

**This is a self-archived version of an original article. This version may differ from the original in pagination and typographic details.**

**Author(s):** Aalto, Eija; Mustonen, Sanna

**Title:** Designing knowledge construction in pre-service teachers' collaborative planning talk

**Year:** 2022

**Version:** Published version

**Copyright:** © 2022 The Author(s). Published by Elsevier Inc.

**Rights:** CC BY-NC-ND 4.0

**Rights url:** <https://creativecommons.org/licenses/by-nc-nd/4.0/>

**Please cite the original version:**

Aalto, E., & Mustonen, S. (2022). Designing knowledge construction in pre-service teachers' collaborative planning talk. *Linguistics and Education*, 69, Article 101022.

<https://doi.org/10.1016/j.linged.2022.101022>



# Designing knowledge construction in pre-service teachers' collaborative planning talk

Eija Aalto\*, Sanna Mustonen

Department of Teacher Education, University of Jyväskylä, Jyväskylä, P. O. Box 3540014, Finland



## ARTICLE INFO

### Article history:

Received 3 June 2021

Revised 27 January 2022

Accepted 1 February 2022

### Keywords:

multimodal meaning-making resources  
knowledge construction  
translanguaging  
collaboration  
pre-service teachers  
teacher education

## ABSTRACT

In this paper, we report on a qualitative study of student teachers' collaboration in planning and implementing a course that integrated physics and the Finnish language. Audio-recorded planning sessions and interviews were examined using qualitative content analysis, first, to discover what kind of space for knowledge construction student teachers designed for learners and, second, to identify the characteristics of their collaboration in developing a new cross-disciplinary pedagogical practice. The analysis revealed challenges in integrating meaning-making resources for knowledge construction; especially the role of language remained mostly invisible. This indicates a need to develop teachable strategies of translanguaging. Student teachers' varied forms of academic knowledge were interpreted as a resource for their collaboration across disciplines. Consequences for teacher education were acknowledged: supervision is needed to make the collaborative process visible and more profoundly conceptualized. More studies on the phases of the collaboration are needed.

© 2022 The Author(s). Published by Elsevier Inc.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

## 1. Introduction

Global educational trends conceive learning as co-construction of knowledge; a process in which social-relational aspects of knowledge generation are promoted, multiple resources are utilized and trans-contextual skills appropriated (see e.g., Damsa & Jornet, 2016). Within this context, the Finnish core curriculum for basic education promotes a school culture that draws on an integrative approach and active involvement of learners (National Research Council, 2012; EDUFI, 2016). Learners need to be enabled to combine, utilize and develop knowledge and skills in collaboration and in multimodal, multidisciplinary contexts (see Cope & Kalantzis, 2009; Lankshear & Knobel, 2011). These alignments call for integrating different subjects, dialogue between teachers, and enabling the active participation of learners as well as supporting their development as critical, cooperative agents. Moreover, they entail a translanguaging approach, that is, rather than treating different meaning making resources as separate systems, the resources are flexibly utilized when constructing knowledge (e.g. Li, 2018).

Core competencies of 'thinking and learning to learn', 'interaction' and 'multiliteracy' run through the core curriculum

(EDUFI, 2016). In addition, the growing linguistic and cultural diversity of classrooms is making knowledge construction processes even more multidimensional and also urgent, as teachers of all disciplines need to be prepared to integrate language and content learning to support the learning of students with varying backgrounds and language proficiency levels (Walqui & van Lier, 2010). However, there is a long tradition of teacher autonomy and independence as well as strict subject boundaries in Finnish schools (Lonka, 2018; Tarnanen & Kostiaainen, 2020). The need to shift this mindset of disconnected teachers and subjects, as well as learning as an individual endeavour while developing the whole working culture, requires socialization into a new kind of thinking about learning and collaborative modes of working already during pre-service education (e.g., Smith, 2018; Tarnanen & Kostiaainen, 2020).

This study contributes to the current research on student teacher (i.e., pre-service teacher) collaboration (e.g., Marquez-García, Kirsch, & Leite-Mendez, 2020; Bush & Grotjohann, 2020) and the research on knowledge construction through translanguaging (e.g., Jones, 2020; Probyn, 2019; Wu & Lin, 2019) by exploring student teachers' collaboration when planning a study unit integrating physics and Finnish language learning. In this study, all learners are seen as language learners, as in the physics classroom they are learners of disciplinary language that is new to them (e.g., Dufva et al., 2011; Schleppegrell, 2020). When integrating language and content knowledge, teachers need to de-

\* Corresponding author.

E-mail address: [eija.aalto@jyu.fi](mailto:eija.aalto@jyu.fi) (E. Aalto).

velop language-aware practices that promote knowledge construction across subject boundaries (e.g., Meyer et al., 2015; Moore & Schleppegrell, 2020). Hence, our analysis focuses on two aspects: first, the translanguaging spaces for knowledge construction that student teachers create for lower secondary school learners and, second, the characteristics of their collaboration in developing a new boundary-crossing, multimodal pedagogical practice.

This study builds on Vygotskian (1978) sociocultural thinking and an ecological approach (e.g., Steffensen & Fill, 2014; van Lier, 2000; see also Mustonen, 2015), which both emphasize the contextual and situated nature of learning and view learning as an inherently social and multisensory phenomenon in which interaction and collaboration constitute the learning process (Lantolf & Thorne, 2006; van Lier, 2000; Walqui & van Lier, 2010; Vygotsky, 1978). The ecological view extends Vygotskian thinking and elaborates this view with respect to the notion of mediational means: the learner's agency in recycling and appropriating semiotic resources is at the centre of the learning process (e.g., van Lier, 2000; Steffensen & Fill, 2014). Not all the resources lead to learning, but those that the agent perceives and chooses to make use of become *affordances* for learning. Thus, the ecological approach treats language as relations and interaction between the learner and the environment (van Lier 2004, p. 4) rather than as objects, such as words and grammar. Language is also studied in relation to other languages and sign systems, such as gestures, visualizations, and artefacts; it is seen in relation to human cognition, action, social forces, and power in communities, as well as the whole material world (Steffensen & Fill, 2014; van Lier, 2000). The flexible, integrated and coherent use of different multimodal tools in making meaning and shaping experiences, understandings and knowledge is often referred to as *translanguaging* in the research literature (Li, 2018; Probyn, 2019).

In the following sections, we discuss this concept in more detail by presenting the literature concerning how learning is promoted across subject boundaries through the concepts of student teacher *collaboration* and *translanguaging space for knowledge construction*. Thereafter, in the subsequent analysis, we examine the kind of space for knowledge construction that student teachers in our study created for learners during discussions surrounding their planning as well as characteristics of the student teachers' negotiation process. Thus, our focus is on student teachers' learning and the learning opportunities they plan to create for learners in the classroom, acknowledging that in both contexts, learning requires recycling and appropriating resources for affordances.

## 2. Promoting learning across subject boundaries

### 2.1. Pedagogical planning through student teacher collaboration

Collaborative learning, rooted in Vygotsky's sociocultural theory (Vygotsky, 1978; see also Dillenbourg, 1999), provides learners with opportunities to develop their cognition and expand their conceptual potential by communicating with peers. The ecological view adds to the classical sociocultural approach by promoting the collaborative learning of equals, not just scaffolding by somebody more skilled. Through multidimensional collaboration, learners interact, share a variety of resources, and thus expand their mutual understanding and construct knowledge that they could not have gained individually (van Lier 2004, p. 158). In the context of teacher education, interaction across subject boundaries provides conditions for developing shared understanding (Damsa & Jornet, 2016).

According to Dillenbourg (1999), collaborative learning situations are typically discerned as symmetrical with respect to power positions, although the team symmetry may vary during the pro-

cess of an activity. Participatory roles may continually shift, but it is crucial that division of labour is minimal and participants engage in working together and reaching a mutual goal. This generates positive interdependence and individual accountability between participants (Dillenbourg, 1999). The shared goal may be defined to some extent at the outset of the project, but in an open-ended task there is room for further discussion and adjustment of the goal based on participants' different viewpoints. Participants can differ in their understanding of the point and aim of their action and approach it from various perspectives. Negotiation of different points of view and misinterpretations is essential, and it is through this collaborative activity that participants develop something together, e.g., solve a shared problem. This process of finding a solution to the problem is assumed to involve learning (Dillenbourg, 1999) as the participants are acting within their zone of proximal development (Vygotsky, 1978). Learning is here perceived as a social process of knowledge construction, in which participants are creating something new, such as knowledge, solutions, understanding or practices (see Damsa & Jornet, 2016; Hakkarainen et al., 2013). Learning can be observed through the construction of new knowledge and the development of shared ideas.

According to the ecological view, learners' agency in recycling and appropriating meaning-making resources is at the core of the learning process (van Lier, 2004). In this paper, we are particularly interested in the resources that the student teachers planned to utilize in creating a knowledge construction space for learners, i.e. the kind of meaning-making tools that they acknowledged as essential for learning. Moreover, while planning talk among student teachers may often echo many ideals of disciplinary and pedagogical traditions or innovations and awareness of multiple tools, it is crucial to examine which of these became affordances and appropriated to their own creative knowledge construction and the classroom action they planned to implement (see e.g., Haukås, 2016; Lilja et al., 2019).

Prior research has shown that collaboration between student teachers and generally in higher education is neither natural nor straightforward (Aalto, 2019; Damsa & Ludvigsen, 2016; DelliCarpini, 2009). Empirical research on collaborative learning encompasses a variety of topics, but few studies have focused on the collaborative trajectories of constructing knowledge and how this knowledge is elaborated and materialized in practice (Damsa & Ludvigsen, 2016). Collaboration itself does not guarantee effective learning. Interpretive talk and advanced elaborations of proposed ideas and conceptualizations are required (Damsa & Ludvigsen, 2016; Roschelle & Teasley, 1995). Teacher education programmes can and should provide contexts for the effective development of skills needed in professional collaboration. However, it is crucial that future teachers are exposed to models of collaboration (DelliCarpini, 2009).

In this study, three student teachers were invited to jointly negotiate a shared plan and put it into practice. The student teachers represented different disciplines (Finnish language and physics) and therefore there existed a built-in knowledge asymmetry. The student teachers had different strengths and, hence, scaffolded each other's personal development. We explore how their knowledge asymmetry is revealed in their collaboration and the dynamics brought to the shared negotiation of multimodal meaning-making resources as well as their mutual elaboration. In cross-disciplinary collaboration, full agreement between participants is not the target. Rather, the aim of the collaboration is to nurture dialogue that supports critical pedagogical reflection and reveals tacit understandings, helping transform the weaknesses and hindering aspects of pedagogical traditions (see e.g., Craig, Meijer, & Broeckmans, 2013; Lund, 2016). The crucial questions, therefore, for teacher education are: (a) What kinds of learning are afforded by

student teachers' collaboration? and (b) How should supervision be timed and structured?

## 2.2. Multimodal resources as tools for knowledge construction

In everyday social interaction, language users move dynamically between languages, language varieties, styles, registers, writing systems, and other kinds of signs, such as visualizations, artefacts, gestures, symbols and actions, to fulfil the strategic and communicative functions relevant in a particular situation, such as a situation where knowledge is constructed. In this sense, the meaning-making tools are not treated as discrete entities but are approached as a unity of tools complementing each other in a flexible and situationally effective way. The view of language in the ecological approach is integrated and holistic: language is perceived as part of the whole semiotic system, as the learning environment includes physical, social and symbolic grounds, all potential affordances for learning (Steffensen & Fill, 2014; van Lier, 2000, 2004). Thus, even if language is one of the main meaning-making tools, interaction should be studied 'in its totality' (van Lier, 2000, p. 250) to understand the space for knowledge construction the participants are creating (see also Blackledge & Creese, 2017; Pennycook, 2017; Bradley et al., 2018).

Employing multi-discursive and multimodal signs and practices for knowledge construction is also promoted in the dialogic approaches to the pedagogy of science (Aikenhead, 2005; Lemke, 1998; Mortimer & Scott, 2003; Pandian, Balraj, & Wei, 2013; Probyn, 2019). Science teachers orchestrate multiple semiotic tools in disciplinary knowledge construction: talking, writing and gesturing; experimenting and demonstrating; and drawing and using other kinds of visualized scientific representations such as graphs, diagrams and models. According to Kuteeva et al. (2014), disciplinary literacy skills cover knowledge construction, negotiation and dissemination using a wide range of meaning-making resources (see also Moore & Schleppegrell, 2020). Therefore, disciplinary language and literacies do not only refer to key scientific concepts but also reflect ways of constructing knowledge (e.g., forming arguments and explaining their reasoning) in a particular discipline (Moore & Schleppegrell, 2020).

Knowledge construction through the flexible use of multimodal resources is also acknowledged in the translanguaging approach (Garcia et al., 2016; Li, 2018). A broad definition of the concept of translanguaging as 'dynamic and creative linguistic practices that involve flexible use of named languages and language varieties as well as other semiotic resources' has been provided by Li (2018, p. 14). Li claims that people have an innate drive to utilize all available cognitive, semiotic, sensory and modal resources in learning and communication. He uses the expression 'translanguaging instinct' to refer to this natural tendency of solving complex communicative tasks in challenging environments through dynamic and flexible use of linguistic and other cognitive and semiotic resources (Li, 2018). However, in the school context, the learners' broad, natural approach to solving problems is easily narrowed to 'school-type activities' that have a limited and isolated focus (Lin, 2015; Zhang, 2010). For instance, in language education it has been customary to focus on one particular grammatical category at a time instead of using language with other semiotic resources for meaningful social activities or content knowledge construction (see e.g., Atkinson, 2011; Walqui & van Lier, 2010). Similarly, science education may be based on teacher-centred transmission of content knowledge without a pedagogical focus on joint knowledge construction through dialogue and widening learners' prior knowledge and understanding (Mortimer & Scott, 2003; Probyn, 2019). Learners may not be encouraged and facilitated in using all their existing multimodal resources for problem solving and constructing new knowledge. Instead, their action might be restricted to copying

notes from the teachers' slides. Moreover, teachers themselves may not be fully aware of the resources they are or could be using in disciplinary meaning making (see e.g., Lemke, 1998; Meyer, Coyle, Halbach, Schuck, & Ting, 2015; Osborne, 2019).

In this study we approach flexible (and conscious) use of multimodal meaning-making tools, or translanguaging, as a pedagogical practice for knowledge construction (Canagarajah, 2011; Creese & Blackledge, 2015; Iversen, 2020). In line with the ecological perspective (van Lier, 2000), our approach leads us to focus on the agency of individuals and their access to engaging in selecting, using, creating and interpreting signs for communication (Creese & Blackledge, 2015; Bezemer & Kress, 2016). Awareness of learners' rich resources and permission to use them flexibly enables the learners to understand the content, to engage in mutual constructing of new knowledge and critical thinking and, furthermore, empowers them to meet new challenging communicative situations (Jones, 2020). Positioning (see e.g., McVee et al., 2018) the students as capable and equal participants and supporting them in engaging in the learning process also promotes identity investment (Garcia & Li, 2014). Thus, translanguaging has the potential to transform power relations between teachers and learners (Creese & Blackledge, 2015; Jones, 2020).

In acknowledging the above, we consider research evidence that the interplay of multiple meaning-making tools facilitates deeper and fuller understanding of content (Makalela, 2015; Meyer et al., 2015). Using multimodal tools allows for the developing awareness of various meaning-making patterns and engages learners in using, creating and interpreting these resources. This makes the learning process multi-layered and provides deeper learning and more routes to both internalization and retrieval from memory (Meyer et al., 2015). Systematic and purposeful pedagogical planning employs all semiotic resources in a unified and orderly way to organize and mediate the process of learning. Integrating languaging, action and other semiotic tools coherently (Walqui & van Lier, 2010) for knowledge construction enables creating a continuum from *doing* things scientifically to *describing, explaining, generalizing* and finally *arguing* the phenomena (Meyer et al., 2015). Learning science – understanding the connections between different scientific facts – entails generalization and explanation (Probyn, 2019). Optimally, education provides a translanguaging space in which learners and teachers can engage in multiple meaning-making systems and generate knowledge and shared understanding of the phenomenon being studied in a meaningful way (see e.g., Garcia & Li, 2014). Translanguaging thus supports the learner in socializing into multimodal subject-specific discourses (Meyer & Coyle, 2017).

In a multilingual science classroom, several parallel shifts of meaning-making resources may take place: the learners move for instance from visualizations, experiments and everyday language understandings and expressions to disciplinary practices and understanding and academic discourse (Probyn, 2015; Wu & Lin, 2019). In particular, the interplay of everyday language and disciplinary language has a crucial role as they mediate the learning and internalization of content knowledge (Gibbons, 2006; Probyn, 2019; Wu & Lin, 2019; see e.g., Flores, 2020, and Mustonen, 2021, for a criticism of the distinction between student's own languages and language of schooling). Disciplinary language is needed to access multimodal subject-specific discourses and practices (Moje, 2008; Moore & Schleppegrell, 2020), whereas the use of everyday language secures deeper understanding of the phenomenon being learned as it requires learners to express their understanding in their own words; technical memorization, for instance of definitions, is not sufficient (Meyer et al., 2015). However, there is research evidence that everyday language is not always recognized as a target-oriented tool in learning; quite the contrary: spoken language, in particular, is used unconsciously without re-

alizing its potential in meaning making (Valdés, Bunch, Snow, & Lee, 2005; see also Mortimer & Scott, 2003; Nikula, Dalton-Puffer, Llinares, & Lorenzo, 2016; Vollmer, 2008).

### 3. Methods

#### 3.1. Research questions

1. What kind of space for knowledge construction do three student teachers working across subject areas create for learners in their discussions surrounding planning for instruction?
2. What characterizes the student teachers' collaborative negotiation process during these discussions?

#### 3.2. Research context, participants and data

In this qualitative study (e.g., Mayring, 2014; Schreier, 2014), we aim to understand the kind of space for knowledge construction jointly designed by three student teachers, Liisa, Anni and Matti (pseudonyms), across subject boundaries in the context of an independent field of practice. We also examine how they collaboratively negotiated the translanguaging space. Specifically, we report on a teaching practice in which the student teacher team planned and conducted a course that integrated physics and Finnish language in basic education. The three participants were fourth-year student teachers: a science (physics) student teacher (Matti) and two Finnish language and literature student teachers (Liisa and Anni). All three were Finnish speakers and former pupils of Finnish comprehensive school.

The participating student teachers were being trained to teach in the nine-year Finnish comprehensive school system, mainly grades 7 to 9 (age 13–16), and in upper secondary school (age 16–19). To qualify as subject teachers, all students across the curriculum are required to complete a master's degree that includes at least 60 ECTS of teacher's pedagogical studies provided by a department of teacher education. Before the teaching practice reported here, the student teachers had completed a short course (six contact hours and ten hours of independent work) on subject-specific pedagogical practices in the linguistically and culturally diverse classroom. The course aimed to raise the student teachers' awareness of diversity in school (see e.g., Kimanen, 2018 and Smith, 2019 for discussions on increasing teacher awareness of diversity) and how to develop a pedagogical approach that serves the needs of all learners (EDUFI, 2016). The course content focused on how to build on learners' prior skills and scaffold language and content learning in parallel. It was emphasized that disciplinary language and content knowledge are inseparable, and that constructing content knowledge requires mastering disciplinary language (Moje, 2008; Moore & Schleppegrell, 2020). Everyday language and disciplinary language were treated as complementary resources, among other multimodal resources.

The three student teachers in this study chose to participate in the optional teaching practice to gain more experience of teaching and learning in a multilingual and multicultural group. They aimed to practice their pedagogical skills as they did not have prior experience of collaborative teaching, multilingual groups or language-aware teaching. The teaching practice took place in a mainstream classroom in a Finnish comprehensive school (7th grade, age 13–14, group of 20 pupils) with two learners with Russian and Estonian backgrounds. However, in this paper we do not focus on specific learners. Instead, the crucial question is how student teachers planned to teach disciplinary literacy skills that were new to all learners in the class. Thus, as discussed earlier, all learners were treated as 'language learners' (hereafter referred to in this study as learners).

The physics in-service teacher (a native speaker of Finnish) of the classroom at the school within which student teachers worked presented the topic of *optical lenses*, but otherwise, student teachers were free to plan their teaching independently. The language focus was not pre-specified; instead, the student teachers were free to define how to connect the topic with the Finnish language curriculum and with the language and literacy skills relevant to learning physics. Student teachers were encouraged to create a practice of their own in a situation where no prior concrete models were at their disposal. In the current research setting, student teachers' participatory roles were symmetrical with respect to power status and the division of labour was minimal (see Dillenbourg, 1999).

As a teacher educator, the first author of this article organized and supervised the teaching practice. She refrained from interfering in the student teachers' process unless they asked for her help, as the aim was to better understand their own pedagogical approach (a more detailed description of the research context is reported in Aalto, 2019). The second author of this article did not participate in the practice. However, she worked with the first author in their roles as teacher educators, collaborating to develop teaching materials for language-awareness pedagogy for pre- and in-service teachers. Both authors are speakers of Finnish.

Data analysed in this study consisted of five audio-recorded joint planning sessions (PL) and two group interviews of the three student teachers (INTW) along with the student teachers' individual diaries (D). Background data also included three video-recorded lessons (L) and field notes made by the first author, but these were not exploited as primary sources in this study, nor were video-recorded lessons analysed. Yet, in the analysis we also acknowledge the lesson implementations when the student teachers refer to them in their planning talk and reason their pedagogical choices as regards translanguaging. The data collection process is illustrated in Fig. 1 (see also Aalto, 2019). The joint planning sessions lasted 60–125 minutes (total 445 min) and the group interviews 80–90 minutes (total 170 min). The first author conducted the interviews and was present during the teaching of the lessons.

The analytical process was not linear but iterative, constantly moving back and forth between the parts and the whole, the data and the theory, following the hermeneutic approach (e.g., Mayring, 2014) and qualitative content analysis (e.g., Mayring, 2014; Schreier, 2014). In line with the qualitative content analysis method, we focused on recurrent themes negotiated among the student teachers, as well as abstracted paths through which the student teachers collaboratively planned the integrated study unit. With regard to Research Question 1, categories of meaning-making resources were identified, and the interplay among them was examined throughout the student teachers' planning sessions. Meaning-making resources were then explored in more detail and their functions classified in relation to the knowledge construction continuum (*doing, describing, explaining, generalizing and arguing*). Moreover, we considered whether the learners were positioned as active participants or as receivers in the knowledge construction process.

Regarding Research Question 2, the analytical procedure included the following steps. First, the interplay of everyday language and disciplinary language as tools for knowledge construction was selected for more detailed analysis as this was recognized as a problematic aspect of the planning process (on the complexities of the distinction between everyday and academic language, see Flores, 2020). The student teachers kept returning to the idea, but it did not seem to develop further, and their negotiation of this process tended to remain at the level of the student teachers' general collaborative efforts. In this process of analysis, episodes of talk about everyday language and disciplinary language were first identified. Those episodes were then examined in relation to each other; in particular, the functions that everyday language and dis-

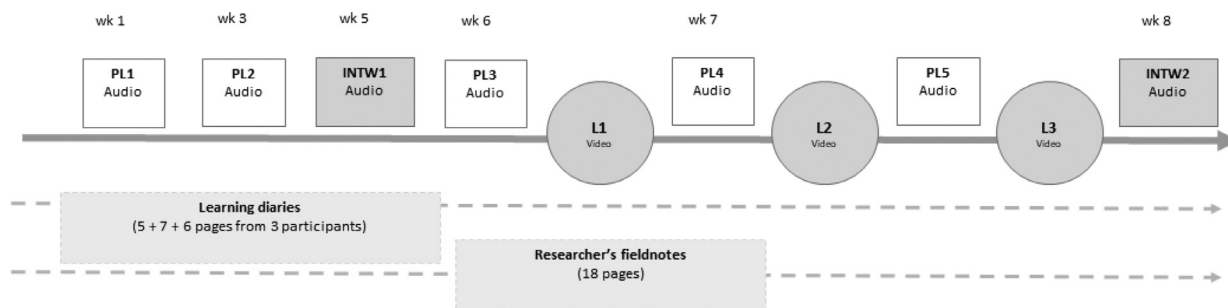


Fig. 1. Timeline of data collection process and data undergirding the study.

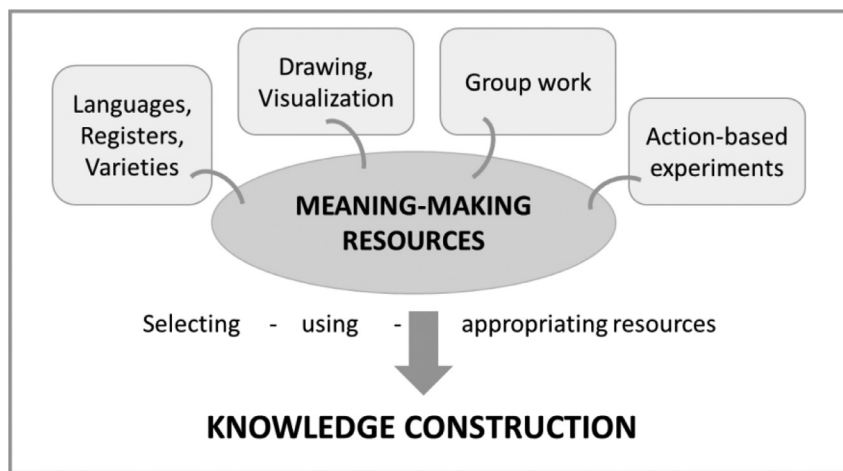


Fig. 2. Meaning-making resources employed by the student teachers for knowledge construction

ciplinary language seem to serve, whether they were treated as complementary resources, and thus, as a means of translanguaging in constructing knowledge. Student teachers' viewpoints expressed in the selected episodes were also examined across time by identifying the characteristics of topical development and each student teacher's individual contribution to practice development.

4. Findings

4.1. Creating space for knowledge construction

In this study, we set out to explore student teachers' collaboration in planning a study unit integrating physics and Finnish language learning. This section reflects findings related to Research Question 1: "What kind of space for knowledge construction do three student teachers working across subject areas create for learners in their discussions surrounding planning for instruction?" In subsection 4.1.1, we first examine the kind of multimodal meaning-making tools acknowledged by student teachers and which became affordances in their planning talk. We then investigate how the meaning-making tools were interconnected: the kind of translanguaging space built by the student teachers. In subsection 4.1.2, we explore the functions for which the tools were used in the knowledge construction continuum (see Meyer et al., 2015).

4.1.1. Meaning-making tools

In response to the first research question, four kinds of mediational means were identified and extracted from the student teachers' planning talk (see Fig. 2). First, we identified *languages*, by which we refer to the different modes of language use: speaking, reading and writing, and different kinds of registers and varieties of language, such as everyday and disciplinary language

(on the multimodality of the disciplinary discourse, see Kuteeva et al., 2014). Second, we acknowledged three additional mediational means – *drawings and visualizations*, *learning in interaction (group work)* and *action-based experiments* – as essential meaning-making tools in the science class, which were involved in the planning process to demonstrate the idea of optical lenses. In addition to these four mediational means, artefacts such as various instruments, textbooks and other learning materials were also planned to be used to construct knowledge; however, in our analysis we focus on the four main tools illustrated in Fig. 2 as the student teachers themselves acknowledged these throughout their planning sessions. From the ecological perspective, these mediational means were perceived as affordances for learning.

We especially elaborate on the role of language in relation to other meaning-making tools as, in line with the Vygotskian (1978) and ecological (van Lier, 2000) approaches, we perceive language as one of the main tools to mediate and reflect on ideas, and the integration of language and content knowledge was from the outset the key goal of the student teachers' project.

Our analysis revealed that although student teachers clearly aimed to see connections between various multimodal resources in their planning talk, the meaning-making tools still seemed to remain disconnected. The meaning-making tools were not designed to complement each other in the knowledge construction continuum (see Meyer et al., 2015); instead, they were mostly treated as alternative tools for meaning making, as shown in the following examples (1-2):

- (1) Liisa: Pictures are better for understanding, because you don't need to know the terms if you can just grasp the idea from the picture (PL1)

(2)

Matti: I think the most important thing in this chapter isn't the written thing at all, I mean the words, I think it's drawing them that's important. (PL2)

The student teachers repeatedly pointed out that, with respect to understanding the core idea, verbalizing it (using terms or writing) was not necessary. Usually, **visualizations** were considered more important. Pictures and drawings were regarded as replacing written or spoken **language**: pictures were seen to mediate the 'idea', so that the learner does not need to read the abstract, linear text or verbalize complex causalities. Student teachers had difficulties also in seeing how **spoken language** is used in knowledge construction while interpreting visualizations and giving instructions for, practising, and modifying drawings. Thus, linguistic resources – especially spoken language – were not explicitly acknowledged as affordances to build understanding, but rather as separate from observations. This is also illustrated by the following excerpt in which Anni compared and evaluated **linguistic** and **visual** resources, as they did repeatedly throughout the planning sessions:

(3)

Anni: Well it's... you sort of always return to the question of what's important after all and what it is that should be learned. Is it important to learn to define something verbally, or is it important to understand the picture, or is it important that you understand the phenomenon? (PL2)

Anni negotiated the main aim of learning: is it to 'define something verbally', to 'understand the picture', or to 'understand a phenomenon'? In doing so, she considered the relationship of different meaning-making tools, but as this excerpt illustrates, the connection between language and other meaning-making tools (such as visualizations) seemed to remain weak. Linguaging also appeared to be separated from perceptions and understanding – it was not acknowledged how crucial a role verbalizing plays in deepening understanding of phenomena.

For the student teachers, visualizations were at times also seen as affordances to complement linear text: they acknowledged that pictures enable learners to predict the content of text, activate their prior knowledge, and summarize core facts. In that sense, language and visualizations were seen to complement each other (and form a translanguaging space). The student teachers also reflected on how visualizations and gesturing intertwine with languaging, as shown in the following excerpt. Gesturing and drawing *rounded* vs. *concave* shapes together with verbalizing them was recognized to support understanding of the concepts:

(4)

Matti: [The teacher] indicated with his hand, 'should I draw it more like this, or that?', and it somehow made it easier that he acted out the [light] beam... I thought it was funny... that after you've eaten a lot you have a belly, and it's rounded, and I mean no matter how bad your language skills are, you understand that after you've eaten a lot your stomach is full and what it looks like. (PL2)

As excerpt 4 illustrates, Matti reflected on how visualizations support learners with developing language skills (on the interaction of visual and linguistic modes in the language learning process, see Dressman, 2020). This kind of reflections recurred in the student teachers' discussions. In that sense, student teachers created a translanguaging space for knowledge construction in which the tools complemented each other. However, the visualizations and language were not consistently connected in a target-oriented

way in the student teachers' planning talk. Interestingly, though, group work interaction and learning materials in Finnish were not emphasized as affordances for developing disciplinary language skills, even though for some learners Finnish was a second language and, for all of them, the disciplinary language was new. The student teachers mentioned language learning explicitly only once when referring to a text written in English, but this remark was not elaborated further.

Spoken language was also not explicitly mentioned in relation to the **experiments**. For instance, in the following excerpt, the science student teacher (Matti) considered the benefits of the experiments and implied that they are practical for learners with developing language skills as language is not needed. However, he eventually realized, in the process of discussing, that experiment *instructions* did actually need to be verbalized accurately and paid attention to:

(5)

Matti: You could sort of imagine for something like... when you think of language skills these kinds of experiments are good for that because here you don't really... okay the instructions have to be precise, I've noticed that also in the teacher training school you can't just say turn to page 46 in your textbook and do exercise two (PL1)

Language is used on a general level as a mediational means in experimental instructions, and this becomes visible here as Matti has previous experience of what happens if the instructions are unclear. However, Matti did not seem to consider how knowledge construction could be supported by combining verbalization with experiments. In parallel with the experiments, learning would be deeper if students are invited to verbalize the process, including descriptions of what they are doing, making questions, and drawing conclusions. It is through verbalized meta-talk that learners understand the point behind the action and learn to link and generalize science facts (see e.g., Probyn, 2019). Teaching science should enlarge learners' everyday perceptions and knowledge and promote their understanding of more abstract and complex perspectives on societal issues with a scientific component. This requires negotiation between teachers and their students (Mortimer & Scott, 2003).

Language as a meaning-making tool was, however, occasionally acknowledged with respect to **written language**. In the following, Liisa and Matti negotiate how to translanguaging between experiments, visualizations, and taking notes:

(6)

Liisa: Something like this could be done, that they could experiment themselves... in this picture 'a glass and water act as a convex lens'... so when you put water in a glass and there is black and white paper behind it, they seem to change places - - And there comes the core point, which one diverges and which one converges [light].

Matti: So they do this page of the textbook after the break and then [comes] the theory part, I mean the theory referring to drawing

Liisa: Making notes in the notebook and drawing exercises

Matti: Yes, and then they could go back to the experimental set-up and do the tasks next in line - - So like, experiment, theory, experiment (PL9)

In the above excerpt, Matti specifies that 'the theory part' means drawing, and Liisa elaborates: 'notes in the notebook and drawing exercises'. However, spoken language, such as negotiations, were not planned to be used as part of the experiments to deepen understanding. Furthermore, it remains unclear whether the notes were planned to be copied or compiled collaboratively.

It therefore appears, given the above, that meaning-making resources were mostly treated as modular tools. Only occasionally were language and visualizations or experiments acknowledged as complementary to each other, thus as tools for translanguaging (Li, 2018). Furthermore, in line with previous research (Valdés et al., 2005; see also Mortimer & Scott, 2003; Nikula et al., 2016; Vollmer, 2008), the role of spoken language remained invisible even though it served as the main operating tool for all actions. In other words, instructions were given and concepts explained through spoken language, and the interpretation and application of theory inevitably required language use (Nikula et al., 2016). Drawings, diagrams, and other visualizations do not speak for themselves; deeper understanding of the phenomena requires verbalizing the causes and effects (Mortimer & Scott, 2003; Meyer et al., 2015), i.e., translanguaging. In the student teachers' planning talk, however, spoken language seemed to remain unconscious without realizing its potential in meaning making (Valdés et al., 2005), and the student teachers did not explicitly plan to invite learners to negotiate the phenomena or elucidate their ideas for further development (Probyn, 2019). In this sense, it seemed that not all meaning-making tools were treated as affordances for deeper learning.

#### 4.1.2. Functions of meaning-making tools in student teachers' planning talk

In this section we respond to RQ 1 by presenting functions of knowledge construction for which mediational means were used, as well as ways in which learners were dynamically positioned as agents in constructing knowledge in the student teachers' planning talk (see e.g., McVee et al., 2018 for the theoretical analytical framework for the concept of positioning and Smith, 2019 for transraciolinguistic perspective to positioning). Regarding the functions, we examine what kind of continuum the student teachers created from *doing* things scientifically to *describing*, *explaining*, *generalizing* and finally *arguing* the phenomena when they collaboratively planned the activities to be conducted in the classroom (Mortimer & Scott, 2003; Meyer et al., 2015).

Our analysis of the knowledge construction continuum showed that in planning the teaching, the student teachers focused mainly on the levels of *doing* and *description*. Linear and visual texts were mainly used to transmit the basic idea (*description*) of the phenomenon. Generalizations were discussed occasionally when applying the theory, for example in drawings, but *explaining* and especially *arguing* were often disregarded.

Firstly, action-based experiments, which are characteristic of physics, often seemed to remain at the *doing* level: 'hands on, but not minds on', as described by Osborne (2019, p. 1283). Experiments seemed to be used mainly as technical teaching methods and for illustrations – hence the focus was on teaching, not so much on learning (Brown, 2003). Occasionally, experiments and group work were not seen as tools to construct knowledge, but rather as additional activities to keep learners occupied and help them concentrate, as shown by Liisa:

(7)

Liisa: So there should be some sort of practical activity, so that they have the energy to concentrate. (PL2)

Notwithstanding, there were certain instances during the planning process where student teachers acknowledged the value of *explaining* what happens during the experiment. For instance, in PL2, Anni proposed a new task type in which action and languaging would be combined: first the learners would do an experiment and then explain what they had just done. In PL4, she then continued to develop the idea of learners explaining their actions, so 'that they'd also get a sense of the point in doing them':

(8)

Anni: There could be some sort of 'explain the phenomenon' [task] or something like that, I'm still a bit unclear on the idea, but it would be a lot of fun if some tasks would be done in a way that they'd also get a sense of the point in doing them.

Liisa: Ah, you mean like it wouldn't be said up front that light rays are being refracted?

Anni: Yeah, maybe something like that, it could be done in many ways, that they should reach a certain goal, or they should test something and then explain what had happened when such and such was done. (PL4)

The above discussion may be seen as an attempt to activate the learners' own critical thinking and deductive reasoning skills. Anni and Liisa seemed to have grasped some aspects of the learner-centred approach to teaching (see Brown, 2003) or the different patterns of classroom interaction: knowledge was not planned to be transmitted by the teacher, instead students were invited to explain the phenomena themselves (see Probyn, 2019 on levels of interaction from teacher-centred monologue to teacher-led dialogue and joint knowledge construction). They tried to balance the power relationships in the classroom (Creese & Blackledge, 2015) and also considered exercises where learners draw and *explain* phenomena to their classmates: '*how they explain them, would be interesting to hear*' (PL3). Anni and Liisa acknowledged how this kind of translanguaging, using both language and visualizations, would promote and deepen learning, and they strived for creating a continuum from *describing* to *explaining*. However, in the planning talk, learners were mainly positioned as receivers of knowledge, not so much as active contributors or agents (e.g., Säljö, 2010; Probyn, 2019).

*Arguing* phenomena was considered when the student teachers were planning to organize a debate on the benefits of glasses vs. eye surgery, but eventually, they abandoned this idea. In their planning talk, student teachers did not seem to trust the learners' potential ability to search for relevant information, listen to each other, negotiate, or work in teams. Thus, they recognized the skills that were needed for argumentation, but could not see that practising debating would actually develop these skills. Instead, argumentation was seen as pointless with respect to the learning process (excerpt 9) because it was perceived to be too difficult a task for 7<sup>th</sup> graders (excerpt 10):

(9)

Liisa: Somehow debating was a good idea at the beginning, but I don't sort of know if it supports their...

Matti: learning process as much. (PL3)

(10)

Liisa: 7<sup>th</sup> graders' basic teamwork and negotiation and listening skills are very limited. Somehow they should also be practised, like 'listening to others'. So I think that as a task debating may be too challenging. (PL3)

Liisa seemed to echo the ideal of sharing, interacting and critical thinking rather than learning by rote. The student teachers were also aware of the challenges of engaging learners in constructing knowledge in collaboration and strove to achieve this, but what seemed to be lacking were the actual means to support engagement, teach interaction skills and build a collaborative space. Occasionally, it was also emphasized that everyone should work independently to avoid 'free-riding' (PL3), which may be perceived as an echo of the traditional teacher-centred concern to have control over the learning process. Hence, interaction seemed to remain as a working method rather than a process of collaboration through which to guide the students (Aalto & Tarnanen, 2017).

In sum, multimodal meaning-making tools were agreed-upon as useful to promote understanding of the basic idea of opti-



cal lenses: learners were planned to be guided through the written and visualized texts, which described and explained the phenomenon. In their discussion surrounding the planning of instruction, the student teachers occasionally made attempts to avoid using the tools just for *doing* things and acknowledged the value of translanguaging through verbalizing phenomena, i.e., describing and explaining pictures and experiments. However, the student teachers repeatedly negotiated how to support learners' understanding of basic science facts – how to transmit them – but hardly ever how to promote their active participation in the learning process: learners were not planned to be encouraged to produce and share their incomplete ideas, which characterizes the collaborative knowledge construction process (Damsa & Jornet, 2016, 43; see also Probyn, 2019). Hence, the focus in the planning discussions appeared to be mainly on teaching and much less on learning (Lonka, 2018).

#### 4.2. Collaborative negotiation of knowledge construction

In this section, we respond to Research Question 2 by illustrating student teachers' collaborative planning of how to use multiple meaning-making resources as tools for knowledge construction. We focus, in particular, on the interplay of everyday language and disciplinary language as an essential form of knowledge construction in physics (and all abstract content) learning. This is used as an example of how student teachers collaboratively negotiate and develop an innovative pedagogical idea, particularly the idea of comparing everyday language and disciplinary language in constructing physics content knowledge. We explore how knowledge asymmetry and subject boundaries between student teachers influence the development of shared practice and the kinds of resources they exploit in their collaboration.

The idea of interplay between everyday language and disciplinary language (Lemke, 1990; Probyn, 2019; Gibbons, 2006) was continuously present in the student teachers' discussions from their first planning session (PL1). Two functions of the interplay between these two registers were identified in the student teachers' planning talk: firstly, to demonstrate understanding of the phenomenon being learned and, secondly, to recognize the characteristics of the disciplinary language of physics. In the following, we analyse the student teachers' negotiation of these functions in more detail.

Everyday language was treated in the student teachers' discussions as **a means to demonstrate knowledge and real understanding** of the issue being studied. They clearly had a mutual agreement that explaining an issue in one's own words, i.e., in everyday language, requires the learner to have some depth of understanding of the issue, as opposed to merely mechanically repeating, for instance, technically memorized definitions (Gibbons, 2006; Probyn, 2019). Everyday language was also considered valuable in making visible learners' understanding of the phenomenon under study. Furthermore, the student teachers criticized the pedagogical tradition of requiring, for instance, written definitions in exams without explicit teaching of the genre of definition (PL2) and without paying attention to learners' real understanding of what they are writing in disciplinary language.

Despite this mutual understanding, Matti's approach to the appropriateness of using everyday language tended to vary. In planning sessions 1 and 2, he articulated that although it is 'ok' to explain a concept in your own words, in an exam there is only one correct answer and learners need to indicate mastery of terminology and use disciplinary language.

(11)

Matti: On one hand it is quite ok that the pupil explains a term in his own words, but then in an exam, there is

only one correct answer. You can explain in your own words what it means, but you still need to know the term because the term has a certain definition and we all discuss it using the same term, and if you know the definition there won't be any kind of confusion. (PL1)

(12)

Matti: These answers are sort of, not really in accordance with physics conventions. You could say that it is wrong. You haven't understood it. (PL2)

According to Matti, an answer that does not follow the disciplinary practices of science is wrong and may even prove that the learner has not understood the phenomenon. He claimed that everyday wording might be useless because disciplinary terms are more expressive:

(13)

Matti: So if you say 'take a lens that is thicker in the middle than at the sides', again, it's useless because there's already an existing word for that thing. (PL2)

Liisa and Anni did not discuss or question Matti's stance, but rather treated him as an expert on what is required in physics exams. Matti's stance regarding the suitability of everyday language nevertheless seemed to vary. Contrary to his previous points of view, in PL3, he criticized a learner's assignment answer for being a literal replication of the textbook. He admitted that the answer was correct, but stated that a copied or rote memorized answer was not ideal.

(14)

Matti: He copied it directly from here to his notebook, whoosh, that 'this is called lateral shift'. So it wasn't explained in his own words, it was more like 'well I read it from the book and I wrote it here'. It isn't wrong, but it's not exactly ideal either.

Anni: Yes, it would be really good if they were first, like, well okay, you find the right section in the textbook, but then there should be another question that tests if you've understood the concept, so, like, that's the precise definition, which you need to grasp, but then there should be a task that says 'now explain it to your classmate so that they can understand it too' (PL3)

In this episode, Anni concluded that both mastery of the disciplinary definition as well as everyday language explanation were needed to prove understanding. The two student teachers thus reached an understanding that disciplinary language alone was not sufficient, but that together the two registers form a unity in knowledge construction as resources of translanguaging. However, writing was mainly used as a technical 'copy and paste' method: the teacher offered ready-made notes for the students to copy (Kibler, Walqui, & Bunch, 2015; Aalto, 2019). When writing was employed as a tool to mediate knowledge in exams, the learners were asked to use disciplinary language. Hence, writing was not used to develop incomplete ideas or to deepen understanding of the phenomenon by using the learners' 'own words', which is characteristic of collaborative knowledge construction (Damsa & Jornet, 2016).

In terms of collaboration, Matti had the expert role in the discussions concerning appropriate language use in physics exams and assignments, and Liisa and Anni did not contribute to these considerations. However, Anni acknowledged Matti's thinking and in PL3 she elaborated and drew conclusions from his perspectives. Thus, knowledge asymmetry (Dillenbourg, 1999) between the student teachers was evident in Matti's expert position, but Anni contributed by elaborating and drawing conclusions.

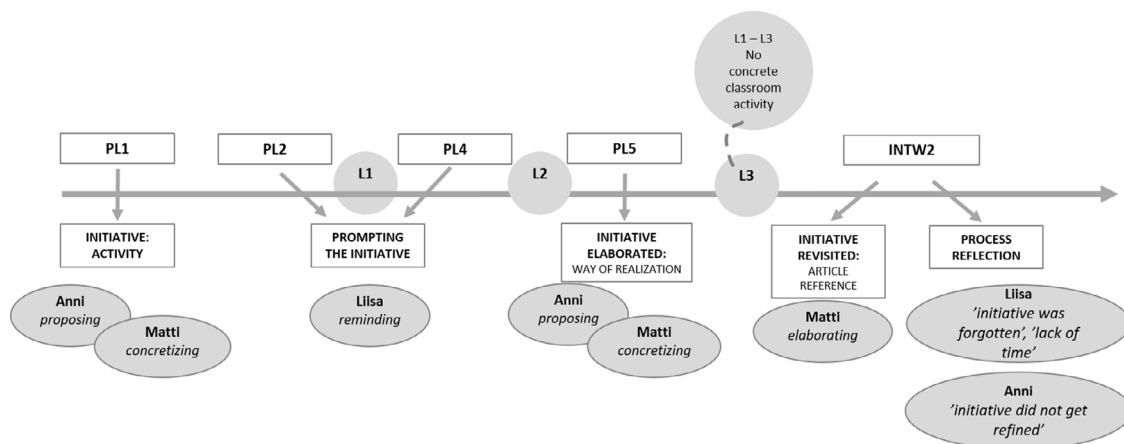


Fig. 3. Trajectory of developing the initiative of comparing everyday language and disciplinary language.

The student teachers' second approach to the interplay between everyday language and disciplinary language focused on the **characteristics of disciplinary language** through comparison of everyday language and disciplinary language. In this discussion line, they treated these two genres as parts of a unity that complement each other. Their approach here can be interpreted as a translanguaging practice (Li, 2018). The idea of a task in which learners would compare an exam answer with an explanation of the same issue to a classmate was introduced already in PL1. The trajectory of dealing with this initiative is illustrated in Fig. 3 and analysed in the following.

In PL1, Anni made an initiative and suggested an activity in which learners write an exam answer and then explain it to a classmate. The following excerpt demonstrates the way she and Matti collaboratively elaborated the initiative.

(15)

Anni: But that could be a brilliant set-up, explaining to a classmate and answering an exam question.

Matti: How do they differ from one another.

Anni: Yeah so some certain concepts or something related to the topic, so like it could be a task of its own

Matti: Maybe it's sort of a different type of text, because you don't explain something to your classmate the same way you answer an exam question.

Anni: Right

Liisa: Well now we're getting to the point ((laughing))

Matti: How you can talk about the same thing in different ways, also just like here the same phenomenon is first explained in everyday language using lots of metaphors like in normal speech and then the same thing again in a cold clinical way using physics terms, so here we can see how the same thing can be expressed in two quite different ways. (PL1)

Interestingly, Anni proposed the idea and during the episode Matti concretized the idea step by step by asking Anni clarifying questions. Matti formulated the activity as a comparison of two genres and re-verbalized the idea in different words to make it clearer and to make sure that they understand it in the same way. He even abstracted the idea by defining the initiative using the concept of *genre*. Apparently, this exchange of views was meaningful to Anni as she reported it in her learner log.

The student teachers returned to the initiative of comparing the two genres only in PL5, although Liisa tried to prompt the initiative in planning sessions 2 and 4 without finding an echo in her peers:

(16)

Liisa: At the beginning when we started planning I don't quite remember which one of you mentioned 'tell a classmate' in relation to the second lesson. What was that about?

Matti: Do you remember Anni?

Anni: I'm not too sure. (PL4)

Finally, in PL5, Anni again promoted the idea of comparing two genres: academic definition and explaining to a classmate. Matti, again, was interested in learning from her thinking and led the discussion by concretizing questions and interpretations. Anni thought that discussion about language should be carried out as a teacher-led activity and that this requires careful listening to the learners' own interpretations and building the discussion around them. Finally, Matti summarized that the goal is to use both disciplinary language and everyday language in parallel and to also facilitate understanding of their difference.

(17)

Anni: Of course this might raise the question, as we have already talked about, of 'how to explain it to a classmate' and 'how to define it more scientifically', so there might be a difference, that you understand the idea, and that you know how to use the correct terms.

Matti: So how would that go in practice?

Anni: In practice probably perhaps like a normal chat, whatever comes up

Matti: So the pupils would talk amongst themselves or?

Anni: Probably teacher-led, not making a big deal out of it but just bringing attention to the language. In addition to the content, otherwise it could be that they just cite the textbook and nothing else like this would take place

Matti: Yeah because they don't try to say it in their own words.

Anni: Right.

Matti: So you thought, for instance with the first question 'What is a lens?' if a pupil answers 'Well, it is a glass thing' Anni: Yes

Matti: Then 'yes, sure, it's a thing made of glass but, like, use the terms that you've learned', the way people, pupils, would generally answer is normally just fine, but in physics class we can define things a bit more accurately. (Anni expresses agreement) (PL5)

The initiative of comparing the two genres was elaborated through collaborative negotiation between Anni and Matti. Matti's contribution was crucial in concretizing how the initiative could be operationalized in the classroom. He seemed to draw on Anni's

expertise and interpret it and put it into practice in light of his own understanding. Nevertheless, despite the recurrent consideration of the interplay of everyday language and disciplinary language, the student teachers did not succeed in elaborating their idea as a concrete activity to be taken to the classroom, as also shown by previous research (Nikula et al., 2016).

In the final interview (INTW2), Matti brought to the discussion an experience from his studies in the pedagogy of physics. He claimed that language is often taken for granted, although learners need support in interpreting academic texts. According to him, learners need to be taught how to talk about science, argumentation, verbalization of observations, and explicit literacy skills. He even recognized that language provides a structure to knowledge.

(18)

Matti: One more thing I was thinking, I don't know if it is done a lot in Finnish language class, but I've read an article 'using language to teach science' about communication skills, that when pupils talk among each other, they should somehow be taught what a fruitful discussion looks like, how to debate and how to verbalize observations. And you need to teach such literacy and language skills, because the pupils can't learn them themselves on the side. Like you pointed out during our planning session, if someone answers to 'What is a lens?' 'A glass thing', so, like, academic language and everyday language aren't the same... a rational structure to knowledge, such as analysis, such things could be [dealt with] (INTW2)

Matti connected the article he had read in his studies to the initiative Anni had promoted earlier. Interestingly, he brought this idea to the discussion only in the final interview and did not refer to it earlier when they were discussing language-related issues in general and Anni's initiative in planning sessions 1 and 5. Clearly, the student teachers could not internalize and make full use of all the resources provided in their pedagogical studies; rather, different ideas tend to become connected gradually over time (Spratt & Florian, 2015).

When the researcher in the final interview asked the student teachers why their idea of comparing the two genres was never developed into a concrete activity, they answered as follows:

(19)

Liisa: We had such an idea during our planning stage but I don't know why it dropped out or whether we forgot it or ran out of time, but somehow that kind of comparison of how to explain to a classmate, it would have been nice for them to see it written as well, sort of how weird their 'a thing made of glass' looks when written and then next to it the exam answer

Anni: I suppose that was the idea and I would have liked to do it there, it just didn't get refined any further (INTW2)

The student teachers had difficulty reflecting the planning process and explaining why their initiative was not elaborated as a concrete activity to be implemented in the classroom; it was either forgotten or there was a lack of time, or it just did not get developed further.

Anni and Matti conducted most of the negotiation on the interplay of everyday language and disciplinary language. Although Liisa did not seem to have an active role in those discussions, she systematically kept the idea in progress, but did not develop it further in terms of content. She prompted the idea in PL2 and PL4 attempting to remind them about the original idea, but neither of her peers took it up. Furthermore, in interview 1, she was the only one who included comparison of everyday language and disciplinary language in the linguistic aims of the study unit.

While Liisa's contribution might at first glance seem less significant in developing the initiative, she nevertheless recycled her peers' ideas and was systematic and target-oriented in keeping the initiative in progress. Moreover, at the end of planning session 5, Liisa formulated the aim of the lesson as 'explaining issues and phenomena in one's own words' in the lesson plan form. Matti commented on that formulation: 'yeah, good, the nonsense generator is switched on'. It seems that the student teachers trod a fine line between the roles of teacher and student. They tended to orient towards professionally planning their own teaching, whereas the required formalities such as written lesson plans roused their student orientation. In line with previous research on in-service teachers (Kuusisaari, 2013), the student teachers had resources situated in teacher education, but they were not quite capable of fully exploiting them to develop their pedagogical skills.

In summary, this collaborative process shows the complex nature of student teacher collaboration. Student teachers' negotiation of the interplay of everyday language and disciplinary language reveals how they echoed the ideals drawn from their education and recycled various ideas. Their collaborative effort to develop something new was apparent, but it was a complex process requiring many joint phases and collaborative elaboration of ideas towards more concrete pedagogical practices. From the ecological perspective, they seemed to have difficulty connecting various approaches provided in the studies and harnessing them as affordances for their development (van Lier, 2000). It is noteworthy that during their project they never consulted the slides or the website provided in the course on language-aware teaching some months earlier. As is characteristic of learning, the student teachers may not draw on all the resources available to them. Only those resources that the student finds relevant and that they can connect to their previous understanding become affordances (van Lier, 2000; Ruohotie-Lyhty & Moate, 2016). This observation is relevant to developing supervision mechanisms in teacher education.

Another noteworthy finding concerns the knowledge asymmetry (Dillenbourg, 1999) of the student teachers. The expert roles changed: Matti had an expert role when focusing on the content knowledge of physics, whereas Anni had a leading role regarding the characteristics of physics language. While one of the team members acted as an expert and main innovator, the other had an active role in elaborating the initiatives and ideas put forward. This knowledge asymmetry and the fluctuation in expert roles tended to enrich the collaboration (Walqui & van Lier, 2010; van Lier 2004, p. 158).

## 5. Discussion and conclusion

This study set out to understand, first, what kind of space for knowledge construction student teachers created for learners in their planning discussion, and second, what characterized the student teachers' collaborative negotiation process. The focus of the study was on the disciplinary language of physics, allowing the study to contribute to the wider discussion of student teachers' ability to learn and work in collaboration crossing subject boundaries and thus, to support all learners' equal opportunities to engage in mutual knowledge construction in various knowledge areas.

Based on our analysis, the student teachers made efforts to create a translanguaging space for knowledge construction for the learners (Walqui & van Lier, 2010; Li, 2018), as also emphasized in the dialogic approaches to the pedagogy of science (Aikenhead, 2005; Lemke, 1998; Mortimer & Scott, 2003; Pandian et al., 2013; Probyn, 2019). However, integrating multiple multimodal tools was challenging and the space for knowledge construction was reduced rather than enriched (Walqui & van Lier, 2010). Markedly, language as a meaning-making tool

remained mostly invisible apart from negotiation of the roles of everyday and disciplinary language (Mortimer & Scott, 2003; Nikula et al., 2016; Valdés et al., 2005). This is noteworthy, as one of the aims of the project was to develop language-aware pedagogical practices.

Additionally, promoting learner agency (van Lier, 2000) was not particularly focused on in the planning talk. Knowledge construction was mainly perceived as understanding and describing the basic ideas or facts; deeper learning, which also requires engaging in explaining and arguing (see Meyer et al., 2015), was not systematically taken into consideration, even though it was occasionally discussed. Instead of practicing them, the student teachers avoided these challenging linguistic practices. This result is in line with Aikenhead (2005) and Pandian et al. (2013), who emphasize that transmitting abstract knowledge in science class does not develop applicable, critical understanding of the scientific phenomena – skills that are crucially needed in the 21st century world – and thus there is a need to develop collaborative approaches to learning (see also Moore & Schleppegrell, 2020).

The findings of this study are also in line with Canagarajah (2011) and Duarte (2020), who promote the need to develop teachable strategies of translanguaging. The student teachers and learners need to be encouraged to change their orientation to content knowledge and learning: new knowledge is not transmitted to learners by the teacher; learners need to be invited and engaged in knowledge construction and shuttle between languages and other meaning-making resources in their learning. Interacting is not just using ‘a language code’, but rather applying multiple, multimodal resources that intertwine (Li, 2018). Pedagogically, creating a translanguaging space for knowledge construction means enabling people to communicate flexibly with any resources available to them: it means supporting participation and engagement and promoting sharing and recycling of resources.

In line with previous research, this study indicates the complex nature of student teacher collaboration (Damsa & Ludvigsen, 2016; DelliCarpini, 2009). Although the expert roles changed, the student teachers were engaged in mutual development of a shared practice and flexibly adapted their roles according to situational requirements. The knowledge asymmetry between the participants was interpreted as a resource for their collaboration (Dillenbourg, 1999). Furthermore, the student teachers' collaboration revealed challenges in connecting theory and practice (see e.g., Lilja et al., 2020) and in bringing together different and indefinite ideas and knowledge sources in order to appropriate them as affordances and refine them into a concrete pedagogical practice (see also Damsa & Jornet, 2016). Clearly, the student teachers would have benefitted from more structured supervision and meta-level conceptual discussion connecting theory and practice in order to strengthen their collaboration and harness all their knowledge sources for developing their shared practice (Kuusisaari, 2013).

There are some challenges to be considered regarding this study. The study represents a practitioner research approach (Heikkinen, de Jong, & Vanderlinde, 2017) as the first author had a two-fold role as a teacher educator and as a researcher. This double position was sometimes problematic as she avoided guiding the student teachers' efforts but, naturally, in her teacher position, if asked, supervised the participants with their specific problems. This two-fold position has been analytically reflected upon and the analytical process was validated by the co-author. It is also noteworthy that both authors are language experts and, hence, the interaction was mainly perceived with respect to the current educational and linguistic approaches; a science expert might have provided the study with different kinds of perspectives. Furthermore, the participants may not represent the plurality of student teachers but embody students who at the outset were highly motivated to learn more about language-aware practices and collabora-

tion across subject boundaries. With less motivated participating students the results might have been rather different.

Drawing on these interpretations, consequences for teacher education can be identified. Even if student teachers are offered a wide array of resources, they seem to need many phases and fairly lengthy negotiation in order to appropriate them as internalized affordances that they can employ dynamically and in a target-oriented way. While it may not be possible to hurry this process, it seems that collaboration across subject boundaries may lead student teachers to fruitful negotiations that require them to dig deeper in terms of developing their understanding and expertise. More research on future teacher collaboration is needed in order to understand the phases needed in transforming the resources offered in teacher education into affordances internalized and appropriated by the student teachers themselves. It seems apparent, though, that supervision is needed to make the collaborative process visible and more profoundly conceptualized. Student collaboration is supported when students understand that fruitful collaborative processes are by definition iterative and require resilience to uncertainty and the ability to share thoughts and ideas in progress, elaborate them, and consult different sources of knowledge over and over again. Moreover, teacher education should refine future teachers' translanguaging instinct (Li, 2018) so that they can exploit meaning-making resources naturally and strategically for solving the problems at hand and support their students with diverse skills in becoming more creative and active agents in the school community.

## References

- Aalto, E. (2019). Pre-service subject teachers constructing pedagogical language knowledge in collaboration [Doctoral dissertation]. Jyväskylän yliopisto. *JYU Dissertations*, 158. <http://urn.fi/URN:ISBN:978-951-39-7950-8>.
- Aalto, E., & Tarnanen, M. (2017). Negotiating language across disciplines in pre-service teacher collaboration. *European Journal of Applied Linguistics*, 5(2), 245–271. <https://doi.org/10.1515/eujal-2017-0011>.
- Aikenhead, G. S. (2005). Science-based occupations and the science curriculum: Concepts of evidence. *Science Education*, 89, 242–275.
- Atkinson, D. (2011). A Sociocognitive approach to second language acquisition: How mind, body, and world work together in learning additional languages. In D. Atkinson (Ed.), *Alternative Approaches to Second Language Acquisition* (pp. 143–166). London: Routledge.
- Bezemer, J., & Kress, K. (2016). *Multimodality, Learning and Communication: A Social Semiotic Frame*. London: Routledge.
- Blackledge, A., & Creese, A. (2017). Translanguaging and the body. *International Journal of Multilingualism*, 14(3), 250–268. <https://doi.org/10.1080/14790718.2017.1315809>.
- Bradley, J., Moore, E., Simpson, J., & Atkinson, L. (2018). Translanguaging space and creative activity: Theorising collaborative arts-based learning. *Language and Intercultural Communication*, 18(1), 54–73.
- Brown, K. (2003). From teacher-centered to learner-centered curriculum: Improving learning in diverse classrooms. *Education*, 124(1), 49–54.
- Bush, A., & Grotjohann, N. (2020). Collaboration in teacher education: A cross-sectional study on future teachers' attitudes towards collaboration, their intentions to collaborate and their performance of collaboration. *Teaching and Teacher Education*, 88. <https://doi.org/10.1016/j.tate.2019.102968>.
- Canagarajah, S. (2011). Translanguaging in the classroom: Emerging issues for research and pedagogy. *Applied Linguistics Review*, 2, 1–28.
- Cope, W., & Kalantzis, M. (2009). 'Multiliteracies': New Literacies, New Learning. *Pedagogies*, 4, 164–195.
- Craig, C. J., Meijer, P. C., & Broeckmans, J. (2013). From teacher thinking to teachers and teaching: The evolution of a research community. *Advances in Research on Teaching*, 19.
- Creese, A., & Blackledge, A. (2015). Translanguaging and identity in educational settings. *Annual Review of Applied Linguistics*, 35, 20–35.
- Damsa, C., & Jornet, A. (2016). Revisiting learning in higher education – Framing notions redefined through an ecological perspective. *Frontline Learning Research*, 4(4), 39–47.
- Damsa, C., & Ludvigsen, S. (2016). Learning through interaction and co-construction of knowledge objects in teacher education. *Learning, Culture and Social Interaction*, 11, 1–18.
- DelliCarpini, M. (2009). Dialogues across disciplines: Preparing English-as-a-second-language teachers for interdisciplinary collaboration. *Current Issues in Education*, 11(2), 1–17.
- Dillenbourg, P., & Dillenbourg, P. (1999). What do you mean by collaborative learning? In *Collaborative learning: Cognitive and computational approaches* (pp. 1–19). Oxford: Elsevier.

- Dressman, M. (2020). Multimodality and language learning. In M. Dressman, & R. W. Sadler (Eds.), *The Handbook of Informal Language Learning* (pp. 39–55). John Wiley & Sons Ltd.
- Dufva, H., Suni, M., Aro, M., & Salo, O.-P. (2011). Languages as objects of learning: language learning as a case of multilingualism. *Apples – Journal of Applied Language Studies*, 5(1), 109–124. <http://apples.jyu.fi/article/abstract/179>.
- Duarte, J. (2020). Translanguaging in the context of mainstream multilingual education. *International Journal of Multilingualism*, 17(2), 232–247. <https://doi.org/10.1080/14790718.2018.1512607>.
- EDUFI. (2016). Finnish National Agency for Education. *National core curriculum for basic education*. Helsinki: National Agency for Education 2014.
- Flores, N. (2020). From academic language to language architecture: Challenging raciolinguistic ideologies in research and practice. *Theory Into Practice*, 59(1), 22–31.
- García, O., & Li, W. (2014). *Translanguaging: Language, Bilingualism and Education*. New York, NY: Palgrave Macmillan.
- García, O., Johnson, S. L., & Seltzer, K. (2016). *The translanguaging classroom: leveraging student bilingualism for learning*. Philadelphia, PA: Caslon Inc.
- Gibbons, P. (2006). *Bridging Discourses in the ESL Classroom: Students, Teachers and Researchers*. London: Continuum.
- Hakkarainen, K., Paavola, S., Kangas, K., & Seitamaa-Hakkarainen, P. (2013). Sociocultural perspectives on collaborative learning. *The International Handbook of Collaborative Learning*. Routledge.
- Haukás, Å. (2016). Teachers' beliefs about multilingualism and a multilingual pedagogical approach. *International Journal of Multilingualism*, 13(1), 1–18.
- Heikkinen, H., de Jong, F. P., & Vanderlinde, R. (2016). What is (good) practitioner research? *Vocations and Learning*, 9(1), 1–19.
- Iversen, J. Y. (2020). Pre-service teachers' translanguaging during field placement in multilingual, mainstream classrooms in Norway. *Language and Education*, 34(1), 51–65.
- Jones, R. (2020). Creativity in language learning and teaching: Translingual practices and transcultural identities. *Applied Linguistics Review*, 11(4), 535–550.
- Kibler, A., Walqui, A., & Bunch, G. (2015). Transformational opportunities: Language and literacy instruction for English language learners in the common core era in the United States. *TESOL Journal*, 6(1), 9–35.
- Kimänen, A. (2018). Approaching culture, negotiating practice: Finnish educators' discourses on cultural diversity. *Journal of Multicultural Discourses*, 13(4), 334–347. <https://doi.org/10.1080/17447143.2018.1546309>.
- Kuuisaari, H. (2013). Teachers' collaborative learning – development of teaching in group discussions. *Teachers and Teaching*, 19(1), 50–62.
- Lankshear, C., & Knobel, M. (2011). *New literacies*. New York: Open University Press.
- Lantolf, J., & Thorne, S. (2006). *Sociocultural theory and the genesis of second language development*. Oxford: Oxford University Press.
- Lemke, J., & Norwood, N. J. (1990). *Talking Science: Language, learning and values*. Ablex Publishing Corporation.
- Lemke, J. (1998). Multiplying meaning: visual and verbal semiotics in scientific texts. In J. R. Martin, & R. Veel (Eds.), *Reading Science: Critical and Functional Perspectives on Discourses on Science* (pp. 87–113). London: Routledge.
- Li, W. (2018). Translanguaging as a Practical Theory of Language. *Applied Linguistics*, 39(1), 9–30.
- Lilja, N., Mård-Miettinen, K., & Nikula, T. (2019). Luokahuone kielipoliittisena ja kielikoulutuspoliittisena tilana. [Classroom as a space for language policy and language education policy.]. In T. Saarinen, P. Nuolijärvi, S. Pöyhönen, & T. Kangasvieri (Eds.), *Kieli, koulutus, politiikka: monipaikkaisia käytänteitä ja tulkintoja* (pp. 175–197). Vastapaino.
- Lin, L. (2015). Exploring collaborative learning: Theoretical and conceptual perspectives. In *Investigating Chinese HE EFL Classrooms. Using Collaborative Learning to Enhance Learning* (pp. 11–28). Berlin Heidelberg: Springer-Verlag.
- Lonka, K. (2018). *Phenomenal Learning from Finland*. Helsinki: Edita Publishing.
- Lund, L. (2016). How teachers reflect on their pedagogy: learning from teachers' pedagogical vocabulary. *International Society for Teacher Education*, 20(2), 22–35.
- Makalela, L. (2015). Translanguaging as a Vehicle for Epistemic Access: Cases for Reading, Comprehension and Multilingual Interactions. *Per Linguam*, 31(1), 15–29. <https://doi.org/10.5785/31-1-628>.
- Marquez-García, M., Kirsch, W., & Leite-Mendez, A. (2020). Learning and collaboration in pre-service teacher education: Narrative analysis in a service learning experience at Andalusian public schools. *Teaching and Teacher Education*, 96. <https://doi.org/10.1016/j.tate.2020.103187>.
- Mayring, P. (2014). Qualitative Content Analysis. Theoretical Foundation, Basic Procedures and Software Solution. Klagenfurt. Retrieved from: <http://nbn-resolving.de/urn:nbn:de:0168-ssoar-395173>
- McVee, M., Silvestri, K., Barrett, N., & Haq, K. (2018). Positioning Theory. In D. E. Alvermann, N. J. Unrau, M. Sailors, & R. D. Ruddell (Eds.), *Theoretical Processes and Models of Literacy* (pp. 381–400). Routledge. <https://doi.org/10.4324/9781315110592-23>.
- Meyer, O., Coyle, D., Halbach, A., Schuck, K., & Ting, T. (2015). A pluriliteracies approach to content and language integrated learning – mapping learner progressions in knowledge construction and meaning-making. *Language, Culture and Curriculum*, 28(1), 41–57.
- Meyer, O., & Coyle, D. (2017). Pluriliteracies teaching for learning: conceptualizing progression for deeper learning in literacies development. *European Journal of Applied Linguistics*, 5(2), 199–222.
- Moje, O. B. (2008). Foregrounding the disciplines in secondary literacy teaching and learning: A call for change. *Journal of Adolescent & Adult Literacy*, 52, 96–107.
- Moore, J. & Schleppegrell, M. (2020). A focus on disciplinary language: Bringing critical perspectives to reading and writing in science. *Theory Into Practice*, 59(1), 99–108, DOI: 10.1080/00405841.2019.1685337
- Mortimer, E., & Scott, P. (2003). *Meaning Making in Secondary Science Classrooms*. Maidenhead: Open University Press.
- Mustonen, S. (2015). *Käytössä kehittävää kieliä: paikat ja tilat suomi toisena kielinä – oppijoiden teksteissä [Doctoral dissertation]: 255*. University of Jyväskylä. Jyväskylä Studies in Humanities <http://urn.fi/URN:ISBN:978-951-39-6213-5>.
- Mustonen, S. (2021). 'I'll always have black hair': challenging raciolinguistic ideologies in Finnish schools. *Nordic Journal of Studies in Educational Policy*, 7(3), 159–168. <https://doi.org/10.1080/20020317.2021.2000093>.
- National Research Council. (2012). *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century*. Committee on Defining Deeper Learning and 21st Century Skills, J. W. Pellegrino, & M. L. Hilton (Eds.), *Board on Testing and Assessment and Board on Science Education, Division of Behavioral and Social Sciences and Education*. Washington, DC: The National Academies Press.
- Nikula, T., Dalton-Puffer, C., Llinares, A., & Lorenzo, F. (2016). More than content and language: the complexity of integration in CLIL and multilingual education. In T. Nikula, E. Dafouz, P. Moore, & U. Smit (Eds.), *Conceptualising integration in CLIL and multilingual education* (pp. 1–28). Bristol: Multilingual Matters.
- Osborne, J. F. (2019). Not 'hands on' but 'minds on': A response to Furtak and Penuel. *Science Education*, 103(5), 1280–1283.
- Pandian, A., Balraj, S., & Wei, V. (2013). Making sense about science literacy: Views of secondary school students on science learning in Malaysia. In A. Pandian, C. Ling, L. D. Muniandy, L. Choo, & T. Hiang (Eds.), *New Literacies: Reconstructing Language and Education* (pp. 429–448). Newcastle upon Tyne: Cambridge Scholars Publisher.
- Pennycook, A. (2017). Translanguaging and semiotic assemblages. *International Journal of Multilingualism*, 14(2), 1–14. <https://doi.org/10.1080/14790718.2017.1315810>.
- Probyn, M. (2015). Pedagogical translanguaging: bridging discourses in South African science classrooms. *Language and Education*, 29(3), 218–234.
- Probyn, M. (2019). Pedagogical translanguaging and the construction of science knowledge in a multilingual South African classroom: challenging monoglossic/post-colonial orthodoxies. *Classroom Discourse*, 10(3–4), 216–236. <https://doi.org/10.1080/19463014.2019.1628792>.
- Roschelle J., & Teasley S. (1995). The construction of shared knowledge in collaborative problem solving. In C. O' Malley (Ed.), *Computer supported collaborative learning* (pp. 69–97). NATO ASI Series, vol. 128. Berlin, Heidelberg: Springer.
- Ruohotie-Lyhty, M., & Moate, J. (2016). Who and how? *Preservice teachers as active agents developing professional identities. Teaching and Teacher Education*, 55, 318–327.
- Schleppegrell, M. J. (2020). The knowledge base for language teaching: What is the English to be taught as content? *Language Teaching Research*, 24(1), 17–27. <https://doi.org/10.1177/1362168818777519>.
- Schreier, M. (2014). Qualitative content analysis. In U. Flick (Ed.), *The SAGE handbook of qualitative data analysis* (pp. 170–183). London: SAGE Publications Ltd.
- Smith, P. (2018). Learning to know, be, do, and live together with in the cross-cultural experiences of immigrant teacher educators. *Teaching and Teacher Education*, 69, 263–274.
- Smith, P. (2019). Re)positioning in the Englishes and (English) literacies of a black immigrant youth: Towards a transraciolinguistic approach. *Theory Into Practice*, 58(3), 292–303. <https://doi.org/10.1080/00405841.2019.1599227>.
- Steffensen, S. V., & Fill, A. (2014). Ecolinguistics: The state of the art and future horizons. *Language Sciences*, 41, 6–25.
- Säljö, R. (2010). Digital tools and challenges to institutional traditions of learning: Technologies, social memory and the performative nature of learning. *Journal of Computer Assisted Learning*, 26, 53–64.
- Ilmiömäistä! : ilmiölähtöinen lähestymistapa uudistamassa opettajuutta ja oppimista. (2020). In M. Tarnanen, & E. Kostiainen (Eds.), *[Phenomenal learning! Reforming teaching and learning through the phenomenon-based approach.]*. University of Jyväskylä <https://www.uuttaluova.fi/download/1273/>.
- Valdés, G., Bunch, G., Snow, C., & Lee, C. (2005). Enhancing the development of students' language(s): An introduction for teachers. In L. Darling-Hammond, & J. Bransford (Eds.), *Preparing teachers for a changing world: What teachers should learn and be able to do* (pp. 126–167). San Francisco, CA: John Wiley.
- van Lier, L. (2000). From input to affordance: social-interactive learning from an ecological perspective. In J. P. Lantolf (Ed.), *Sociocultural theory and second language learning* (pp. 155–177). Oxford: Oxford University Press.
- van Lier, L. (2004). *The Ecology and Semiotics of Language Learning. A Sociocultural Perspective*. New York: Kluwer Academic Publishers.
- Vollmer, H. (2008). Constructing tasks for content and language integrated learning and assessment. In J. Eckerth, & S. Siekmann (Eds.), *Task-based language learning and teaching. Theoretical, methodological, and pedagogical perspectives* (pp. 227–290). Frankfurt am Main: Peter Lang.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological functions*. Cambridge: Harvard University Press.
- Walqui, A., & van Lier, L. (2010). *Scaffolding the academic success of adolescent English language learners*. San Francisco: WestEd.
- Wu, Y. A., & Lin, A. (2019). Translanguaging and trans-semiotising in a CLIL biology class in Hong Kong: whole-body sense-making in the flow of knowledge co-making. *Classroom Discourse*, 10(3–4), 252–273. <https://doi.org/10.1080/19463014.2019.1629322>.
- Zhang, Y. (2010). Cooperative language learning and foreign language learning and teaching. *Journal of Language Teaching and Research*, 1(1), 81–83.