inquiry investigations imitating the notebooks that scientists use. They engage students in authentic scientific thinking and, thereby, facilitate learning through several avenues [6].

The target of the present article is twofold: a) to visualize the possibilities of taking advantage of science notebooks in order to explore the understandings of elementary preservice teachers towards models and modeling practices; and b) to highlight science notebooks as active elements to improve the current standards of preservice teachers training towards MCI.

2. Methodology

2.1 Context of study

During the last three years science notebooks have been used in all the undergraduate elementary science teachers' courses of the University of Vic (Barcelona, Spain). The teacher program for science education at this institution is relatively small. It is composed of two semester-long compulsory courses, plus another methodological optional one.

All courses are conceived as a whole. Under a paradigm of a constructivist classroom culture, they include explorations of the nature of science, instruction on science learning goals in elementary schools, curricula content, inquiry-based-science, science lesson planning, evaluation, students' conceptions about science and science content and conceptual change teaching. As a novelty regarding previous years, courses also incorporate instructional activities associated with modeling. The aim of this new content is double: to develop PCK for scientific modelling; and to promote metamodeling knowledge regarding MCI practices. Courses combine inquiry-based lessons (where preservice teachers experience themselves how they should teach in their own future classrooms); and lecture lessons to promote reflection on inquiry experiences and pedagogical content.

As already mentioned above, throughout all these courses, preservice teachers are required to maintain a science notebook. Specifically, they are required to provide a spiral bound notebook to be used only for the inquiry parts of the courses. During the first and second class meeting, preservice teachers are given a short presentation on using science notebooks and recommendations on what to include. Specific examples from scientists' notebooks are also reviewed and discussed.

Within notebooks, students are asked to formulate their own questions or the ones that arise at the class; record and display observations and data using charts, graphics, etc.; use these data to propose explanations; create, use, review apply models for the phenomena under study; communicate predictions and hypothesis, etc. Although science notebooks are individual, teachers always work in groups of 3-4 during inquiry activities. Furthermore, collaboration among group members and between groups in the class is always encouraged. Thereby notebooks reflect both, individual and collective achievements.

Science notebooks are viewed informally by the instruction during every session with oral feedback provided. They are collected for feedback and non-graded formative assessment at the mid-semester and submitted for a final evaluation at the end of each course.

2.2. Data sources and analysis

Forty-three students' science notebooks form a whole class were examined. Study participants were all in their sixth semester of the undergraduate elementary teacher education program of the University of Vic (Spain). All of them but nine were female and most of them were in their early twenties although three were older. None of them had taken prior college-level science courses and most of them expressed little or relative interest in science.

Entries of each student's science notebook were identified and analysed in order to characterise their typology (i.e.: question, data, model, etc.). For the purpose of this study, entries referred to models and model practices were selected. A double 4-point scale based on previous work on learning progressions for models and modelling practices [7] was used to evaluate the level of performance of this entrances (table 1). The early and later entries were compared for any evidence of change in performance regarding models and modeling practices.

	Understanding models as generative tools for predicting and explaining	Understanding models as changeable entities
Level	**Performance**	**Performance**
1	Students construct and use models that show literal illustrations of a single phenomenon. Students do not view a model as tool to generate new knowledge, but do see models as a means of showing others what the phenomenon looks like.	Students do not expect models to change with new understandings. They talk about models in absolute terms of right or wrong answers. Students compare their models to assess, if they are good or bad replicas of the phenomenon.
2	Students construct and use a model to illustrate and explain how a phenomenon occurs, consistent with the evidence about the phenomenon. Students view models as a means of communicating their understanding of a phenomenon rather than a tool to support their own thinking.	Students revise models based on information from authority (teacher, textbook, peer) rather than evidence gathered from the phenomenon or new explanatory mechanisms. Students make modifications to improve detail, clarity or add new information, without considering how the explanatory power of the model or its fit with empirical evidence is improved.
3	Students construct and use multiple models to explain and predict more aspects of a group of related phenomena. Students view models as tools that can support their thinking about existing and new phenomena. Students consider alternatives in constructing models based on analyses of the different advantages and weakness for explaining and predicting these alternative models possess.	Students revise models in order to better fit evidence that has been obtained and to improve the articulation of a mechanism in the model. Thus, models are revised to improve their explanatory power. Students compare models to see how different components or relationships fit evidence more completely and provide a more mechanistic explanation of the phenomena.
4	Students construct and use models spontaneously in a range of domains to help their own thinking. Students consider how the world could behave according to various models. Students construct and use models to generate new questions about the behavior or existence of phenomena.	Students consider changes in models to enhance the explanatory power prior to obtaining evidence supporting these changes. Model changes are considered to develop questions that can then be tested against evidence from the phenomena. Students evaluate competing models to consider combining aspects of models that can enhance the explanatory and predictive power.

Table 1. Levels of performance for model practices used to evaluate notebooks entries. Source [7].

To explain how we approached the evaluation of modeling practices through science notebooks, two typical examples of students' notebooks entries (figures 1 and 2) are discussed. In these examples, students had to create models to explain the disposition of the particles that compound a gas (figures 1 and 2); a liquid or a solid (figure 1) after making an experience of compressibility. Students put air, water or sugar (one at each time) in a sealed syringe, and tried to compress the substance. In both cases, results from the experience were reported in previous entries and were supposed to be used to create the models.

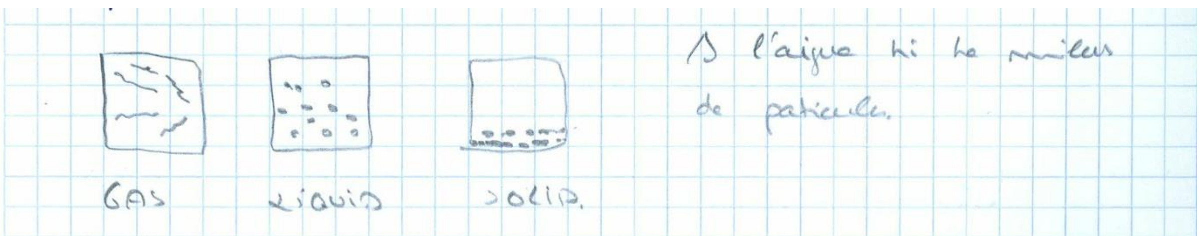

Figure 1. Example of student notebook entry (quoted as 4.1-2.1).

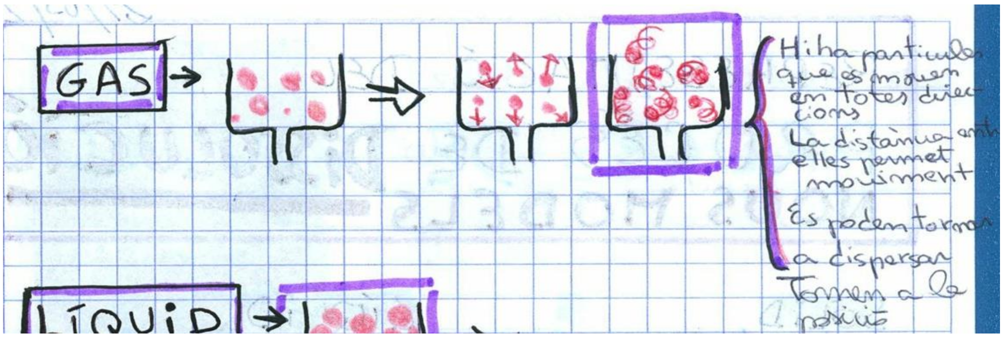

Figure 2. Example of student notebook entry (quoted as 4.3.2).

Both entries are quoted with a code with three numbers. The first number is, in both cases a "4 ", and indicates that it is an entry related to models and modeling practices. The second part indicates the level of performance related to understanding models as generative tools and, the third part, the level of performance regarding the comprehension of models as changeable entities (table 1). Quotations are discussed in section 3 of this article.

3. Results

Preliminary results show the feasibility of the use of preservice teachers' science notebooks to track their comprehension on MCI. Science notebooks offer a privileged window into students' mind and, thus, appear to be a way to continually gather information from them and an interesting avenue to provide feedback.
Science notebooks are a compilation of entries that record what students have been doing over a long period of time. When students are enhanced to create, review and use models within science notebooks, they do not only expose how their conceptual and procedural understanding is being built or their ability to apply/transfer these knowledge to a new situation. Indeed, the evaluation of students' entries regarding to models can also reveal us their metaknowledge on models and modeling practices, as well as their progress over time.
Although, by the time they were done, students have had the same inquiry experiences and had recorded the same data, entries in figures 1 and 2 reveal us great differences on understandings on models and modeling practices. Illustrations like in figure 1 can be seen frequently in the student's initial entries analyzed. The inclusion of microscopic particles in his draw, suggest us that the student is attempting to depict non-observable features involved in the phenomenon. Nevertheless, the model lacks any representation of how these structural components help to explain the observations done, thus indicating that the student is just starting to understand models as tools to explain phenomena. The fact that the student annotates "in water there are many particles", makes us think that the student is considering authoritative evidence from discussions in the class to build his model. Representations like in figure 2 (also common at initial stages), add complexity in several ways. In this figure, the student considers alternatives in constructing the model and evaluates them to finally use the one that better explains the observed phenomena (the circled one). Relations between these kind of entries and later entries also give information about the understanding of models as generative tools for predicting or as changeable entities.
Results indicate that instruction and specific scaffolding based on notebooks' reviews can help preservice teachers to develop more sophisticated understandings of scientific models and modeling practices. Throughout the course, all students developed increasingly sophisticated views of models and modeling practices. All students were able to construct increasingly accurate models; they were able to use them to make predictions for closely related phenomena, and they also developed more elaborated reasoning to revise models. However, even with scaffolding, the majority of these preservice teachers tended to decrease their level of performance when phenomena to model were completely new to them.

4. Conclusions

Science notebooks appear to be valuable tools to understand progressions towards MCI. They give direct information on how students engaged in modeling practices move along levels of performance on understandings on models and modeling practices. Through an accurate analysis, they provide insights on how these understandings are being built and which are the challenges to face. Feedback given to preservice students based on this analysis, reverts positively into students' progress.
We suggest the use of science notebooks as a possible unobtrusive method, among others, to monitor preservice students' teachers progress on MCI. In order to foster students' enhancement on MCI, instructional practices should be adjusted and specific scaffolding to students should be given based on the information gained through notebooks entries.

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