International Society of the Learning Sciences

From "Playful Activities" to "Knowledge Building": A Case Study about a Teacher's Perceptions on the Role of Experiments

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Abstract: Science education reform initiatives and the integration of maker resources into formal education have the potential to promote new ways of learning. However, well-prepared teachers are central to implement such changes. Using a case study, we describe how the ideas of one teacher about the role of experiments changed as he participated in a PD program. Based on our findings, we suggest strategies for programs aimed at integrating makerspaces resources into science curricula.

Introduction

Significant efforts have been employed to develop and implement new science standards that emphasize not only conceptual knowledge but also the practices of science and engineering. At the same time, makerspaces are becoming increasingly popular in schools, and the new resources they provide can make science learning more aligned with such practices. However, effective makerspace integration into science learning depends not only on the available resources and standards but, most importantly, on teachers prepared to implement new approaches. Student learning and sensemaking come from the productive cognitive effort afforded by well-designed activities, and not solely from the engagement in hands-on experimentations or demonstrations (Duckworth et al, 1990; Furtak & Penuel, 2019). Thus, the integration of makerspaces into school curricula must be accompanied by professional development focused on using maker resources not just as ways to "entertain" or motivate students, but to engage them in meaningful and authentic learning experiences.

As part of a larger effort to reform science education in a medium-sized Brazilian city, we developed a professional development (PD) program for science and makerspace teachers based on two principles: (1) the redesign and implementation of curricular units, as research has shown that changes in teachers beliefs and attitudes usually happen *after* they experiment new teaching approaches and notice the results on students learning (Guskey, 1986), and (2) three iterative cycles where teachers could progressively incorporate new ideas and implement changes based on their experiences in previous cycles, as it has been shown that teachers changes are cyclical and complex processes with interactions between multiple domains (Clarke & Hollingsworth, 2002). Activities in the PD program included workshops, co-design sessions between teachers and researchers, support for classroom implementation, and reflective meetings. Here, we analyze the process of change of one teacher, investigating how his ideas about the role of experiments were transformed as he participated in the program.

Methods

In this study, we analyze the trajectory of one focus-teacher, João (pseudonym), over the four years in which he participated in the PD program, using an in-depth case study methodology. João had a bachelors degree in Biology and 16 years of teaching experience at the beginning of the project. He used to teach science for grades 8 and 9, and during the program (cycle #2) was reassigned as a lab teacher.

Data sources included: audio recordings of interviews (transcribed for analysis), self-assessment reports, and field notes from classroom observation and meeting sessions. Data were analyzed using the Integrated Model of Teacher Professional Growth (Clarke & Hollingsworth, 2002) as a framework for identifying the key elements related to his changing pathways. Although our data analysis process resulted in a series of detailed growth networks describing his changing process, here we present only our main findings.

Findings

Cycle #1

In the beginning of Cycle #1, teachers participated in a 2-day workshop and co-designed a curricular unit with researchers using the backwards design framework. Based on teachers' requests, researchers provided resources and references for the design of the classroom activities aligned with their learning goals. In this initial cycle, João was not expected to introduce constructionist approaches or advanced technology into his classroom, but rather to try out new ways of teaching within his "comfort zone". Before the program, João used the science lab mainly

to perform demonstrations of experiments. In his words, "experiments were used for students to see something happening. (...) They just watched me doing it". Students' roles in these classes were very passive: "they just copied what I put on the blackboard and didn't ask anything". After participating in the workshop, João mentioned that he started to try out new teaching formats in his lab classes: "My first change was in the way students wrote lab reports. I only asked them two open questions: "what did you learn from the activity?", and "what were the materials and procedures?". He also started to incorporate groupwork and more open-ended activities into his classrooms. With this new approach, he saw students more engaged and interested in his classes. However, his perceptions about students' enjoyment and engagement were the main indicators that the lesson was "good." As such, in his view, science classes should be more "playful" and "dynamic" as a means to entertain students, which was taken as a direct proxy for learning. In this cycle, he co-designed a unit about genetics, implementing small changes in his teaching, but still mainly relying on traditional, familiar strategies. Since students enjoyed his new way of teaching, he felt confident with these changes to his pedagogical practices.

Cycle #2

In the second co-design cycle, teachers were invited to (1) include science practices as a central part of their units, (2) integrate makerspaces resources for students to engage in deeper inquiry processes, and (3) use formative assessment tools (designed by researchers). For him, experiments and hands-on activities were still seen as the primary way to engage students. However, as he observed students learning in new ways, he was surprised with the results and became interested in collecting and analyzing data about their learning outcomes. Together with the researcher team, João also created a reflection tool to be filled out by him after each classroom implementation.

Cycle #3

In the last cycle, teachers were invited to design, use and analyze formative assessment tools for their lessons. As he said in his last interview, using these tools shifted his evaluation focus to students' learning processes: "I did not use this type of assessment before - then, what showed me that they learned something was if they knew how to answer a question correctly in the final exam. After we started using these new assessment tools, we were also able to see their performance during the activity, so I started to have a more process-oriented view: the mistakes they make, the questions they ask...". In this cycle, João designed worksheets for his students and started to video record his classes. After each lesson, he analyzed the worksheets and the video recordings. In a representative utterance during the last cycle, *João stated that the goal of his classes started to be "for them to actually learn".*

Conclusions and implications

As our findings suggest, at the beginning of the program, João saw *experiments as a way to confirm the theory and to entertain students*, and evaluated his classes based *on the perceived enjoyment and instantaneous engagement* of students. However, as he *incorporated formal assessment tools* to analyze students' learnings, experiments and "hands-on" activities started to be seen as a *knowledge-building activity*.

One of the implications of our study to the design of PD programs aimed at integrating makerspaces into school curricula is that teachers need *scaffolded and continuous support* to implement changes in their practices: in each co-design cycle, researchers looked carefully at his trajectory to design supporting materials and conduct meetings based on his specific needs. Moreover, special care should be given to the *connections between learning goals and the design of activities*, as well as their *assessment*. In this way, makerspaces' resources can be used but as a way to engage students in meaningful and authentic learning experiences, and not only to "entertain" them.

References

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Acknowledgments

Partial funding provided by the Lemann Foundation in Brazil. The authors would like to thank all participant teachers.