Co-teaching robotics and e-textiles with non-linear maker pedagogy

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Abstract: Non-linear maker pedagogy (NMP) provides opportunities for collaborative invention and improvisation, pupil-directed situated inquiry, and artifact creation combining material and digital realms. With co-teaching platforms to introduce NMP via the digital technologies of robotics and e-textiles, and through six co-teacher team interviews, we identified both successes and challenges. Despite some conservative reactions, several pupils excelled at collaboratively making unique smart artifacts, and most of the teachers thought their selected pedagogical approaches were not unduly ambitious.

Introduction

Successful teaching of 21st-century skills requires a profound change in teaching, schools, and educational systems **(**Schleicher**,** 2012**).** To address these reformation needs, we propose a non-linear maker pedagogy (NMP) for teaching such skills and innovative making practices. NMP emphasizes higher level objectives rather than pre-defined skills or knowledge to be mastered. Students engage in open-ended learning activities to solve design tasks that are ill-defined, authentic, and challenging (Seitamaa-Hakkarainen, Viilo, & Hakkarainen, 2010). Emergent goals are formulated and modified by students during the course of pursuing them (Scardamalia, Bransford, Kozma, & Quellmalz, 2011), intentionally introducing multiple ways of working, thinking, and making. Given students' greater scope to negotiate their own goals for learning and making, teachers can no longer rely on scripted and pre-established procedures. Moreover, NMP emphasizes iterative and cyclic co-design processes, in which students and teachers collectively generate an epistemic environment that affords learning and action (Markauskaite & Goodyear, 2016). This requires adaptive orchestration, on-demand scaffolding to support each class's unique aims, and formative assessment.

NMP also involves a shift from individual learning and solo teaching to collaborative work and multiple ways of knowing, often extending subject boundaries. This affords opportunities for co-teaching; that is, teacher collaboration in planning, instructing, and assessing (Murawski & Lochner, 2011). Our understanding of co-teaching includes variable compositions of teacher teams, as in two or more class teachers, class and subject teachers, or several subject teachers teaching together. As such, co-teaching is both a pedagogical practice and a platform for teacher professional development (Rytivaara, Pulkkinen, & Bruin, 2019). From these premises, this research explores co-teaching as a platform for introducing digital technologies and NMP. To that end, we posed the following research question: What are the successes and challenges of NMP, digital technologies, and co-teaching from the teacher's perspective?

Research design

The data were collected during an Innokomp program (2017–2020) aiming to support the implementation of Finland's latest elementary-level national core curriculum by introducing co-teaching and digital technologies. The program introduced structures suitable for non-linear maker projects supported by workshops and training in selected digital technologies. The teachers co-innovated pedagogical practices and chose the elements they introduced into their own school projects. Six projects based on open-ended learning tasks and e-textiles or robotics were selected for this study. Participants were teachers of Crafts, with little or no previous co-teaching experience; one team shared a co-teaching history. The teams were interviewed when the projects were finalized. The resulting five hours of audio data was analyzed with a qualitative, data-driven content analysis.

Results

In the team interviews, teachers evaluated their accomplishments by describing and reflecting on pupils' reactions and achievements, which ranged from successful to challenging along a scale that can be considered continuous rather than dichotomous. Differences between individual pupils and pupil groups were larger than differences between classes, and almost all classes encountered the same successes and challenges to differing degrees. Therefore, we report the results as summaries of key pedagogical aspects, technology, and co-teaching.

Pedagogical aspects. The novel tasks inspired many pupils due to the absence of right or wrong solutions, which gave them freedom to experiment. Pupil groups were engaged in gradually deepening problem solving, and teachers often became co-learners, which was not accepted by all pupils. Some pupils were motivated by their own unique projects and knowledge needs and were able to work independently, but others depended heavily on teacher support. Some (but not all) pupils' initial resistance to the non-traditional content (i.e., robotics, group work, ideation, knowledge creation) turned to celebrations over their final creations; when successful, co-creation proved very rewarding. Group work provided valuable learning experiences for pupils; simultaneously, supporting pupils' co-regulation proved to be one of the most challenging tasks for teachers. Moreover, co-creation tasks made it uncomfortably clear that some pupils were unable to work without stepwise instructions or to create artifacts with no material precedent. As each group was working on a different project with different needs, teachers often felt overwhelmed.

Technology. While pupils welcomed e-textiles, robotics proved divisive—inspiring and highly motivating for some pupils but rejected altogether by some. In many projects, technological solutions did not achieve the targeted level as learning tasks were not adequately constrained and pupils lacked motivation.

Co-teaching. The most valued co-teaching outcome was the ease and fairness of pupil evaluation. Three of the six co-teaching relationships appeared enjoyable and fulfilling, with teachers sharing a strong commitment to pedagogy development. Two relationships were strained, with the teachers pulling in different directions with their development orientations. One relationship suffered seriously from a lack of shared time.

Discussion and conclusions

The participants faced numerous challenges that were reflected in classroom performance. Despite some teachers' previous experience in teaching these technologies, technology posed challenges to all teacher teams. This might suggest that co-teaching offers no competitive edge in terms of novel content. However, teams with a functioning co-teaching relationship proved more effective than those who were less well aligned—not in terms of their projects' success but in how they addressed their difficulties. *For committed co-teachers, co-reflection offered a developmental space that they valued highly and setbacks were seen as positive challenges*.

The central challenge of technology teaching lay in defining the initial design challenge and constraints to keep pupils' projects innovative but realistic. Learning task formulations significantly influenced teachers' division of labor, which, in turn, translated to equality in their roles and experienced professional capability. For several reasons, robotics afforded more opportunities for equal teacher roles and accountability than e-textiles.

The NMP approach was ambitious as it was unfamiliar to pupils who had 4–7 years of exposure to traditional teaching; thus, their resistance to the move from knowledge transmission to knowledge creation and co-regulated progressive inquiry was understandable. However, a clear majority of the teachers are committed to continuing to develop their teaching practices along the lines of NMP. In our view, co-teaching is a suitable and necessary vehicle for such substantial changes. Nevertheless, successful change requires administrative support and a teacher learning community. At the same time, co-teaching needs to be recognized as a skill in itself. For co-teaching transversal skills and novel technologies, the principle is the same as for pupils' projects; rather than right or wrong, solutions are either functional or in need of further development and testing.

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