Bringing Practices of Co-Design and Making to Basic Education

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Abstract: The purpose of this study was to analyze five student teams' (Grade 7) co-design processes that involved using traditional and digital fabrication technologies for inventing, designing, and making complex artifacts. A methodological framework for analyzing maker-centered learning, by relying on ethnographic video data and participant observations, was developed. The study examined the extent to which young students are able to productively participate in creative design and making activities. The results indicated that four of the five student teams successfully engaged in the co-invention processes. The importance of a shared epistemic object of co-design was prominent on every team. Some teams experienced challenges in organizing collaborative processes and the team size appeared to have a significant effect in this regard. The successful teams were able to take on complex and multifaceted epistemic and fabrication-related challenges.

Keywords: co-design, knowledge-creation, maker culture, epistemic objects, teamwork, co-invention

Introduction

The purpose of the present study was to analyze five Grade 7 student teams' co-design processes that involved using traditional and digital fabrication technologies for inventing and making complex artifacts. The study involved developing a methodological framework for analyzing maker-centered learning as well as examining the nature of the student teams' co-design processes. Productive participation in the emerging innovation-driven knowledge-creation society appears to require cultivation of sophisticated innovation competencies by all citizens, starting from an early age. Concurrent educational practices do not, however, sufficiently foster young peoples' creative competencies, because of the strong focus on the transmission of pre-given content knowledge and routine procedures to students. To overcome such limitations and make school learning a more inspiring experience, our Laboratory of Co-Inquiry, Co-Design, Co-Teaching and Co-Regulation (Co^4-Lab) project aims to bringing elements of the maker culture (see Anderson, 2012) to Finnish schools. To that end, students are engaged in collaborative efforts to invent complex artifacts, sparking intellectual, technical and aesthetic challenges. In this paper, the term "co-invention" is used to characterize artifacts created in students' knowledge-creation projects, consisting of intertwined co-design and making processes. Exceptional Finnish craft education, technology education, and science-lab infrastructure provide a solid foundation for integrating such maker practices with core curricular activity. We are creating high-end makerspaces in Finnish schools by expanding crafts classrooms with instruments of digital fabrication, such as 3D CAD, robotics, electronic circuits, and wearable computing (e-textiles), with which one may create multi-faceted complex artifacts (cf. Blikstein, 2013). This study examined the co-design processes of small teams of students aged 13 to 14, who participated in the Co^4-Lab co-invention project at Aurinkolahti basic school, located in Helsinki, Finland. In this article, we analyze and describe to what extent and how the student teams participated in the co-design processes. In the following paragraphs, we will first present the theoretical framework of our investigations. Then we will go through the research setting and methods of data collection and analysis. Finally, we will present our results and discuss the significance of the findings.

Creating knowledge through artifact-mediated co-design processes

The present investigation relies on our longstanding effort to cultivate knowledge-creating learning that, beyond knowledge acquisition and social participation, involves systematic collaborative efforts in creating and advancing shared epistemic objects by means of externalizing ideas and constructing various types of intangible and tangible artifacts. Learning by making entails, in accordance with Papert's (1980) constructionism, that learners are not only building conceptual knowledge but also using digital instruments to design and make materially embodied artifacts and cultivating new ways of thinking and acting during the process. Maker-centered learning involves students externalizing their ideas through conceptual (spoken or written ideas), visual (drawing, graphs) or material (3D prototypes and models) artifacts, creating an opportunity for themselves and their peers to build on these ideas, discuss and elaborate on them and embody ideas in progressively more advanced artifacts. Using sophisticated digital fabrication instruments for creating artifacts may be interpreted as providing material agency for pursuing more complex and challenging inquiries than the participants would otherwise be able to accomplish. We consider knowledge creation as a practical communal activity that, to a significant extent, relies on operational methods, creative processes, and practices ("knowledge practices") that a learning community can appropriate and cultivate with adequate facilitation, guidance, and real-time support. Artifact-mediated knowledge creation is an emergent and nonlinear process whereby the actual goals, objects, stages, digital instruments or end results can neither be pre-determined nor the flow of creative activity be rigidly scripted (Scardamalia & Bereiter, 2014b).

Collaborative design is an essential aspect of the invention and making processes. In accordance with the Learning through Collaborative Designing (LCD) model (Seitamaa-Hakkarainen & Hakkarainen, 2001), we examine co-design as communal efforts of creating artifacts by solving complex and ill-defined problems through iterative processes in which design ideas are elaborated and refined through analysis, evaluation, deliberation, sketching, prototyping, and making. Previous studies of knowledge creation processes suggest that advanced collaboration requires group members to focus on a shared object that they jointly construct during the design process (Barron, 2003; Hennessy & Murphy, 1999; Kangas, Seitamaa-Hakkarainen, & Hakkarainen, 2013; Paavola & Hakkarainen, 2014; Seitamaa-Hakkarainen et al., 2001). The knowledge-creation process may be seen to be guided and directed by envisioned "epistemic objects" that are incomplete, being constantly further defined and instantiated in a series of successively more refined visualizations, prototypes, and design artifacts (Ewenstein & Whyte, 2009; Knorr-Cetina, 2001). Inventions can be designed only through repeated iterative efforts of solving complex problems, overcoming obstacles and repeated failures with practical experimenting, obtaining peer and expert feedback, trying again, and ending up with outcomes that may not have been anticipated in the beginning. The important aspects of craft making are "designerly" ways of thinking and the manipulation of materials and tools (see Cross, 2006). The importance of participating in embodied design activities, and working with concrete artifacts, in learning has been emphasized by many researchers (e.g. Blikstein, 2013; Kafai, 1996; Kangas et al., 2013; Kolodner, 2002). Making is a very effective way of engaging students in a design mode (Bereiter & Scardamalia, 2003) that guides them to focus on the usefulness and adequacy of ideas and, moreover, invest efforts in the continuous improvement of design ideas.

The basic tenet of our investigation is that every student could be an inventor, regardless of gender, school achievements, ethnicity, or other characteristics. The co-invention projects are intended to provide diverse students a strong sense of contribution, that is, they experience that they are doing something worthwhile together, each student's unique efforts and accomplishments matter, and that the whole team is jointly reaching something that no one could have done on his or her own. The success of collaborative creation of knowledge is critically dependent on students who actively engage in and take responsibility for the process (Paavola & Hakkarainen, 2014; Sawyer, 2006; Scardamalia & Bereiter, 2014a). Focused creative pursuit requires students to actively work toward a joint epistemic object, to listen, understand and help each other, and to engage in shared efforts of testing and constructing artifacts being developed (see e.g. Barron, 2003). The present type of technology-enhanced making processes has not been formerly implemented in basic education. Co-invention projects may be experienced as very challenging by students and their teams because of working with unfamiliar digital fabrication technologies, encountering unanticipated construction problems, and carrying out design inquiries leading to unforeseen directions (see Zhang, Scardamalia, Reeve, & Messina, 2009). These processes may overwhelm the students, if they are not supported adequately (e.g. Linn, 2006). It is essential to understand, how students participate and collaborate in a small group setting when participating in open-ended co-design and making processes, if we want to design successful pedagogical approaches and practices that advance knowledge-creating learning. Collaboration in small teams of students has been investigated quite rigorously, especially from the perspectives of collaborative talk and actions (see e.g. Ching & Kafai, 2008; Hennessy & Murphy, 1999; Kangas et al., 2007, 2013; Linn, 2006). However, how open-ended co-design and co-invention processes, aimed at the creation of new complex artifacts, truly unfold through student teams actually organizing and working from phase to phase throughout the process calls for further investigation (cf. Hennessy & Murphy, 1999). This present study seeks to contribute especially to this area of research.

Research setting: Co-invention project in Aurinkolahti basic school

The present investigators organized a co-invention project with the Aurinkolahti basic school in spring 2017. All of the Grade 7 classes, 70 students in total, aged 13 to 14, participated in the project. Finnish curriculum for basic education involves compulsory weekly craft lessons until Grade 7. Integrated design and making activities, which are characteristic of Finnish craft education, provide ample opportunities for bringing together STEAM subjects. This enabled us to implement learning-by-making projects as a part of regular curricular activity. For assistance, teachers relied on collegial (co-teaching) resources to negotiate emerging challenges: we engaged two craft subject teachers with three other subject teachers (science, ICT, and visual arts) to orchestrate the project. Moreover, we engaged Grade 8 students to function as "digital technology" tutors to provide additional support in guiding the student participants. The Innokas network (innokas.fi/en) offered support regarding digital instruments, materials, and coding initially to the tutor students and when necessary also to the inventor teams. The teachers were familiarized with the technologies used as well as given pedagogical support.

The co-invention challenge, co-configured between teachers and researchers, was open-ended: “Invent a smart product or a smart garment by relying on traditional and digital fabrication technologies, such as GoGo Board, other programmable devices or 3D CAD”. Before the project, the Grade 8 tutor students arranged a GoGo Board workshop for every participating class, so as to familiarize the students with the possibilities and infrastructure of the GoGo Board and to promote the emergence of ideas on how programmable devices could be utilized in the inventions (cf. Ching & Kafai, 2008). GoGo Board is an open-source hardware device, developed at the MIT Media Lab, for prototyping, educational robotics, scientific experiments, and environmental sensing (Sipitakiat, Blikstein, & Cavallo, 2004). The actual co-invention project was initiated in February, with a two-hour ideation session, arranged in collaboration with the Finnish Association of Design Learning. During this session, the students self-organized into teams and constructed the preliminary ideas of their inventions. The project involved eight to nine weekly co-design sessions (two to three hours per session) during March, April and May 2017. The teams also presented their co-inventions in two Co^4-Lab events, held at the University of Helsinki.

Research aims and methods

By relying on ethnographic video data and participant observations of the student teams’ co-invention processes, the present investigation focuses on examining the student teams’ participation in co-design and making processes. The specific research questions guiding our investigations were as follows: 1) What was the nature of the co-design processes of the student teams? 2) How did the student teams organize and collaborate during the co-design processes? 3) What kind of co-design-related differences occurred between the teams? 4) How did the co-design approaches and the nature of collaboration relate to the success of the co-invention processes?

For video recording and intensive follow-up by the first author, we randomly selected two whole classes that consisted of seven students’ co-invention teams. The recordings were carried out separately for each team, using an individual GoPro action camcorder, placed on a floor-standing tripod, and a separate wireless lavalier microphone for each team. The camera was positioned at a high side angle to capture a team’s actions as fully as possible. The first author was also present during every co-design session and made observations and field notes to support in-depth analysis of the data. Five of the seven videoed teams were selected for the detailed analysis. One team was discarded due to fragmented data, caused by technical difficulties during the recording process. The other team was discarded because of ethical issues within the team. Diverse invention projects and digital tools and fabrication methods employed provided us with very rich data (see Table 1).

Table 1: Analyzed teams, video data in hh:mm, inventions and technologies used in the inventions

Name	Members	Data	Basic ideas of the inventions	Digital technologies used
Bike	3 boys	14:07	A three-wheel bike that contains smart technologies, such as an environment responsive, rechargeable LED lighting system	GoGo Board
MGG	4 boys	13:15	MGG (Mobile Gaming Grip), a pair of handles that improves the ergonomic of a mobile phone while playing games	3D CAD modeling, 3D printing
Moon	6 girls	13:09	A smart outfit for sports, including for example. an environment-responsive lighting system to improve safety	Adafruit Flora and Gemma, light sensors, RGB LEDs
UrPo	6 boys	12:34	A smart outsole for sport shoes, including for example an automatic warming system for winter sports	Adafruit Flora and Gemma, temperature sensors
Plant	7 girls	12:21	An automatic plant care system, that incorporates decorative elements.	GoGo Board

A theory-driven coding template was constructed for characterizing the co-design and making processes. The coding template and codes, relevant to this research, are presented in Appendix A. Codes for verbal and embodied design actions were based on design research literature and the Learning by Collaborative Design (LCD) model (e.g. Goel, 1995; Seitamaa-Hakkarainen et al., 2001; Seitamaa-Hakkarainen, Viilo, & Hakkarainen, 2010), as well as on our earlier experiences of investigating maker-centered learning (e.g. Kangas et al., 2013; Lahti et al., 2016). The data analysis was based on systematic observation and coding of the videos. The videos were coded in 3-minute segments using the ELAN multimedia annotator (4.9.4 and 5.0.0-beta). For every segment, primary design actions were determined for the whole team and possible subgroups of students. Instances of design process engagement were emphasized over non-task-related actions and speech. For instance, if a team discussed non-task-related issues while being actively making a prototype, the segment was coded as model making rather than non-task-related action. The present analysis aimed at providing an overview of the co-design processes; in subsequent studies, we will zoom into more detailed microlevel analyses of the data. Four investigators took part in coding the data. After the coding process, all segments containing no action were removed from the video data. To avoid distortion of the data, the data was further adjusted by removing intervals of process organizing or non-task-related actions, such as when a team had to wait and was therefore unable to continue the design process further (e.g. waiting for a teacher to arrive to give obligatory instructions for the safe use of tools, or waiting for computers to open or update). The final, adjusted video data, consisted of 65 hours, 27 minutes of coded team session videos in total, 12 to 14 hours per team (Table 1).

To make the massive amount of complex data from the teams' and individual students' processes analyzable, we developed a new method for visual analysis of the data. Based on verbal and embodied design actions of the teams and individual students, systematic process visualizations, *striped process rugs*, in the form of color-coded, layered diagrams, were built. The striped process rugs, presented in Figure 1, represent the teams' design processes as design actions in 3-minute stripes. Every design session of a team is separated with a blank horizontal stripe, with the first session being on top. Blank areas in participants' individual design processes signify that the participant was absent. In stripes where both verbal and embodied design actions occur simultaneously, verbal design action is presented on the left side of the segment and the embodied design action on the right. The construction of the striped process rugs not only provided us with insight into the overall design processes of the teams and activities of individual team members, but also preserved plenty of information about collaboration within the teams. When necessary, results drawn from the process rugs were compared to the ethnographic observations, which were made by the first author, or to the corresponding sections of the raw video data to further verify the findings or to gain further information.

Nature of the student teams' co-design processes

In terms of the process outcomes, four teams (Bike, MGG, Moon and UrPo) achieved a successful co-design process. They developed well-articulated design ideas, produced visualizations and prototypes, and tested and refined their design ideas. On the other hand, the Plant team failed almost completely on all the above outcomes. They produced only a few separate objects that did not have any functionality. The process rugs indicate clearly that the co-design processes varied significantly between the successful teams and the Plant team. The successful processes were iterative, yet still progressing, in nature. The successful teams spent most of the working time deeply engaged in the design-related activities, especially model making and digital experimenting. The process rugs indicated that the periods of design actions appear to be longer and more coherent for the smaller teams (i.e. Bike and MGG) than for the larger teams. Furthermore, the successful teams, especially the smaller ones, spent very little time on non-task-related activities, whereas the Plant team spent most of their working time on non-task-related actions, to an extent that some sessions were spent almost entirely doing non-task-related things. In addition, the Plant team's co-design process was very scattered in nature. The lack of design actions, especially model making, compared with the successful teams was remarkable. The design actions varied between the teams also due to the differences between the inventions and fabrication methods. In the following paragraphs, we will describe each teams' co-design projects.

The invention of the Bike team was a three-wheel bike that contains an environment-responsive, rechargeable LED lighting system, utilizing the GoGo Board. During the first project sessions, they made mechanical experiments for possible structures of their bike. Based on their experiments and the knowledge they sought from the Internet, they refined their ideas intensively, especially during the second working session. Their co-design process was clearly iterative in nature in terms of stages of making the actual model and further refining the design idea alternating. Towards the end of the project, they crystalized their idea and concentrated mostly on the model making. They used several advanced fabrication methods that were all new to them, such as welding and metal lathe turning. Simultaneously, they had to learn the new methods of fabrication, consider the final product and its mechanics, deliberate on materials and structures, as well as, organize their process.

The MGG team invented a mobile gaming grip, a pair of handles that improve the ergonomics of mobile phones in gaming contexts. They had a two-stages process, in the sense that they first built a concrete prototype from basic materials (wood, rubber and masking tape), and then, from session six onwards, created 3D CAD-models based on the first prototype. When building the first prototype, they worked very iteratively, ideating, testing their ideas, evaluating and refining the ideas further. They paid particular attention to the ergonomics and usability of the handles and on how to make the handles suitable for as many smart phones as possible. Their process highlights the importance of embodied and concrete model making, although the final fabrication method was a 3D CAD model, and later a 3D-printed model. The second phase, the 3D CAD model making began with a session during which they tried to create the 3D-model with SketchUp. However, that turned out to be too complex for the team. Therefore, they decided to spend the next session experimenting with three different 3D modelling software options (Blender, SketcUp and Tinkercad). Based on the experimenting session, they chose to use Tinkercad and SketchUp together for the modelling, and at the end, they were able to produce a printer-ready 3D model of the handles.

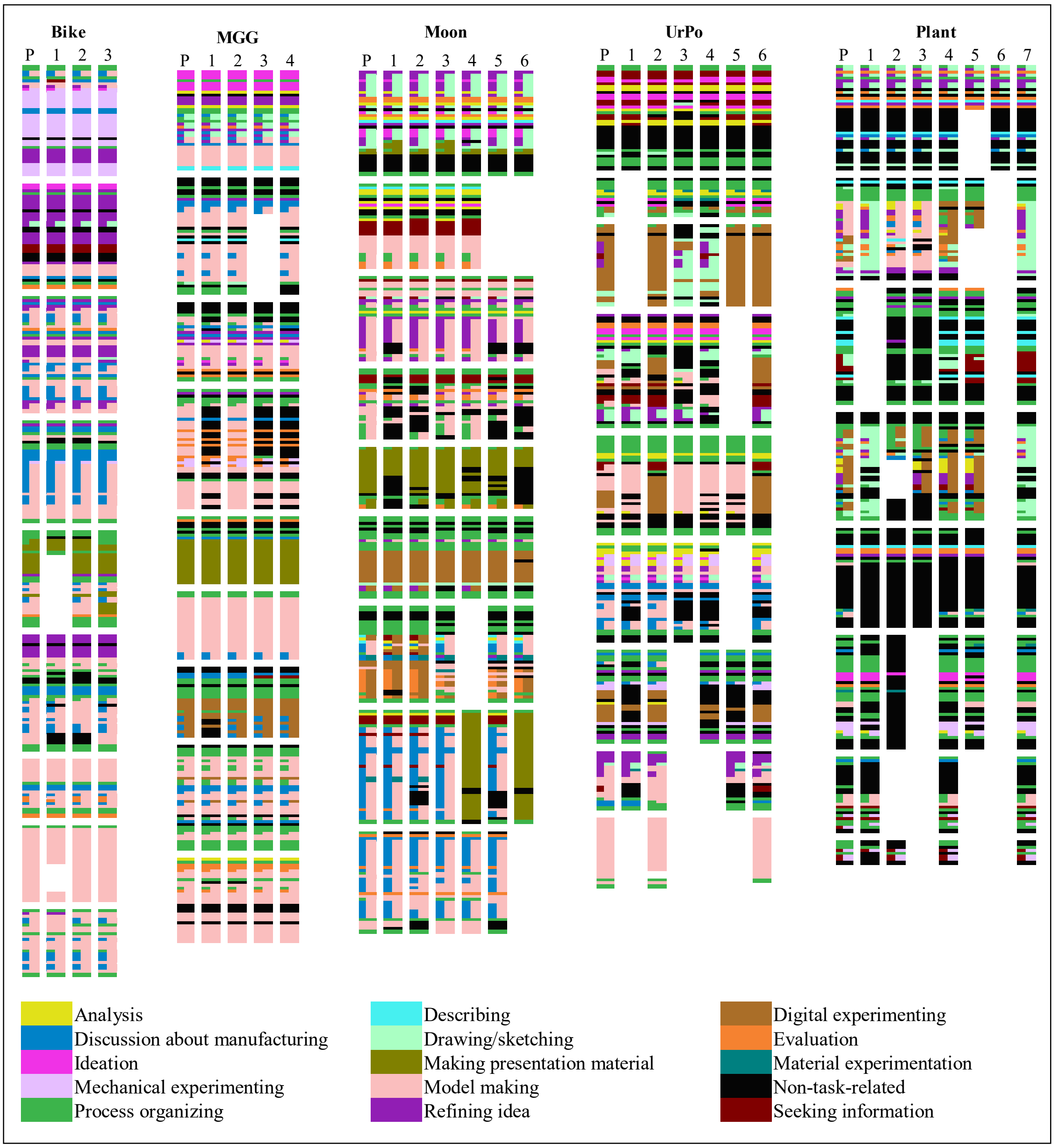

Figure 1. Striped process rugs. P = teams' primary design actions, 1…n = actions of individual team members.

The Moon team stepped into the world of e-textiles in their design process and invented an environment-responsive outfit for sports (cf. Litts et al., 2017). During the first sessions, the team concentrated on crystalizing their idea and on pattern making for the clothes. Towards the end of the process, the team engaged in three separate but partially interlinked activities: sewing the actual clothes, programming and assembling the electronics, and making presentation material for their product. During their process, they designed and made the actual clothes from elastic materials, designed the electronic circuits, sewed the conductive threads and programmed the electronics for the clothes – all actions that they had never done before. They used Adafruit Flora, a wearable electronic platform, lighting sensors, and programmable NeoPixel LEDs as their electronic components.

The UrPo team invented a smart outsole for sports shoes that can also be regarded as an e-textile (cf. Litts et al., 2017). They used Adafruit Flora and Gemma as the electronic platforms to produce the functionalities of the insole. Additional challenge emerged from the temperature sensor-controlled warming system that they designed for the insole; they had to design this functionality from scratch, using resistance wire. Their design process became a truly iterative one, where the refining of ideas occurred even during the second-to-last session. The team produced several concrete prototypes and sketches of different and alternative structures of the insole, especially elaborating on the placement of the Adafruit Gemma board on the insole.

The Plant group intended to build a plant care system that also served as a decor element. However, their process was very scattered in nature and did not lead to any actual prototypes. They only produced a few sketches and simple objects that could have been used to build a prototype. Sketching, which mostly meant producing colourful drawings without any new contribution to the idea, was their most prominent design practice. They were guided to make tests with the GoGo Board and later with possible power supply and connection of a pump system, but they did not fully engage in these activities and mostly left the work to the Grade 8 peer tutor students.

Collaboration and process organizing in the co-design processes

From the process rugs, the differences between the collaboration of the teams emerge clearly. The two smaller teams, Bike and MGG, worked through the whole process in intensive, jointly organized collaboration. The Moon and UrPo teams often worked together, but divided tasks among the team members more often than the two smaller teams. Especially in the larger teams, some students were more active and orchestrated the process more than the other team members. Nevertheless, they did not dictate the processes at any level. In the Bike and MGG teams, all participants were highly engaged in the processes and participated. Even when some of the students did non-task-related things, their engagement with the process did not deteriorate. For example, during MGG teams' fourth session, student number 2 modified the fine details of the first prototype. During the modifications, the other students did non-task-related things around the table, but every time a modification was made, the whole group rapidly gathered to evaluate the modifications and to decide upon, how the handles should be further improved.

In the Moon and UrPo teams, the slight scattering of the collaboration demonstrated itself during periods of ideation, evaluation and refining of ideas – the most important phases of decision-making. Although the teams, in most cases, gathered together to make decisions, periods of divided attention occurred more often than in the Bike and MGG teams, during the decision-making activities. Further scattering also occurred, from time to time, in the larger teams, due to some students drifting to non-task-related activities, although they could have engaged in the co-design process and collaboration. The Plant team's inability to collaborate may be because the dominant figures within the team, students 2 and 3, were also the ones who concentrated mostly to non-task-related activities. The team tried to organize from time to time to start working on the task, but often this did not lead to any actual productive design actions. The relatively long time spent on process organizing is striking on the process rugs. In addition, it must be noted that the actions related to the design process, during the last four sessions, mostly occurred when the teacher or one of the tutor students was present in the group. None of the group members took responsibility for the process. In contrast with the Plant team, the process rugs indicate that the process organizing in the successful teams often led to distinct design actions. The organizing occurred typically at the beginning and end of the sessions and when students or the whole team moved from one design activity to another. The process rugs highlight how the larger teams, although successful, required more time to organize compared with the smaller ones. Furthermore, the larger teams needed more guidance on how to organize their processes than the Bike and MGG teams did.

Both the success and collaboration within teams appeared to relate to the team sharing the same epistemic target object. It was very clear from the videos and the observations made that the Bike and MGG teams shared the same epistemic object throughout the whole process that they actively sought to develop. Also, the Moon team, although their collaboration scattered every now and then, seemed to share the same epistemic object across the design process. The UrPo team, however, seemed to concentrate on different epistemic target objects, especially during sessions three and four, although they regrouped around one object towards the end of the project. In contrast with the successful teams, the Plant team did not have a shared epistemic target object at all. They had a shared idea at the beginning, but it did not evolve or crystalize in any way.

Conclusions and discussion

The purpose of the present investigation was to analyze five student teams' co-design processes that involved using traditional and digital fabrication technologies for inventing and making complex artifacts. The systematic coding procedure and visualization of the group processes, based on that coding, proved to be very effective methods to analyze the large and complex group session video data. The striped process rugs provide deep insight into the processes of the co-invention teams and the individual students. The amount of information that such visualizations can convey, at a glance, would be very difficult, if not impossible, to produce using other analytic methods. When supported with the observations made during the co-design sessions by the researcher, and the ability to return to the raw video data, the results can be, both, confirmed and deepened. The 3-minutes analysis segment size is, however, likely to have reduced the occurrence of certain activities in the analysis results. For example, short moments of reflection or ideation may have been overridden by more prominent, longer lasting actions. However, we managed to disclose the iterative nature of the successful co-design processes, using the 3-minutes analysis segment. The process rugs not only provided us with the results of this research, but also offer us information on those parts of the data that could be interesting grounds for further analysis from other perspectives, such as more detailed micro-level analyses on how conceptual and materially embodied aspects of knowledge-creation inter-related during the processes.

A very promising finding of this research is that most of the teams were able to participate successfully in the co-invention project, although coming up with successful solutions required overcoming both epistemic and technological challenges. The four successful teams were able to design and invent complex, targeted artifacts. The importance of a shared epistemic object of the design process and collaboration was prominent on every team. Our findings further confirm the results of previous studies made about the importance of such objects for co-design and knowledge-creation processes (Paavola & Hakkarainen, 2014; Seitamaa-Hakkarainen & Hakkarainen, 2001). We also suggest, in agreement with previous research, that the importance of concrete making cannot be over-emphasized in these types of co-invention processes (cf. Kafai, 1996; Kangas et al., 2007, 2013; Kolodner, 2002). We argue that without designing and making the concrete prototypes, the processes of every team would have lacked key opportunities for improving the students' ideas, which is a critical aspect of knowledge creation. In addition, we must commend the importance of the crafts subject teachers and the Grade 8 tutor students for the successful completion of the project; their guidance enabled student participation in the advanced design processes and concrete prototyping. Teacher expertise regarding design, fabrication methods, mechanics and materials, as well as on the pedagogics of invention and making appear to be crucial when conducting these types of knowledge-creating projects. The present results indicate further that team size has a significant effect on the nature of the team collaboration. While the two smaller teams (Bike and MGG) worked throughout the whole process in very intensive and close collaboration, the larger teams (Moon, UrPo and Plant) scattered, at least to some extent. The collaboration in the small teams was also more democratic and balanced than in the larger teams. However, to confirm these findings, more research into similar co-design processes is needed. When continuing these design experiments, we will limit the team size.

The present investigation reveals that significant aspects of the maker culture can be integrated with the regular curricular activity of Finnish schools. By relying on traditional and digital fabrication technologies and practices, young students can be engaged in co-designing, co-inventing, and joint making of complex artifacts, sparking intellectual, technical and aesthetic challenges. Students who have completed successful co-inventions projects, such as those of the Bike, MGG and Moon teams, will be engaged as peer tutors for the new cohort of student inventors regarding programmable devices, 3D CAD-modeling and 3D-printing. Rigorous research as well as collaboration with teachers, students, and other players in the field of education is needed for expanding maker-centered learning at school.

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Appendix A: Structure of the coding template and code descriptions
Description and notes (written description of what the group was doing and notes for later analysis)
Primary verbal design action: ("Non-task-related action" code was used only if there was no applicable primary embodied action.) Codes: seeking information, process organizing, analysis, ideation, evaluation, refining idea, describing, discussion about manufacturing, non-task-related action, no action
Primary embodied design action Codes: drawing/sketching, material experimentation, mechanical experimenting, digital experimenting, making presentation material, model making
Pupil 1…n: (Left empty if the pupil is absent.) Codes: active, passive
Group work: Codes: all together, divided. For divided group work three additional codes were applied: subgroup 1…n (including student numbers divided by comma, e.g. Subgroup 1: 1,3 and Subgroup 2: 2), subgroup 1…n verbal design action (See primary verbal design action for codes, applied individually for every subgroup.), subgroup 1…n embodied design action (See primary embodied design action for codes.)