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The sociomaterial ecology of emotions in a school’s makerspace

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Abstract

In this chapter, we investigate the sociomaterial ecology of emotions in students’ engagement within a school’s makerspace. The notion of sociomaterial ecology accentuates the holistic view of emotions that emerges in the multifaceted relations among people, technologies and the sociocultural environment. The empirical data of our study consist of video recordings of 9–12-year-old students’ interactions in a makerspace called the FUSE Studio in a Finnish primary school. The video data were subjected to a multimodal analysis to investigate the multiple modes and embodiments through which students’ emotions were expressed, shared and negotiated in situ. Our study shows how the students’ engagement in maker activities involved multiple and – at times – tension-laden emotions ranging from excitement, joy, happiness, pride and humour to irritation, frustration and disappointment. We also show how these emotions were entangled with fellow students, teachers, the makerspace, its material artefacts and requirements, as well as the rules and practices of the school. Overall, the display of emotions was found to be strong in situations in which the students experienced challenges. However, the ways in which the students responded to and negotiated these challenges, such as ownership of emotions, gave rise to different opportunities for their engagement and learning. In all, the chapter demonstrates the integral role of emotions in students’ maker activities, pointing out the value of researching and understanding emotions from the perspective of sociomaterial ecology.
The sociomaterial ecology of emotions in a school’s makerspace

Introduction

One of the more recent societal phenomena that is generating educational interest internationally is the growth of makerspaces. These are spaces that are designed to enable student engagement in hands-on creative science, technology, engineering, arts and mathematics (STEAM) activities by using a range of digital tools (e.g., electronics, coding tools, game-making apps, laser cutters and 3D printers) and more traditional everyday tools and materials (e.g., sewing machines, woodwork equipment and natural ingredients from nature; Halverson & Sheridan, 2014; Peppler, Halverson, & Kafai, 2016). In Finland, there is growing interest in makerspaces as a way to democratise and broaden educational opportunities in STEAM fields and beyond (e.g., Kumpulainen, Kajamaa, & Rajala, 2018; Kajamaa, Kumpulainen, & Rajala, 2018).

Research has shown how engaging in makerspaces enhances students’ creativity and imagination (Burke & Crocker, 2019), design thinking (Hughes, Morrison, Kajamaa, & Kumpulainen, 2018), transformative agency (Kajamaa & Kumpulainen, 2019) and STEAM learning (Bevan et al., 2016). Makerspaces are also suggested to enhance students’ interest-driven engagement, and the development of transversal competencies, including collaboration, creativity, critical thinking and problem solving (Blom-Ross, Kumpulainen, & Marsh, 2019; Honey & Kanter, 2014; Sheridan et al., 2014). Research has further shown how participation in makerspaces can enhance peer pedagogies (Dezuanni, 2019), transform the traditional roles of the teacher/other adult experts and students and enable students and teachers to draw on each other’s relative expertise (Vossoughi & Bevan, 2014; Kajamaa, Kumpulainen & Olkinuora, 2019).

In parallel, evidence on makerspaces has identified the critical features that call for further attention (Peppler & Bender, 2013). For instance, makerspaces have yet to fully engage with a wide range of young people because of their narrowly defined activities and goals (Blikstein & Worsley, 2016). As a result, educators are encouraged to ensure that makerspaces consist of activities that are meaningful for the students and that have personal and/or community-related relevance (Blikstein, 2013). Here, existing research points to the need for quality and inclusive makerspaces and urges for further investigations into makerspaces as they relate to creating equitable and meaningful learning experiences for all students.

Although there is a growing body of research on the educational potential and challenges of makerspaces, little attention has been paid to understanding the emotional dimensions of student engagement in makerspaces. In this chapter, we argue that this lack of focus on the emotional element is a serious limitation that deserves further research attention. We base our argument on
our observations of the pervasiveness of emotions in students’ engagement in makerspaces, as well as research evidence that demonstrates the integral unity of emotion in human experience, activity and learning (Vadeboncoeur & Collie, 2013; Vygotsky, 1994, 1999; Zembylas, 2014). As Jaber and Hammer (2015) have summarised, emotions are integral to students’ science inquiry, including their emergent disciplinary engagement (Engle & Conant, 2002), epistemic agency (Scardamalia, 2002) and sense of having ‘wonderful ideas’ (Duckworth, 2006). Furthermore, emotions – for instance, a sense of engagement, intensity, commitment, dedication, disappointment and satisfaction – are inherent in scientists’ careers and pursuits (Feynman, 1985; Gruber, 1974; Keller, 1983; Lorimer, 2008; Varelas, Becker, Luster, & Wenzel, 2002). As a result, if we want to educate students to experience and learn about the authentic work of scientists, designers and makers, it is important that students experience and contend with diverse emotions in makerspaces. In addition, investigating student engagement by looking at emotions can generate important insights into how and why some students care and find an interest in making whereas others do not.

The aim of this chapter is to contribute to the current research knowledge on how emotions emerge, are expressed, are shared and are negotiated during students’ engagement in the makerspace. We will address the following question: What characterises the sociomaterial ecology of emotions in an educational makerspace? We are particularly interested in understanding emotions as situational, relational and embodied in the sociocultural and sociomaterial contexts of the makerspace and will consider how these are related to the nature of students’ engagement and learning opportunities. Hence, we direct our attention to the complex entangled processes through which emotions emerge and are negotiated in situ. We refer to this complexity as the sociomaterial ecology of emotions.

Conceptualising the sociomaterial ecology of emotions

Our approach to researching and understanding the sociomaterial ecology of emotions in makerspaces is framed by sociocultural (Bozhovich, 2009; González Rey, 2014; Fleer & Hammer, 2013; Vygotsky, 1994, 1999) and sociomaterial theories (Braidotti, 2013; Barad, 2013; Horton & Kraftl, 2006), as well as by theories on what is termed ‘affect’ (Ahmed, 2014). Although there are some conceptual differences between these theories, they offer valuable complementary insights into understanding emotions as relational and embodied, interactional, contextual, intertextual and consequential. By drawing on these three theoretical lenses, we introduce the notion of the sociomaterial ecology of emotions that accentuates a holistic and relational view of emotions as emerging in multifaceted relations among people, technologies and the sociocultural environment.

In our study, we do not regard emotions as the property of individual subjects or as psychological states but rather as something that arises from relations (Boiger & Mesquita, 2012;
In what follows, emotions are viewed as entangled with embodied actions across the self, other people, technologies and the sociomaterial context (Holodynski, 2009; Holodynski & Friedlmeier, 2006). Depending on what situation is being analysed, emotions might be observed between students and their teachers, between students and material artefacts or among any combination of these in a sociomaterial ecology.

In her influential work on the cultural politics of emotion, Sara Ahmed (2014) focused on the social relationships between emotions, language and bodies, considering how these relationships perform inclusion and exclusion in communities. From this perspective, emotions account for cultural practices. Thus, emotions are material rhetoric with affective power that open and disclose people’s opportunities to the social and material worlds. Understanding emotions from this perspective can guide our investigation of the relational dynamics of emotions in makerspaces as they relate to educational opportunity and equity (Ahmed, 2014).

To address the students’ emotions in their multidimensional relations that emerge in the makerspace, we start with sociomaterial theorising. We hold that the sociomaterial view is well suited for our purposes given its holistic focus on the interdependencies among multiple agents in the organisation of an activity (Braidotti, 2013; Barad, 2013; Horton & Kraftl, 2006). We also view the sociocultural context, including its rules and norms, as connected to the students’ ongoing emotional work (Kumpulainen et al., 2018). From this perspective, emotions are given cultural and social meaning through their interaction with other participants and the sociomaterial and cultural situation. Similarly, Boiger and Mesquita (2012) explore the situatedness of emotions and how emotions are embedded in the moment-to-moment interactions imbued in both the history and future of relationships. Furthermore, collective environments and communities are important for the development of emotions and their collective regulation (Bozhovich, 2009; Fleer & Hammer, 2013; Ojanen & Little, 2010). These modify emotions in terms of their quality, intensity, frequency, course and expression (Fleer & Hammer, 2013; Holodynski, 2009). As a result, an analysis of students’ emotions requires close attention to where and how, between whom, between what points and processes and to which ends and consequences emotions are expressed and negotiated in the moment and over time (Hufnagel & Kelly, 2017).

Further, in our work, we move beyond seeing certain kinds of emotions as intrinsically superior to others, instead recognising the ambivalence of all forms of emotions for students’ participation and learning opportunities in makerspaces (see also Sinatra, Broughton, & Lombardi, 2014; Wickman, 2006). Our study differs from those approaches that hold that epistemic emotions (i.e. emotions directly related to disciplinary practices) need to be studied as separate from other types of ‘nonepistemic’ emotions (e.g. Jaber and Hammer, 2015). In contrast, in our holistic approach, we want to pay attention, investigate and understand the sociomaterial ecology of different kinds of emotions that emerge from students’ engagement in makerspaces.
Study

Our empirical study is situated in a city-run school in Helsinki, Finland. The students come to this school from a local catchment area and represent diverse socioeconomic and cultural backgrounds. The school introduced the FUSE Studio makerspace (www.fusestudio.net) in its programme as a way to respond to its curriculum goals of enhancing students’ interest-driven, creative STEAM learning (Stevens et al., 2016). The FUSE Studio is a makerspace providing ‘a choice-based digital infrastructure for STEAM learning’, and it aims to cultivate students’ interest in STEAM, thereby aiming to broaden access to participation in STEAM learning (Stevens & Jona, 2017).

The FUSE Studio offers students STEAM challenges. Each FUSE challenge is designed to engage students in different STEAM topics and skills, and these challenges have been structured to introduce students to new ideas and support them through more complex iterations of those ideas. The challenges are accompanied by various tools, such as computers, 3D printers and other materials (e.g., a foam rubber, a marble, tape and scissors), as well as instructions to process the challenges. Table 1 provides a summary of the 29 FUSE challenges available to students. In the table, we have highlighted those FUSE challenges that we will discuss in our empirical study.

Table 1. FUSE challenges that students can choose from based on their interests

<table>
<thead>
<tr>
<th>FUSE challenge</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D You</td>
<td>Invites students to create a 3D model of themselves and printing it out on a 3D printer.</td>
</tr>
<tr>
<td>Coaster Boss</td>
<td>Invites students to build the fastest roller coaster.</td>
</tr>
<tr>
<td>Cookie Customizer</td>
<td>Invites students to design and print unique cookie cutters, make awesome cookies and then eat them.</td>
</tr>
<tr>
<td>Crystal Ball</td>
<td>Invites students to programme LED lights to create a fantastic light display.</td>
</tr>
<tr>
<td>Dream Home</td>
<td>Invites students to design their dream home in 3D.</td>
</tr>
<tr>
<td>Dream Home 2</td>
<td>Invites students to take on the role of an architect and redesign a family home or renovate a teen centre.</td>
</tr>
<tr>
<td>Electric Apparel</td>
<td>Invites students to customise their clothing and accessories so that they light up when they use them.</td>
</tr>
<tr>
<td>Eye Candy</td>
<td>Invites students to design their own glasses and print them out.</td>
</tr>
<tr>
<td>Game Designer</td>
<td>Invites students to use video game design tools to help their hero beat a game.</td>
</tr>
<tr>
<td>Get in the Game</td>
<td>Invites students to design controllers for online gamers that make the game more fun and interactive.</td>
</tr>
<tr>
<td>How to Train Your Robot</td>
<td>Invites students to train a Sparki robot to walk, bark, draw and fetch treats.</td>
</tr>
<tr>
<td>Jewelry Designer 2.0</td>
<td>Invites students to design their own jewellery and print it out in 3D.</td>
</tr>
<tr>
<td>Challenge</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Just Bead It!</td>
<td>Invites students to create gel beads using the same cutting-edge techniques scientists use to grow human cells.</td>
</tr>
<tr>
<td>Keychain Customizer</td>
<td>Invites students to design and 3D print a keychain with their name or custom message.</td>
</tr>
<tr>
<td>Laser Defender</td>
<td>Invites students to create a laser beam security system to protect a valuable ‘treasure’ and challenge their friends to break in.</td>
</tr>
<tr>
<td>LED Color Lights</td>
<td>Invites students to combine and control light from three LEDs to produce a rainbow of different colours.</td>
</tr>
<tr>
<td>Mini Jumbotron</td>
<td>Invites students to fill up a screen with text, images and games.</td>
</tr>
<tr>
<td>MiniMe Animation</td>
<td>Invites students to use 3D animation software to bring a CGI figure to life by customising their colours, giving them expressions and making them dance.</td>
</tr>
<tr>
<td>Music Amplifier</td>
<td>Invites students to build an amp for their phone, mp3 player or computer.</td>
</tr>
<tr>
<td>Party Lights</td>
<td>Invites students to build a light display that blinks and fades in a pattern of their own design.</td>
</tr>
<tr>
<td>Print My Ride</td>
<td>Invites students to design their own model car and then print it out in 3D, complete with rolling wheels.</td>
</tr>
<tr>
<td>Ringtones</td>
<td>Invites students to mix their own custom ringtone.</td>
</tr>
<tr>
<td>Robot Obstacle Course</td>
<td>Invites students to make a robot navigate through sharp turns, bridges and lava.</td>
</tr>
<tr>
<td>Smart Castle</td>
<td>Invites students to upgrade a toy castle with clap on/off lightning and intruder alerts.</td>
</tr>
<tr>
<td>Selfie Sticker</td>
<td>Invites students to make a sticker self-portrait.</td>
</tr>
<tr>
<td>Solar Roller</td>
<td>Invites students to master a racetrack by getting their solar powered car through tunnels and distance tests.</td>
</tr>
<tr>
<td>Solar Roller Showcase</td>
<td>Invites students to set the record for the fastest 60-inch dash with their Solar Roller car.</td>
</tr>
<tr>
<td>Spaghetti Structures</td>
<td>Invites students to build with spaghetti so that they can break the record for the tallest tower.</td>
</tr>
<tr>
<td>Wind Commander</td>
<td>Invites students to harness the power of the wind to lift weight, make electricity and turn on lights.</td>
</tr>
</tbody>
</table>

The students can access the FUSE challenges and their instructions through a website (www.fusestudio.net). On this website, the students can watch trailers of each FUSE challenge. Based on the trailers, the students can choose the challenge that is the most appealing to them. They can then access the challenge’s instructions, including both written instructions, pictures and video tutorials.

**Participants and Methods**

Our empirical data comprise of 85 hours of video records of 9–12-year-old students’ (N:94) engagement in the FUSE Studio makerspace; the videos were collected over a period of one academic year. The students were separated into three groups from several classes. Group 1 consisted of 32 students (22 males and 10 females), Group 2 of 30 students (19 males and 11 females) and Group 32 of students (19 males and 13 females). Each of these groups was
supported by two to four teachers and teaching assistants. At the beginning of school in the fall, each group had one 45-minute FUSE session a week. Later in the fall, each session was extended to 60 minutes. All the student groups and sessions followed the same format: while working in the FUSE Studio, the students could choose whatever challenges they wanted to work on and whenever and with whom they wanted. There was no formal grading or assessment by teachers; instead, using photos or videos, the students could document their completion of a challenge into their personal account in the FUSE Studio programme.

The data collection took place once a week for each of the three groups. Five researchers took responsibility for the video data collection by using four mobile cameras. Usually, two of the cameras followed the teachers, and two were set to record the students’ activities. We decided on the students and teachers they videoed throughout each session. The main principle that guided the decisions regarding the focus of the cameras was motivated by the need to form a comprehensive picture of the nature of the interactions and activities in the FUSE Studio. To support the data collection, we produced an Excel spreadsheet that identified the students, teachers and the FUSE challenges that the students chose to work on each session. The spreadsheets guided the focus of the video cameras for the next session and later supported the analysis of the collected video data. Altogether, the data consist of 85 hours of video records.

Analysis

Our analysis of the empirical data utilises an interaction analysis (Jordan & Henderson, 1995) and multimodal analysis (Kress, 2010; Sakr, Jewitt, & Price, 2016; Streeck, Goodwin, & LeBaron, 2011; Taylor, 2014) to explore the multiple modes through which emotions are expressed, shared and negotiated in ongoing interactions. Paying attention to multiple semiotic resources in the students’ interactions was necessary to investigate the situated, embodied and relational nature of emotions in line with our theoretical framing. For this, we continually engaged in an iterative analysis of the interaction data found in the videos (Derry et al., 2010; Jordan & Henderson, 1995) to challenge, revise and refine our analysis and interpretations. In addition, we made constant comparisons between data-driven interpretations and the literature to make sense of the complex sociomaterial ecology of emotions, hence situating our analysis within an abductive approach that moved between inductive and deductive reasoning (Dey, 2003).

The data analysis consisted of two sequential phases. The first analysis phase was inductive and descriptive (Elliott & Timulak, 2005), focusing on the range of modes in the students’ expressions, sharing and negotiation of emotions. To dig deeper into these modes, we then identified specific emotional markers in the flow of the students’ multimodal interactions (see also Taylor, 2014), here focusing on the students’ verbal expressions (e.g., excitement,
frustration and surprise), the paralinguistic channels of their communication (e.g., intonation, cut-offs and sound stretches), body postures and movement (e.g., head movement, standing up and postural shifts), facial expressions and gaze, turn-taking patterns and temporal coordination of the students’ gesture and talk. Thereafter, we entered short descriptions, including illustrative data examples of each identified mode of emotion and their emotional markers, into a spreadsheet (Excel).

The second phase of our analysis was interpretative and motivated by the need to understand how and why the identified emotions occurred (Elliott & Timulak, 2005). Here, we moved beyond labelling and describing the modes of students’ emotions and instead looked into the sociomaterial and sociocultural processes, that is, the sociomaterial ecology of emotions. In this analytic phase – and following the work of Hufnagel and Kelly (2017) – we paid attention to the aboutness of emotions, that is, the relationship of the expressed emotion to a specific situation, event and/or body. In addition, we examined the ways in which the ownership of emotions was expressed, shared and negotiated. Analysing the ownership of emotions allowed us to investigate how the students positioned themselves and others in their emotional work.

**Results: The Sociomaterial Ecology of Emotions in Students’ Making**

Next, we turn to discussing our findings with illustrative vignettes. These vignettes, derived through purposeful sampling (Patton, 2002), have been selected to demonstrate our key findings about the sociomaterial ecology of students’ emotions during their engagement in the makerspace. In Vignette 1, we discuss the emergence and negotiation of a struggle that turns into collective excitement and happiness between the students and teacher as the students achieve success with the Solar Roller challenge. In Vignette 2, we illustrate the sociomaterial ecology of the emergence and negotiation of happiness and pride among the students as they document the outcome of their maker work from the Solar Roller challenge. Vignette 3 illuminates collective humour and joy between the students as they manage the difficulties encountered in processing their maker activity from the Dream Home challenge. Vignette 4 shows the emergence of irritation towards a fellow student who is trying to help and how this results in a lack of emotionally and experientially shared space between the students. Finally, Vignette 5 shows the sociomaterial ecology of frustration and disappointment among a student in relation to the teacher’s actions and time-boundness organisation of the school. Together, these vignettes offer rich insights into the situated, embodied and relationally entangled emotional work of the students in their engagement in the makerspace.

**Vignette 1: When struggle turns into collective excitement and happiness**
Four students – Emmi, Silja, Nellie and Una (females) – have chosen to work together on a FUSE challenge called the Solar Roller, which asks the students to construct a vehicle that can move using solar power. To get the vehicle to work, the students need to engage in electrical wire work and attach the solar panel. The students have been working on the FUSE challenge with intensity. They are starting to show signs of a struggle because they have not managed to get the vehicle to move even though they have checked the wiring many times (including with the teacher’s help).

Suddenly, the vehicle starts moving slowly, and one of the girls, Nelli, exclaims with an excited voice, ‘This started to move’¹. A second student, Emmi, gets excited as she makes the same observation, exclaiming, ‘It started to move!’ All four students cheer together shouting, ‘Yay!’ Silja claps her hands and then raises her fists up in the air as a sign of achievement and joy. Una then leaves to share the good news with the teacher who was assisting them earlier. She says to the teacher, ‘We got it work!’ The teacher sounds excited and happy for the students as he replies, ‘Did it move? Great!’

Picture 1: ‘It moves!’

In this vignette, we witness the students’ persistent work on the maker challenge, despite the difficulty of not getting the solar car to move. After struggling with the challenge, the car finally starts working, which results in excitement and joy in the students’ multimodal interactions. The emotions of excitement and happiness evidence themselves in the students’ verbal expressions, intonation, body postures and movement, facial expressions and gaze, turn-taking patterns and the temporal coordination of gesture and talk when they observe the solar car moving. The ownership of these positive emotions is first shared collectively among the students and then with the teacher after the students share the good news with him. Hence, our analysis makes

¹ All verbal interactions in the vignettes shown in this chapter have been translated from Finnish to English.
visible the emergence of the collective sharing of happiness of the students’ accomplishment and how it travels to include the teacher as well. Here, the sociomaterial ecology of positive emotions is entangled across the students, the material and its workings and the teacher, creating a shared emotional and experiential space for the students’ maker activity.

**Vignette 2: The fun and pride of engaging in the maker activity**

Two students – Riku and Timo (males) – have decided to work on the Solar Roller challenge. They have just completed the final phase of the challenge, which asks them to film the vehicle moving over a one-and-a-half-metre distance. Timo uses the camera to film, while Riku is holding a lamp close to the vehicle’s solar panel to make the vehicle move.

The students are then watching the video they made on the camera screen. Riku, who was responsible for holding the lamp, sounds very happy about the video and says, ‘That is very good. That is VERY good!’ His happiness can be heard in his tone of voice. The boys continue to make arrangements to film once more when Riku looks at the camera and says once again, ‘That was a good video, that’. This time, he says it more quietly, as if it was a mental note.

![Picture 2: ‘That is VERY good!’](image)

In this vignette, we can see how the students’ joint documenting of their finalised maker work, here with a camera, creates satisfaction and a sense of pride among the students. In this case, the ownership of the positive emotion is entangled between the students and the joint documentation of the final product of their maker activity. The emotion of pride can be witnessed in Riku’s verbal expressions, intonation and sound stretches, as well in both students’ body postures and movement and facial expressions. In this vignette, we can witness a positive, shared emotional and experiential space in the students’ engagement in their maker work.

**Vignette 3: Approaching a difficulty with collective humour and joy**
Two students – Hilma and Piia (females) – have chosen to work on the Dream Home challenge, where they must both design and make their own dream homes in 3D, side by side. The conversation between the students begins by Hilma’s initiation when she says, ‘This does not somehow…’ as she is trying to figure out how to design a roof for her house. Both students start to laugh when the roof moves in a funny way on the screen. Then, Hilma continues, ‘Okay, what if we take it out (deletes the line), like this’. Piia comments on this and says, ‘What on earth’. Hilma continues, ‘It should work now (lifts the roof), wohoo!’ and Piia joins in and says, ‘Wohoo!’ raising her hand in the air and saying, ‘It works’. She responds and raises her hand as well, and the students give each other a ‘high five’ for the accomplishment.

Picture 3: ‘High five!’

In this vignette, we can see how difficulty with a maker challenge (i.e., how to use the 3D design software) was approached by the students with collective humour and joy, which is evidenced in the students’ verbal expressions, intonation, body postures and movement, facial expressions and gaze, turn-taking patterns and coordination of gestures and talk; in the end, this resulted in the joint celebration of success in overcoming difficulties. Here, the ownership of the positive emotion travelled between the materiality of the maker activity and the students. This vignette demonstrates how experiencing challenges and difficulties during the maker activity are important elements of working and learning in the makerspace. Specifically, it evidences how collective humour can play an important role in establishing and negotiating a joint emotional and experiential space for students to pursue their maker work.

**Vignette 4: When peer help does not count**

Two students – Markus and Antti (males) – are working independently, side by side, on their computers on a Dream Home challenge. Markus has been trying to build a roof for his house for more than 15 minutes without any success. A teacher has come to assist him, and Antti, who has been sitting next to him, is now standing and trying to help him out as well. Markus is trying to explain what he is doing as Antti starts to point out something on the screen. Markus gets
irritated by Antti’s action and says, ‘I know what the problem is, go away!’ He then pushes Antti away and continues to work on his own. The teacher does not react to the situation.

This vignette demonstrates a negative emotion of irritation by Markus, who is having problems with the FUSE challenge and is in the midst of explaining this difficulty to a teacher while another student, Antti, interrupts him. The negative emotion of irritation is witnessed in Markus’ verbal expression, intonation, body postures and movement and facial expressions. Clearly, in this situation, the students fail to reach a common emotional or experiential ground for their joint interaction and work. In addition, the teacher does not manage to support the students in reaching a shared space for their interaction. The situation results in Markus continuing to work on his own, trying to figure out the problem by himself, whereas the others move elsewhere.

**Vignette 5: When the teacher and organisation of the school get in the way**

Four students – Niina, Lilja, Emma and Kaisa (females) – have chosen to work on the Coaster Boss challenge, during which they are designing and making a roller coaster in the hallway and where, once completed, they will place a ball and have it travel on the roller coaster. The students are intensively engaged in their maker activity when the teacher joins in, offering her help as the FUSE session is about to end. The teacher then shows the students how to hold the loop to make it work. One of the students, Niina, says, ‘I cannot hold the loop in the right position with my hand the whole time’. The teacher responds and explains, ‘You need to hold the loop in place only when the marble goes through’, but Niina insists and says, ‘But I want to use the painter’s tape’. The teacher leaves, and Niina whispers quietly to the other students, ‘Those teachers are so irritating’.
This vignette demonstrates how the organisation and time structure of the school and the teacher’s actions created tension for the students’ engagement in their making activity, resulting in frustration and disappointment for at least one of the students. The negative emotions of frustration and disappointment are demonstrated in the student’s verbal expression, intonation, cut-offs, sound stretches, body postures and movement, facial expressions and gaze. Here, the students’ interest-driven activity is interrupted by the school hours and is amplified by the teacher’s interest to help the students finish their work quickly. In this vignette, the sociomaterial ecology of emotions is related to the sociocultural context, organisation and rules of the school that conflict with the design principles of the FUSE Studio makerspace that emphasises students’ interest-driven and persistent engagement (Stevens & Jona, 2017).

Discussion and Conclusions

In our chapter, we have attempted to understand the sociomaterial ecology of emotions in students’ engagement in a school’s makerspace. Drawing on sociomaterial and sociocultural theorising and studies of affect, our conceptualisation of the notion of the sociomaterial ecology accentuates a holistic view of emotions that emerge in multifaceted relations among people, technologies and the sociocultural environment. Overall, our research shows how emotions are an integral part of students’ engagement in makerspaces. The emotions we depicted were not simply related towards goals or outcomes but rather entangled within the actual maker activity and its situated sociomaterial ecology. In one respect, our findings are similar to the studies on young children and play, where it is the pleasures and struggles of play in and of itself that bring emotions to the fore (Sutton-Smith, 2001).

Our analysis reveals how the students’ engagement in maker activities was filled with multiple and – at times – tension-laden emotions ranging from joy, enthusiasm and pride to struggle, frustration and disappointment. These modes of emotions emerged in complex and multidimensional relations among the students, teachers, the makerspace (its artefacts and requirements) and the organisation of the school, including its practices and rules. The display of
emotions was found to be strong in situations in which the students experienced difficulties and/or challenges, for instance, when the students had difficulties in their designs or in their use of technology. However, the ways in which the emotions were responded to and negotiated in the students’ multimodal interactions, as well as the students’ ownership of their emotions, gave rise to different opportunities for student engagement, as highlighted in the vignettes.

Interestingly, positive emotions such as joy, happiness and humour were often contagious and typically resulted in collective sharing and negotiation, whereas more negative emotions, such as frustration, disappointment and irritation, seldom resulted in collective negotiation or joint resolution. Based on our findings, we can conclude that the ownership of emotions was related to the nature of the emotion; more positive emotions resulted in collective ownership and negotiation, whereas more negative emotions did not lead to collective negotiation or sharing. These findings have pedagogical implications, suggesting that more attention needs to be given to supporting students in managing and negotiating different emotions, as well as more negative ones. Also, how to create opportunities for every student to feel success and pride over their own and each other’s maker activity and its outcomes is worthy of further research attention.

Our study shows how students are learning and becoming familiar with the various emotions involved in the authentic work of designing and making during their engagement in a makerspace. This includes experiencing the pleasures and struggles of generating and having ideas and trying them out, tackling emerging challenges and persisting in maker activities, as well as experiencing pride and success in overcoming challenges and completing maker work and its material artefacts. This also relates to how students learn to deal with, manage and respond to different emotions, both positive and negative, in collaboration with others. The results of our study give evidence of such educationally valuable interactions in the sociomaterial ecology of the makerspace.

In sum, our study and its results show how emotions are part of the ‘material’ needed to learn in makerspaces. In addition to considering how teachers and peers can support each other in managing and dealing with different types of emotions, attention could also be directed at the material design of the makerspace, which could offer various types of emotional support for students to manage and share their emotions. In parallel, we have learned that teachers need to be in tune with the emotional work that emerges in makerspaces; this includes sensitively responding to and harnessing the various emotions brought into being through ongoing interactions. When emotions, such as excitement, pride and joy – and also irritation and frustration – are welcomed to become the resources that organise and structure the interactional activity and that drive the learning activity, the students can take more ownership of their emotions and develop confidence in their roles as designers and makers in STEAM (see also Jaber & Hammer, 2015; Kumpulainen et al., 2018). We also recognise the important role of peer pedagogies (Dezuanni, 2019) in makerspaces and how it is important for the students to learn to
manage and deal with emotions collectively, responding and drawing on each other’s emotional support and expertise in their maker activities. Put differently, it is the collective and sense of community that are the cornerstones of an authentic maker culture (Gauntlett, 2011; Schrock, 2014).

Our study demonstrates the value of a multimodal interaction analysis for researching the sociomaterial emergence and negation of emotions in ongoing situated interaction in the makerspace; it shows how focusing on the multiple modes of interaction, including verbal expressions, paralinguistic channels of communication, body postures and movement, facial expressions and gaze, turn-taking patterns and the temporal coordination of gesture and talk, are pivotal in developing a more nuanced understanding of the sociomaterial ecology of emotions in the makerspace context. In addition, exploring the aboutness of emotions helped us understand the ways in which emotions are related in complex ways to a specific situation, event or agent. Focusing on the ownership of emotions allowed us to investigate how the students positioned themselves and others in their emotional work, including how emotions were collectively shared (see also Hufnagel & Kelly, 2017). In sum, our study points to the importance of viewing emotion not just as a matter of communicating an emotion from one person to another, but as a complex sociomaterial assemblance that is entangled by multifaceted relations among people, technologies and the sociocultural environment (Braidotti, 2013; Barad, 2013; Horton & Kraftl, 2006).

Taken together, this chapter shows how researching students’ emotions-in-interaction is essential for understanding the organisation of student engagement and learning opportunities in makerspaces. At the same time, our study calls for further research on the sociomaterial ecology of emotions in various types of makerspaces with diverse students, teachers and materialities because there is still a large range of possible dynamics to observe and understand. In addition, future research is needed to address more specifically how the sociomaterial ecology of emotions interacts with students’ interests, identification with and learning in STEAM and beyond in situ and across longer timescales.

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References


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