þÿStudents Funds of Knowledge and Knowledge C During STEM Learning in a Computer-supported Makerspace

Kajamaa, Anu

ISLS International Society of the Learning Sciences
2019-06-21

þÿKajamaa , A & Kumpulainen , K 2019 , Students Funds of Knowledge a Creation During STEM Learning in a Computer-supported Makerspace . in K Lund , G P Niccolai , E Lavoué , C Hmelo-Silver , G Gweon & M Baker (eds) , A Wide Lens : Combining Embodied, Enactive, Extended, and Embedded Learning In Collaborative Settings,13th International Conference on Computer Supported Collaborative Learning (CSCL) 2019, Volume 2 . vol. 2 , Computer-Supported Collaborative Learning , ISLS International Society of the Learning Sciences , Lyon , pp. 585-588 , International Conference on Computer Supported Collaborative Learning , Lyon , France , 17/06/2019 . < https://www.cscl2019.com þÿ: upload : pdf : CSCL-2019-Volume-2 >

http://hdl.handle.net/10138/326452

unspecified
publishedVersion

Students' Funds of Knowledge and Knowledge Creation During STEM Learning in a Computer-Supported Makerspace

Anu Kajamaa and Kristiina Kumpulainen
anu.kajamaa@helsinki.fi, kristiina.kumpulainen@helsinki.fi
University of Helsinki, Finland

Abstract: Despite increased research attention to novel design and making environments, often referred to as "makerspaces", students' funds of knowledge and knowledge creation are still a fairly unexplored issue in these contexts. To address this gap, we draw from sociocultural theorizing, with a specific interest in the notions of funds of knowledge and knowledge creation. We ask: how do the students' funds of knowledge mediate their knowledge creation during STEM learning in a novel computer-supported makerspace? Our findings indicate three forms of knowledge creation during STEM learning: "horizontal knowledge creation", "vertical knowledge creation", and "extended knowledge creation". Our work joins with the line of research focused on complex intersection between students' funds of knowledge and schooled knowledge in a third space. It makes visible how a novel computer-supported makerspace makes available a repertoire of digital, material and social resources that can advance the emergence of creative third spaces.

Introduction

Digital learning tools and technologically enhanced learning environments often referred to as "makerspaces" have aroused recent educational interest (Honey and Kanter, 2013; Halverson and Sheridan, 2014; Kafai, Fields and Searle, 2014, Peppler, Halverson and Kafai, 2016, Kumpulainen, Kajamaa and Rajala, 2018). Makerspaces account for interest-driven engagement in hands-on creative activities with a range of tools and artefacts. Despite the growing importance and popularity of these learning environments, how students' use their funds of knowledge and create knowledge in these contexts is still fairly unexplored. To address this research gap, we investigate students' funds of knowledge and knowledge creation in a novel computer-supported makerspace, the FUSE Studio, which is a choice-based digital infrastructure for STEM (i.e., Science, Technology, Engineering and Mathematics) learning (Stevens and Jona, 2017). It is located within a school context and provides digital tools and other material means for mediating between school and the out-of-school lives of the participating students. Ideally, the students can make their implicit funds of knowledge explicit and expand these in innovative learning processes by constructing novel solutions to the STEM challenges during the design and making activities. This thus provides an intriguing context for the investigation of students' funds of knowledge and knowledge creation during STEM learning. Drawing from sociocultural theorizing, we ask: How do students' funds of knowledge mediate their knowledge creation during STEM learning activities in a novel computer-supported makerspace? To answer this research question, we draw on the theoretical notions of funds of knowledge (e.g. Moll, Amanti, Neff and Gonzales, 1992; Vélez-Ibáñez and Greenberg, 1992; Barton and Tan, 2009; Esteban-Guitart, Maria Serra and Llopart, 2018) and knowledge creation (e.g. Nonaka and Takeuchi, 1995; Paavola, Lipponen and Hakkarainen, 2004; Hakkarainen, 2009; Ritella and Hakkarainen, 2012).

Conceptual background

"Funds of knowledge" refers to a student's multiple cultural resources that stem from their life worlds in and out of school. Earlier studies applying the funds of knowledge approach have largely focused on promotion of inclusive educational practices, highlighting that pedagogical practices built upon students' funds of knowledge can generate positive consequences for their learning and participation in the classroom, potentially leading to improved educational quality (e.g. Moll et al., 1992; Vélez- Ibáñez and Greenberg, 1992; Gonzales, Moll and Amanti, 2005; Barton and Tan, 2009). Recent research has shown that classroom interaction plays a crucial role in mediating students' opportunities to draw upon their funds of knowledge and productively connect this knowledge to their academic learning (Rodriguez, 2013; Esteban-Guitart et al., 2018; Silseth and Erstad, 2018). Research also shows how new digital tools and online spaces can support students' sense making and meaning-making and coherence between the students' funds of knowledge across school and out-of-school contexts (e.g. Kamberlis and Wehunt, 2012; Lantz-Anderson, Vigmo and Bowen, 2013; Kumpulainen et al., 2014). Recently, studies have explored students' funds of knowledge in STEM education of non-dominant groups' mathematics learning (Civil, 2016) and to understand math, science and engineering concepts, at the secondary and postsecondary level (Verdin, Godwin and Capobianco, 2016). However, at present little is known how students' funds of knowledge mediate their knowledge creation in novel, computer-supported makerspaces that differ from regular classroom contexts with teacher-centered classroom practices. Our study is based on Vygotsky's sociocultural idea of conceptual (signs, language) and material (artefact/tool) mediation of human action (Vygotsky, 1978, see also Ritella and Hakkarainen, 2012). We stress tensions, questions and questioning as important mediators, mediating the student's interaction and innovative learning and knowledge advancement. We view knowledge creation as a non-linear process, drawing from the funds of knowledge of the participants, always embedded in practices and mediated by language and tools (Vygotsky, 1978). Further, the explication of students' funds of knowledge is considered central in the genesis of students' creative processes (Nonaka and Takeuchi, 1995). In our case, in the technologically enhanced design and making activities, following Nonaka and Takeutchi (1995), we view knowledge as created through a continuous dialogue between tacit and explicit knowledge, in our study the tacit referring to the student's funds of knowledge and the digital tools and other material means and the collaborative interaction seen as enabling the articulation of tacit knowledge, and mediating the transfer between the tacit and the explicit knowledge.

Empirical study

The context of this study is a city-run comprehensive school with 535 students and 28 teachers at the primary level. The school strives for student-centredness and stresses design and digital learning, which is aimed at enhancing students' creative problem-solving skills across the curriculum. In 2016, as a response to the new national core curriculum requirements, the school introduced the FUSE Studio (www.fusestudio.net) as one of its elective courses. The FUSE Studio is a technological and pedagogical infrastructure that provides digital tools (computers, 3D printers) and other materials (e.g., foam rubber, a marble, tape and scissors) for science, technology, engineering and mathematics (STEM) learning. In the FUSE Studio, students are free to select which 'challenges' to pursue, who with (or alone) and when to move on. The challenges level up within sequences, following the basic logic of video game design principles. Each challenge is designed to engage students in different STEM topics and skill sets. A *Solar Roller* challenge, where the students build a toy car and try to move it by charging it with power from the lamp, as an example. The challenges are accompanied by computers, 3D printers and other materials, as well as instructions on how to process the challenges. The core idea is to promote young learners' STEM learning and to cultivate STEM ideas and practices among those who are not already affiliated with them, and by so doing broadening the access to participation in STEM learning. The assessment of a student's participation and learning does not include grading, but is carried out by utilizing photos, video or other digital artifacts and the student's own documentation (Stevens and Jona, 2017).

Methodology

Our primary data comprise 111 hours of transcribed video recordings and field notes of groups of students (N = 94) aged between 9 and 12 years old and their facilitator-teachers carrying out making and design activities in the FUSE Studio. The video recordings were collected intermittently over a period of one academic year. The data come from three groups of students and their teachers who participated in the FUSE Studio elective course. Due to the elective nature of the course, the groups consisted of students from several classes. Group 1 consisted of 32 students (22 boys and 10 girls), Group 2 consisted of 30 students (19 boys and 11 girls) and Group 3 consisted of 32 students (19 boys and 13 girls). Each group was supported by two to four teachers and teaching assistants. At the beginning of the first semester, each group had one 45-minute FUSE session a week. Later in the semester, each session was extended to 60 minutes. All relevant parts of the video data and field notes of students' and teachers' collaborative interaction in the design and making environment were transcribed. Our analytic approach can be defined as abductive, involving repeated iterations between theory and data. Our analysis focused on the interaction taking place between the students and their teachers in their making activities. Our analysis proceeded from inductive analysis of the discursive acts in the student's interactions (Jordan and Henderson, 1995) in which the student's explicated their funds of knowledge. We depicted episodes where the students' funds of knowledge were either supported or overrun by the peers and/or the teachers. For this, we first engaged in close and iterative readings of all the interview data and started to extract funds of knowledge from the data. On this basis, the students out-of-school and school experiences were given codes, and connections were then looked among codes, and the codes were then progressively clustered in emerging main themes. With the aim of deepening our analysis of the students' funds of knowledge, and to investigate it in relation to their knowledge creation that emerged in the students' collaborative interaction, we then focused on further analyzing the parts of the transcripts in which the students experienced challenges and success during their STEM activities. Our interaction analysis proceeded to the tracing of the main forms (or patterns) of student's knowledge creation from the depicted interaction episodes. Moreover, inspired by the approach on knowledge creation developed by organization scholars, Nonaka and Takeuchi, (1995), we developed a typology of forms of knowledge creation which gave evidence of how the students' funds of knowledge mediated knowledge creation, moving across different domains of STEM practice—everyday life, school, and STEM disciplines (see also Civil, 2016).

Findings

Our study revealed three forms of knowledge creation in the students' design and making activity in the FUSE Studio. *Horizontal knowledge creation* refers to the bottom-up and student-driven nature of knowledge creation during which the students actively explicated their funds of knowledge to others in their making activity. For example, the students enthusiastically interacted and instructed one another, and their funds of knowledge were recognized and taken into account, by their peers and / or the teacher. This often reframed the activity, extending the original FUSE maker challenges. While drawing on their everyday experiences, the potential of the FUSE Studio to contribute to knowledge creation between school and out-of-school was effectively realized. Here, the students relied on their personal funds of knowledge that potentially contributed to their creation of new knowledge and STEM learning. *Vertical knowledge creation* refers to the top-down directed nature of knowledge creation in which there was little room for the students' funds of knowledge. The students' funds of knowledge remained implicit and were not explicated in ongoing interactions. For example, the students drew from their existing knowledge without questioning or reconceptualizing the FUSE challenges or the teacher's instructions. The students' activity was focused on STEM learning, however, the FUSE studio then privileged a traditional classroom interaction through which students followed authorized instructions given from the outset with little recognition of their personal funds of knowledge. This created multiple tensions between the students and their teachers. *Extended knowledge creation* refers to hybridized forms of knowledge creation in which the students' funds of knowledge hybridized with and advanced schooled knowledge and practice. In these episodes, the students' funds of knowledge created extended possibilities for their knowledge creation and STEM learning. The students stepped beyond the horizontal and vertical knowledge creation and applied knowledge in creative ways while working on the FUSE maker challenges. We illustrate how this process may lead to creative processes (see also Sefton-Green et al., 2011), as well as to the development of the student's "conceptual artifacts", which are symbolic in nature and enhance the student's learning activity (Paavola et al., 2004).

Potential significance of the work

Our findings highlight the importance of not only the students bringing in their funds of knowledge into the design and making activity, but also how creative processes emerge when the students' personal funds of knowledge are explicated and hybridized with schooled knowledge, advancing their knowledge in ongoing collaborative interactions. In the FUSE Studio, the students creatively explicated their funds of knowledge in the collaborative interaction, and also broke away from the situation and the instructions. In some cases, extended, innovative and unexpected ways of working and solutions on the FUSE challenges emerged. However, often times the students quite mechanically carried out vertical knowledge creation, in other words, strictly followed the structures and instructions of the FUSE Studio and/or facilitating teachers. Our work joins with the line of research focused on complex intersection between students' funds of knowledge and schooled knowledge in a third space (see also Moje et al., 2004; Gutiérrez, 2008; Barton and Tan, 2009). The study makes visible how a novel computer-supported makerspace, in our case, the FUSE Studio makes available a repertoire of digital, material and social resources that can advance the emergence of creative third spaces. Widening of the understanding of the different forms of students' knowledge creation can provide valuable lessons and guide knowledge advancement and transformation of school contexts, yet due to the tensions, this presents a challenging endeavor.

References

Barton, A. and Tan, E. (2009). Funds of knowledge, discourses and hybrid space. *Journal of Research in Science Teaching, 46*(1), 50–73.

Civil, M. (2016). STEM learning research through a funds of knowledge lens. *Cultural Studies in Science Education, 11*, 41–59.

Esteban-Guitart, M., Maria Serra, J. and Llopart, M. (2018). The Role of the Study Group in the Funds of Knowledge Approach. *Mind, Culture, and Activity, 25*(3), 216-228.

Gonzáles, N., Moll, L. C., and Amanti, C. (2005*). Funds of Knowledge: theorizing practices in households, communities, and classroom.* Mahwah, NJ: Lawrence Erlbaum.

Gutiérrez, K. D. (2008). Developing a sociocritical literacy in the third space. *Reading Research Quarterly, 43*, 148–164.

Hakkarainen, K. (2009). A knowledge-practice perspective on technology-mediated learning. *Computer-Supported Collaborative Learning, 4*, 213-231.

Halverson, E. R. and Sheridan, K. (2014). The maker movement in education. *Harvard Educational Review, 84*(4), 495-504.

Honey, M. and Kanter, D. (Eds.) (2013). *Design, make, play: Growing the next generation of STEM innovators*. New York: Routledge.

Jordan, B. and Henderson, A. (1995). Interaction analysis: Foundations and practice. *Journal of the Learning Sciences, 4*(1), 39–103.

Kafai, Y., Fields, D., and Searle, K. (2014). Electronic textiles as disruptive designs: Supporting and challenging maker activities in schools. *Harvard Educational Review, 84*(4), 532-556.

Kamberelis, G., and Wehunt, M. D. (2012). Hybrid discourse practice and science learning. *Cultural Studies of Science Education, 7*(3), 505–534.

Kumpulainen, K., Lipponen, L., Hilppö, J., and Mikkola, A (2014). Building on the positive in children's lives: a co-participatory study on the social construction of children's sense of agency, *Early Child Development and Care, 184*(2), 211-229.

Kumpulainen, K., Kajamaa, A., and Rajala, A., (2018). Understanding educational change: Agency-structure dynamics in a novel design and making environment. *Digital Education Review*, 33, 26-38.

Lantz-Andersson, A., Vigmo, S., and Bowen, R. (2013). Crossing boundaries in Facebook: Students' framing of language learning activities as extended spaces. International Journal of Computer-Supported Collaborative Learning, 8(3), 293–312.

Moje, E. B., Ciechanowski, K.M, Kramer, K., Ellis, L., Carrillo, R. and Collazo, T. (2004). Working toward third space in content area literacy: An examination of everyday funds of knowledge and Discourse. *Reading Research Quarterly, 39*(1), 38–70.

Moll, L. C., Amanti, K., Neff, D., and Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into Practice, 31*(2), 132–141.

Nonaka, I., and Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation.* New York: Oxford University Press.

Paavola, S., Lipponen, L., and Hakkarainen, K. (2004). Models of innovative knowledge communities and three metaphors of learning. *Review of Educational Research, 74*(4), 557–576.

Peppler, K., Halverson, E., and Kafai, Y. B. (Eds.). (2016). *Makeology: Makerspaces as learning environments* (Vol. 1). New York: Routledge.

Ritella, G. and Hakkarainen, K. (2012). Instrumental genesis in technology-mediated learning: From double stimulation to expansive knowledge practices. *International Journal of Computer-Supported Collaborative Learning, 7*(2), 239–258.

Rodriguez, G. M. (2013). Power and agency in education: Exploring the pedagogical dimensions of Funds of Knowledge. *Review of Research in Education, 37*(1), 87–120.

Sefton-Green, J., Thomson, P., Jones, K., and Breslin, L. (Eds.). (2011). *The Routledge international handbook of creative learning.* London: Routledge.

Silseth, K., and Erstad, O. (2018). Connecting to the outside: Cultural resources teachers use when contextualizing instruction. *Learning, Culture and Social Interaction*. Published online before print, February 2018, https://doi.org/10.1016/j.lcsi.2017.12.002

Stevens, R., and Jona, K. (2017). Program design. FUSE Studio -website. Retrieved May 20, 2017 from https://www.fusestudio.net/program-design

Vélez-Ibáñez, C. G., and Greenberg, J. B. (1992). Formation and transformation of funds of knowledge among U.S.-Mexican households. *Anthropology and Education Quarterly, 2*3(4), 313-335.

Verdin, D., Godwin, A., and Capobianco, B. (2016). Systematic review of the funds of knowledge framework in STEM education. *School of Engineering Education Graduate Series, 59*(6), 26–48.

Vygotsky, L. S. (1978). Mind in society: The development of higher mental processes. Cambridge, MA: Harvard University Press.

