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Interactive dynamics of imagination in a science classroom

Jaakko Hilppö[a], Antti Rajala[b], Tania Zittoun[c], Kristiina Kumpulainen[b], Lasse Lipponen[b]

[a]Northwestern University

[b]University of Helsinki

[b]University of Neuchâtel

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Abstract

In this paper, we introduce a conceptual framework for researching the dynamics of imagination in science classroom interactions. While educational interest in imagination has recently increased, prior research has not adequately accounted for how imagination is realized in and through classroom interactions, nor has it created a framework for its empirical investigation. Drawing on a theory of imagination situated in cultural psychology (Zittoun et al., 2013; Zittoun & Gillespie, 2016), we propose such a framework. We illustrate our framework with a telling case (Mitchell, 1984) of imagination from a Finnish primary science classroom community. Our illustration focuses on the dynamics of imagination as it unfolds in classroom interactions and how qualitatively distinct loops of imagination are formed. In specific, we show how the students' meaning making expands in time and space and can become more refined and differentiated through loops of imagination and their dynamics. In all, our paper argues that imagination is a constitutive element of science learning. Our proposed conceptual framework provides potential avenues for further empirical research on the dynamics of imagination in science learning and teaching.

Keywords: Imagination; Science Learning; Classroom Interaction

Corresponding author: Jaakko Hilppö, Northwestern University, School of Education and Social Policy, Walter Annenberg Hall, 2120 Campus Drive, Evanston, Illinois 60208, United States. Email: jaakko.hilppo@northwestern.edu
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1. Introduction

Imagination is increasingly identified as an important aspect of learning (Nemirovsky, Rasmussen, Sweeney & Wawro, 2012; Pelaprat & Cole, 2011; Zittoun & Gillespie, 2016; Fleer, 2015). For example, interest in imagination is evident in recent research on learning as knowledge creation (Damsa & Jornet, this issue), and on playful and creative learning (Connery, John-Steiner, & Marjanovich-Shane, 2010; Wegerif, 2007). While imagination is closely related to creativity, we consider the outcomes of imagination as creative only when they are socially acknowledged as such (Glăveanu, Gillespie, & Valsiner 2015). The power of imagination lies in its potential to enrich the way people experience and interact with their worlds. In imagination, actions can be disconnected from their usual consequences and phenomena not available in the immediate proximal experience can be conjured. Imagination can thus involve experimenting with new ideas without real-life repercussions or constraints, and as such imagination is a fundamental aspect of learning. Furthermore, it is a crucial part of science-in-the-making, that is, the actual work of scientists (Latour & Woolgar, 1986).

Despite this growing interest, imagination in science learning, has only recently become the focus of conceptual and empirical research. For example, Fleer (2015) showed how imagination, emotions and concept formation are united in children's interaction with their lifeworlds. Van Eijck & Roth (2013), in turn, showed that in science classrooms and textbooks, scientific endeavors are predominantly imagined as epic stories depicting scientists as heroes. While these studies have started to unpack how imagination interacts with other aspects of learning and instruction, the dynamic characteristics of imagination as part of science education are not yet conceptualized. Such a lack, in our opinion, undermines attempts to further understand the importance of imagination in learning.

In this paper, we build on and extend a theory of imagination situated in cultural psychology (Zittoun & Gillespie, 2016) to assemble a conceptual framework for researching how students make meaning of science through imagination. We also illustrate and enrich this framework by analyzing a telling case (Mitchell, 1984) of the dynamics of imagination in a Finnish primary science classroom community. Lastly, we shortly discuss the contribution of our framework for empirical research on imagination in learning. We also discuss the strengths and limitations of the framework as well as propose avenues for future research on the topic.

2. Assembling a conceptual framework: On loops of imagination...

Drawing upon a cultural psychological theory of imagination proposed by one of us (Tania Zittoun) and colleagues (Zittoun & Gillespie, 2016; see also, Vygotsky, 1931), we define imagination in this study as "the process of creating experiences that escape the immediate setting, which allow exploring the past or future, present possibilities or even impossibilities. Imagination feeds on a wide range of experiences people have of, or through the cultural world, through diverse senses, now combined, organized and integrated in new forms" (Zittoun & Gillespie, 2016, p. 2).

Zittoun & Gillespie (2016) continue by theorizing that imagination involves a partial and temporary decoupling from the here-and-now of a particular situation. This partial decoupling is *triggered* by an event, like being bored in class or struck by an inspirational piece of art, that disrupts one's ongoing engagement. During this decoupling one's experience is expanded into semiotically mediated and more distal experiences. A work of art, like a book, might evoke imagining other times and worlds and thus lets the reader enrich her experience by imagining elements not present otherwise. The partial separation of experience ends in the eventual reconnection back to the here-and-now. This process of back-and-forth movement between proximal and distal experiences negotiated in interaction constitutes what Zittoun and Gillespie (2016) call loops of imagination.

Loops of imagination take different context-specific forms. They can be characterized along the dimensions of temporality, plausibility and generalization (Zittoun & Cerchia, 2013). For example, discussing futuristic societal utopias during civic lessons, reading about ancient Egypt or daydreaming about the upcoming summer holiday represent different temporal characteristics, plausibilities, and generalizations as loops of imagination. The temporal dimension designates the temporal “aboutness” of imagining; discussing ancient Egypt involves imagining the past and anticipation involves imagining the future. These loops can pertain to issues that are either plausible or improbable in a given social setting and that can vary from concrete personal experiences to generalized abstractions. In this paper, we suggest that the loops of imagination also include a spatial dimension that has not yet been conceptualized in connection to imagination loops. This spatial dimension is evident in the above examples; imagining about future societies, the ancient Egypt or the summer holiday all entail a spatial displacement from the here-and-now to an imagined distal space.

What Zittoun’s and Gillespie’s work highlights is the ubiquity of imagination in human activities. Rather than being something that people do only at certain times, imagination is a constitutive element of even the most mundane situations (see also Pelaprat & Cole, 2011). More fundamentally, from a cultural psychological perspective the emergence and use of cultural tools in human activities – namely cultural mediation – has relied on and spurred our capacity to imagine. Moreover, although single persons can imagine, their imagination is nonetheless constituted by social and cultural means and their sometimes conflicting perspectives (Wertsch, 1991; Bakhtin, 1981).

3. ….and their dynamics in science education

In the context of formal science education students are often required to imagine phenomena not available to them in the immediate here-and-now. The students are also asked to explore different explanations to phenomena in the natural world and judge their plausibility (Varelas & Pappas, 2006; Kumpulainen et al., 2003), all of which require imagination. In other words, when learning about particular phenomena, students (like scientist) revisit and revise how they imagine these phenomena. While Zittoun’s and Gillespie’s theory of imagination is sensitive to the process nature and context specificity of imagination, it does not account for this type of dynamics of imagination. They do, however, provides us with initial direction.

Building on Vygotsky (1931) and Werner & Kaplan (1963), Zittoun and Gillespie point out that imagination can expand and become more refined over time. For example, after first imagining going to the beach, one can start populating this image with different beach activities or imagine a different destination. On a longer time scale, with the progressive mastery of specific culturally available means, a child’s version of his dream home can become more differentiated when she re-designs it as a professional architect and also expand when she applies her design ideas into a new design domain, like cars. These dynamics are relevant aspects of imagination and thus a conceptual framework of imagination should address them.

In this paper, we propose that imagination in science education holds two distinct but intertwined dynamics, expansive and refining. In our proposed conceptual framework the *expansive dynamics of imagination* accounts for movement in meaning-making between proximal and more distal times and spaces. The expansive dynamics of imagination permits a classroom community to explore topics that extend in space and time beyond their immediately experienced worlds (e.g., addressing phenomena ranging from microscopic to planetary spaces and timescales). This dynamic is thus primarily related to the temporal and spatial dimensions of the loops of imagination. It also relates to the dimension of generality because it involves moving between particular lived experiences and more abstract and general descriptions of objects and events. In turn, the *refining dynamics of imagination* accounts for how a classroom community develops a progressively more refined understanding of science topics under discussion. This dynamic makes possible for the classroom community to settle on what they consider as an acceptable explanation. In this regard, the refining dynamics is primarily related to the plausibility dimension of the loops of imagination. Thus, this dynamic connects to an important goal of formal science learning: the development of plausible interpretations and explanations that hold across contexts. Table 1 summarizes the proposed conceptual framework.

Table 1

Dynamics of imagination in science learning

Dynamics of imagination	**Definition**	**Associated dimensions of imagination loops**
Expansive dynamics	• accounts for shifts in meaning-making between proximal and more distal times and spaces. • permits a classroom community to explore topics that extend in space and time beyond their immediately experienced worlds.	Temporality, spatiality, generality
Refining dynamics	• accounts for how a classroom community develops a progressively refining understanding of science topics under discussion • permits a classroom community to distinguish what is accepted as plausible explanation	Plausibility

We will next illustrate and enrich the proposed conceptual framework by analyzing empirical data consisting of video-recorded social interactions in a science classroom. Like others, we consider imagination as a socially mediated process (Zittoun & Gillespie, 2016; Fleer, 2015; Pelaprat & Cole, 2011). This requires that our analytical approach must be sensitive to how imagination is realized in and through social interaction between participants. The microgenetic analysis we employ to our telling case abides to a dialogical methodology (Linell, 1998; Jordan & Henderson, 1995) and allows us to study imagination as a process and outcome of joint action. Our approach resembles those used in research of creative classroom interactions, in which creativity is conceptualized as a social and distributed process (e.g., Wegerif, 2007; Sawyer, 2004).

4. Enriching the conceptual model by analyzing illustrative examples

In this section, we analyze a student-led classroom discussion that occurred during a science project. In the discussion the students explore topics which, due to their unfamiliarity, extend beyond their immediately experienced worlds and thus mobilizes the student's imaginations. The class in question is a culturally and socio-economically heterogeneous third-grade classroom community of eighteen students (9-10 years old) and their teacher (one of us, Antti Rajala) from the metropolitan area of Helsinki, Finland. The teacher's pedagogical thinking was influenced by sociocultural and dialogic approaches, mainly the

Thinking Together project (Dawes, Mercer, & Wegerif, 2000), which he applied in his classroom to promote constructive ways of using language as a social mode of thinking (see e.g., Rajala, 2016).

The discussion analyzed in this paper began when one of the students, Maija, asked a question concerning the origin of stones (February 8, 2008). The class was discussing a pile of stones that the students had encountered in the forest. Maija requested for the floor and raised a new question (line 134 Maija: *But tell me that where have the stones come from?*). The teacher designated Maija as the chair for what became a lively and extended discussion on this topic.

Maija's wondering acts as a *trigger* for a loop of imagination. Through this loop, the classroom community decouple from their immediately experienced world to explore distal times and spaces to explain the origin of stones. As a result, a rich array of new meanings are developed, deployed and refined in the ensuing discussion. Yet, no conclusion is reached for Maija's question and the topic is postponed until a later, unspecified occasion. The topic resurfaces and a new imagination loop regarding the origin of stones is triggered after more than a month later when Maija reiterates her question. This happens while the class was discussing a film on moon formation that they had seen in a science center (March 19, 2008).

Next, we will show the formation of these imagination loops and illuminate expansive and refining dynamics that loops of imagination can involve. Through these two dynamics, the students' meaning making expands in time and space and becomes more refined and differentiated.

4.1. Expansive dynamics of imagination

In the expansive dynamics of imagination the students' meaning making shifts from proximal to increasingly distal times and spaces when the classroom community explores different explanations for the origin of stones in their discussion. When discussion began the students' explanations were embedded in a spatio-temporal frame that concerned objects and events within the confines of the Earth as an existing planet. Within this frame the explanations did not extend to the issue of Earth's formation or events or objects beyond its boundaries. The following example illustrates this time-space frame that we named as a *geological time-space frame.*

4.1.1. Example 1. Geological time-space frame

149 Maija: Can I say, if they have come from sand so, like, do stones, like, grow?

150 Kimmo: No

151 (unidentified): No

152: Teacher: Give out turns at talk

153 Kimmo: I think they have come, like, there has been some rocks and then the rocks have at some point collapsed. They might have come from there.

154 Maija: Where have ro-

155 Kimmo: Well there was that rock over there and it might have collapsed

156 Maija: But where have the rocks then come from?

157 Teacher: Maija is now the chair. Maija can talk when she wants to and designate speaking turns.

158 Kimmo: Well, it has come from Earth.

The example begins when Maija reiterates a previous answer to her question on the origin of stones (stones can come from sand) and asks for confirmation. Kimmo and others refute this explanation, and Kimmo proposes that stones originate from collapsing rocks. Kimmo then concretizes this image in terms of personally experienced time and space by referring to the specific rocks that the class saw during their field trip (line 155). Maija provokes Kimmo to explain how the rocks have formed in the first place. Through Kimmo's response the student's meaning making begins to expand in time and space.

Maija's question (line 156) represents a recurrent social dynamic in the discussion that serves as means for expanding the scope of meaning making. In the next example, we will see how the students' meaning making further expands to address more distal times and spaces within what we named as a *planetary time-space frame*. In this frame Earth is positioned in the wider solar system, and issues of its formation and interactions with extra-terrestrial objects, such as meteors, are addressed. We enter the interaction when Saara asks a question that pushes the class to think beyond their intermediate conclusion that sand is stone.

4.1.2. Example 2. From geological to planetary time-space frame

172 Saara: So, like, sand is stone. So, like, where has sand come from?

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180 Kimmo: I think it has come from (unclear) Earth. Like, there has been in the beginning a fiery, a sun or some sort of a fireball and then it has hardened and then -

181 (Kimmos ideas are laughed at)

182 Timo: A fireball (laughing)

183 Kimmo: I mean a big one

184 (Timo mimics a fireball and ridicules Kimmo's idea)

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194 Oliver: So I'm not like believing that there suddenly comes this fireball, that there comes this fireball or like or like (laughter) then all of a sudden the sand appears.

Triggered by Saara's question, Kimmo first explains that sand has come from Earth (line 180). Next, he moves to talk about the formation of the planet Earth by evoking an image of a blazing celestial body which then solidifies. Kimmo's new explanation expands the class's meaning making in time and space for the first time to a planetary scale. Here, the laughter, Timo's sneering, and most evidently, Oliver's response (line 194) all acknowledge Kimmo's effort in creating the new distal time-space frame. Yet, at the same time Timo, Oliver and the others are resisting the expansion and this tension, stemming from the demand for plausibility of the explanations, becomes a source for further dynamics in the discussion.

In all, in both lessons through the loops of imagination the students' meaning making expands in time and space. In the first lesson, the imagination primarily moves within a geological time-space frame but is expanded to include a planetary time-space frame. Imagination also occasionally recouples with personally experienced times and spaces when the students make references to events and objects within the scope of their lifeworlds, such as Kimmo's reference to the nearby rocks (Example 1). In contrast, planetary time-space frame is the dominant frame of the second lesson. This shift in the dominant time-space frame is primarily due to the symbolic mediation by the film about moon formation that the class is discussing. During the second lesson the meaning making further expands beyond the planetary time-space frame. This happens when the teacher explains the big bang theory and how it accounts for the emergence of matter in the universe. In response, the class also discusses alternative religious explanations of Earth's creation. Maija's question about the origin of God (line 145 Maija*: Who made God?*) further illustrates the role of continuing questions in the expansive dynamics of imagination and how different symbolic materials feed that process.

4.2. Refining dynamics of imagination

Through the loops of imagination meaning making in classroom interaction can also become more refined, as illustrated in the following example. The example begins when Oliver continues to ridicule Kimmo's incipient explanation that sand emerged from a ball of fire when Earth was formed.

4.2.1. Example 3. Refining the meaning making

240 Oliver: So, like, how come, like, if a piece gets detached from Earth, then how come it can, like, suddenly start to come back as a fireball (Hussein and Timo laugh) so, like, the Earth circulates the pieces.

241 Kimmo: Nooo (laughing)

242 Timo: Are there holes in the Earth

243 Kimmo: No, if you'd dig long enough into the Earth-

244 Esa: There would be lava (in a silly voice)

245 Kimmo: Yeah, I meant just that, in the beginning there was a (Hussein: It would burn) lava or a ball

246 Timo: (overlaps with Kimmo) No first, no. There's the mantle of Earth

Oliver first expresses his doubts about Kimmo's explanation. Hussein and Timo support Oliver's ridiculing by laughing. Kimmo also laughs and refutes Oliver's interpretation of his explanation. Timo then asks whether there are holes in Earth. Kimmo defends his explanation and proposes a thought experiment of digging a deep hole through Earth. While the students argue and counter-argue with each other and evaluate various lines of reasoning that are put forth, their meaning making around the formation of Earth becomes progressively more refined. The students use their background knowledge to build a more differentiated image of the structure of Earth, and Kimmo uses this image in an attempt to convince the other students. In particular, he elaborates his explanation that the fireball that is indicated in his explanation is of similar to hot lava deep under the Earth's surface. The students' deployment of technical language, such as 'lava' and 'mantle of Earth', constitutes effective means whereby their imagination is refined.

Figure 1 shows a rough overview of both the expansive and refining dynamics of imagination during the two lessons. The expansive dynamics can be seen, for example, in Turns 170-194 when the discussion shifts into a new time-space frame. In turn, the refining mode can be seen in the continuous block of speaking turns in the planetary time-space frame between turns 240-246.

Figure 1. The expansion of meaning making in time and space during lessons February 8 and March 19 and also the location of examples 1-3 in the interaction.

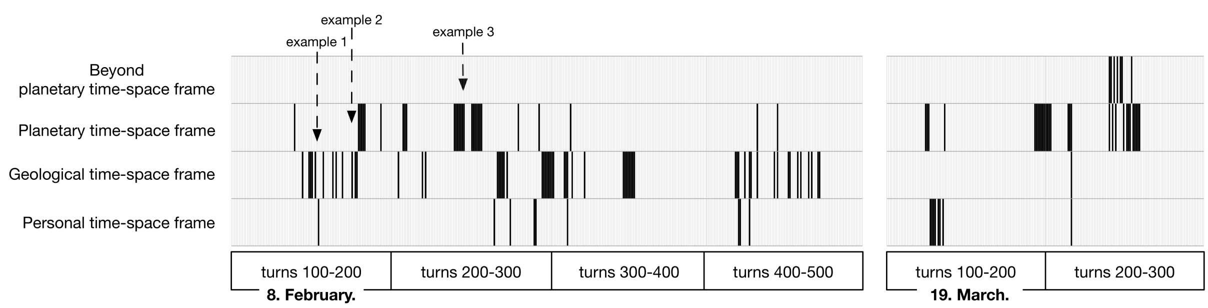

Figure 1. The expansion of meaning making in time and space during lessons February 8 and March 19 and also the location of examples 1-3 in the interaction.

5. Discussion

Although imagination in science learning has been previously conceptualized as a situated and shared process (e.g., Fleer, 2015), prior research has not provided for a framework for studying the dynamics of imagination in classroom interactions. In this paper we have presented such a framework by drawing on and extending a theory of imagination situated in cultural psychology (Zittoun & Gillespie, 2016). We have also illustrated the proposed our framework by analyzing a telling case of imagination in science education.

As demonstrated by our telling case, the expansive and refining dynamics foregrounded imagination in the joint meaning making of the classroom. The *expansive dynamics of imagination* highlighted the dynamics of the loops in relation to their spatial and temporal dimensions. Here our new suggestion, the spatial dimension, appeared to sit well with Zittoun's and Gillespie's theory as it provided a way to address the movement of imagination in more detail (cf. Zittoun & Cerchia, 2013). Our framework also highlighted loop dynamics in relation to the dimension of generality when the students repeatedly moved between general descriptions of more distal objects and events and their particular experiences in their joint meaning making.

The *refining dynamics* illuminated the plausibility dimension of imagination. That is, our examples made evident that the students themselves demanded plausible explanations and explicit reasoning from each other based on what they know about the topic or what is common sense to them. In particular, our conceptual framework highlights the formation of a dialogical space (Wegerif, 2007) that revolves around the tension between plausibility (*what is)* and playful exploration of ideas (*what could be)*. This dialogical space created a generative dynamic that pushed joint meaning making to expand and become more refined and differentiated. The ensuing discussion presented the students a fruitful context for defining and learning to use field-specific, differentiated vocabulary. This observation also raises more fundamental questions about what knowing, or learning to know something means in science classroom practices. Specifically, learning to know about the origin of stones, or any other phenomena, seems to emerge out of a tensional process where an array of different imagined explanations is ordered in relation to their plausibility (Law, 1998). In other words, the importance of imagination for science education is not just in how it makes possible for the students to think about the studied phenomena as they *are*, but also as they *are not*, and making the difference between these two. Our conceptual framework highlights this process.

In all, our conceptual framework illuminates the dynamical characteristics of imagination in science classroom interactions. It also contributes to research on science learning more generally (e.g., Varelas & Pappas, 2006; Kumpulainen et al., 2003), by showing how students – through imagination – can create and evaluate contrasting explanations, even seemingly implausible ones. More specifically, our conceptual framework illuminated what triggered the loops of imagination and the different forms these loops took Furthermore, our conceptual framework helped to unpack the social work needed for imagination to take place in classroom interactions.

While a single case analysis does not allow us to evaluate how our conceptual framework applies to more varied instances of imagination, we feel that the work presented here offers grounds for further research on the topic. In particular, it generates new relevant research foci and empirical research questions for science education and learning. Future research could, for example, investigate the role of imagination in students' construction of explanations and how teachers and the educational context can support this process. Knowing what triggers, sustains and/or hampers as well as personal imagination in educational settings is also of great importance. It would also be interesting to investigate how imagination in science learning is mediated by material tools and artifacts or how, if at all, the dynamics of imagination differ in the different phases of the learning process. Future research may also want to address the 'dark side' of imagination, that is, how imagination can limit the ways in which people interact with their world(s).

Keypoints

- Imagination is a central aspect of science learning and science education
- Through loops of imagination students' meaning making expands in time and space and becomes progressively more refined and differentiated
- The introduced conceptual framework for the study imagination opens up new research foci for science education and learning

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