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Title **Expansive Design for Teachers**
An activity-theoretical approach to design-based research

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Abstract Innovative designs for learning have implications for the teaching practices and the system in which they are created, often with conflicting motives and tensions on systemic levels. Co-design processes with teachers and researchers require tools and concepts to grasp this complexity and to create durable changes. In the case studied in this article, activity theory and change laboratory methodologies were used in a participatory design process with a small group of teachers. Five key characteristics of the epistemological principles behind the change laboratory methodology were identified and analysed. The theoretical framework enabled tools for a collective analysis of the origin and development of systemic contradictions as well as a model to envision future practices and concrete learning designs. Findings suggest that the combination of participatory design and change laboratory methodologies can serve as a vehicle for expansive learning and new innovative learning designs in educational settings.

Keywords participatory design
activity theory
change laboratory

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Expansive Design for Teachers

An activity-theoretical approach to design-based research

Dennis Augustsson

1.0 Introduction

Innovative designs for education have implications for the teaching practices and the settings in which they are implemented, often with conflicting motives and tensions on systemic levels (Lewin et al., 2018). Co-design processes with teachers and researchers require tools and concepts to grasp this complexity and to create durable changes. From a Participatory Design (PD) perspective, participants' agency and situated needs are fundamental for understanding and facilitate a co-design process between teachers and researchers (Di salvo & Di salvo, 2014). Proponents of the Scandinavian school of Participatory design further suggests that conflicts and tensions is an important feature in design research (Björgvinsson et al., 2012) and DiSalvo et al. has showed that collaborative articulation of these issues is an important part of a co-design process (DiSalvo et al., 2011). A focus on participants' agency and embedded conflicts and tensions needs to account for the socio-cultural context of teaching and learning, viewing educational settings as situated, complex activity systems. (Engeström, 2008; Greeno, 1998). Cole and Packer (2016) used the concept of the double artificial to point to the fact that the activity systems of schooling are as artificial as the designed curricular and technological innovations that are implemented there. To grapple the doubly artificial in a co-design effort, there is a need for a theory and methodology that can embrace this complexity.

This article is exploring how Cultural Historical Activity Theory (CHAT: Engeström, 2015) can be used to structure and analyse a co-design process for teachers. From a CHAT perspective, teaching and learning are complex with several stakeholders in a system of complicated relations between explicit and implicit rules, different cultures, resources and division of labour, often with conflicting motives and tensions on systemic levels (Penuel, 2014; Sannino, 2010). Co-design processes with the purpose to promote learning and changing the practice of teachers requires tools and concepts to grasp this complexity and CHAT has the potential to address these issues (Voogt et al., 2015; Gutiérrez et al., 2016; Severance et al., 2016) Researchers from the field of developmental psychology have developed an intervention method based on CHAT called the Change Laboratory (CL) for a collaborative analysis of activities with focus on critical tensions and contradictions. It is performed to develop and implement new models or

ways of working through cycles of *expansive learning* (Engeström, 2015).

The case in this article is a PD process of developing a new international and cross curricular learning design on marine biology for upper secondary schools in Sweden and USA. As tensions and issues on systemic levels emerged in the design process, a CL approach was adopted. Traditionally, CL interventions are initiated in larger activities in acute crises, but it could be relevant to explore the potential of the methodology in a smaller setting where the conflicts and tensions are not so aggravated and part of an ongoing design process. By identifying and analysing empirical manifestations of the epistemological principles behind CL interventions in the process, this article aims to contribute to the discussion and understanding of CHAT as a productive tool for promoting and analysing a PD process in educational settings.

Two questions are posed for this article:

1. What empirical manifestations of the epistemological principles of a CL can be found in a small-scale intervention for teachers as part of a PD process?
2. How can a combination of tools from PD and CL be productive for co-design efforts in educational settings?

2.0 Theoretical framework and the Change Lab methodology

CHAT is both a generative theory and a descriptive and explanatory theory that reveals processes and relationships (Kapetelini & Nardi, 2009). CHAT explains human activity and development as a systemic and socially situated phenomenon, and the unit of analysis for understanding human actions is the activity system represented in a model with six interconnected components: subject, object, mediating artefacts or tools, community, rules, and division of labour (Engeström, 2015).

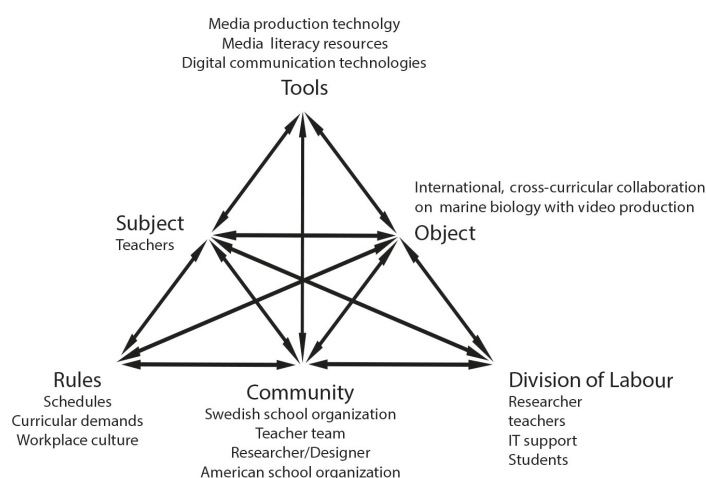


Figure 1: The activity system of the international collaboration (adapted from Engeström, 2015)

Figure 1 illustrates the activity system of participating teachers in this study. The subject, being the participating teachers, is part of an activity system working towards the object of the activity, which is the development and enactment of a new cross-curricular, international collaboration. The relationship between subject and object is mediated by tools such as educational technology and other resources. Actions towards the object are dependent on the community and the division of labour between participants, as well as explicit and implicit rules such as curricular policies and workplace cultures. This model was used by the researcher and participants in this study for the purpose of analysis and collaborative articulation of tensions and contradictions in the co-design process, using the CL methodology.

The CL methodology is based on two epistemological principles: *the principle of ascending from the abstract to the concrete* (Davydov, 1990) and *the principle of double stimulation* (Vygotsky, 1987). Both principles are used to facilitate volitional action and transformative agency in an intervention or change effort and are key features in CHAT (Sannino & Engeström, 2017).

2.1 The principle of ascending from the abstract to the concrete

The principle was developed by Davydov and applied to methods for mathematics instruction (Davydov, 1990). It is a process, where theoretical analyses are used for identification and the modelling of principles (the abstract) before one analyses and transforms the particular phenomena (the concrete). Davydov's 1st grade students were introduced to general representations of mathematical concepts (letters) before the introduction of numbers to understand and experiment with the underlying principles of mathematics. This helped pupils to understand and solve more complex equations later on (Davydov, 1990).

This principle has been developed and expanded by Engeström into the theory of expansive learning (Engeström, 2015). Expansive learning is understood as a collective process in which participants, in a similar process, through analytical learning actions, change and create new activities by going beyond the already known and current practices within the activity system. It's a process of 'learning what is not yet there' (Sannino & Engeström, 2017, p. 81).

The theory of expansive learning proposes seven steps or learning actions for the process: Questioning, Analysing, Modelling, Examining, Implementing, Reflecting, and Consolidating. These steps form an ideal cycle of expansive learning, quite similar to a traditional design cycle. The difference is a special focus on questioning and analysis of the activity to bring systemic tensions and contradictions to the forefront. For teachers and researchers engaging in a co-design process, this means a possibility to analyse and reflect upon the situated teaching practice to address the challenges and complexity as part of an activity system. The method of revealing contradictions and the inner conflicts of the activity system has the intention of generating a *zone*

of proximal development (Sannino et al., 2016), in which new concepts and practices can emerge. The zone of proximal development (ZPD) is an extension of Vygotsky's concept that a child's development is advanced through the interaction with more knowledgeable others (Vygotsky, 1978). The asymmetry between an individual's abilities and those of their more experienced peers creates a ZPD where skills and new knowledge can develop through social interaction.

In a CL intervention a ZPD is understood as an expansion of Vygotsky's notion where the collaboration between participants and the intersection of different activity systems creates a space for a collective analysis and design. The result of identifying and modelling a functional relationship that explains a simple principle behind a complex whole is called a *germ cell*. A germ cell can take many forms and is not a final step in the process of ascending from the abstract to the concrete but a concept or model that can capture the problem in a simple idea and then be transformed and expanded into new forms of practice. A germ cell from CL interventions can take the form of abstract concepts like *knotworking* (Sannino & Engeström, 2017) or a concrete embodiment of the problem and possible solutions like *standing up from a chair* for elderly adults in an intervention with home care practitioners (Engeström et al., 2012). Modelling a concept in a CL process could be described as prototyping or a *design before design process* (Ehn, 2008) and a learning design as a result of this process could possibly carry the potential of a germ cell. A CL intervention is constructed to promote a cycle of expansive learning using a number of sessions with a script to promote desired learning actions. A key feature in the process is the principle of double stimulation.

2.2 The principle of double stimulation

Double stimulation is a theory and method in experimental psychology developed by Vygotsky (1987) using two groups of stimuli. When we are faced with a problematic situation, we can become paralyzed by conflicting motives for our actions and need external artefacts to gain control of the situation. An example is Vygotsky's *waiting experiment* (Vygotsky, 1987), in which subjects were asked to wait in a room and were left there without any further instructions. As time went by, this created a conflict of motives between the urge to leave and the commitment to stay and almost all participants looked for external points of support to get out of the dilemma. As an example, one participant used a clock, deciding that if nothing had happened by the time the hand reached a vertical position, he would leave. Here the problematic situation was the first stimulus and the clock as an external artefact was used as a second stimulus to find a solution. Conflicts of motives is a key concept in double stimulation understood as a principle of agency. Mediating artefacts become agentive tools when facing conflicting motives. As a principle in CL interventions, double stimulation has evolved from an experimental method to a theoretical generaliza-

tion which characterizes human beings' ability to transform their circumstances through volition and agency (Sannino, 2015; Sannino & Engeström, 2017). In a CL process, the conflict of motives can be manifested in many ways, ranging from latent dilemmas to aggravated systemic conflicts that require urgent collective action (Engeström & Sannino, 2011).

In a school context, many conflicting motives might emerge when designing innovative solutions for learning and teaching that also have an impact on activities and levels outside the classrooms of participating teachers. If the new designs are to be shaped and implemented in a lasting and durable way, it is important to analyse and bring these conflicts and tensions to the surface. Using the principle of double stimulation in this study, the first stimulus was created by the researcher through analysing the current activity. The purpose was to create a tool for participants to make contradictions and conflicts of motives visible and tangible by representing them in the CHAT triangular model. The second stimulus was created by giving participants tools to model new and possible solutions for the activity. The different tools used in the process are called *mirror materials* and usually consist of graphic representations of the activity systems and video recorded material from ethnographical research done beforehand (Engeström & Sannino, 2010). In this study the mirror materials used were CHAT models, a graphical representation of a ZPD, documents and excerpts from previous sessions presented as PowerPoint slides.

3.0 Case and setting

The CL sessions analysed in this study were part of a participatory design project, conducted with upper secondary schools in the USA and Sweden as a collaborative media production to create an international collaboration on Ocean Literacy. New learning sequences were designed as the researcher, teachers, and students collaborated to plan, implement, and evaluate video production as a tool for learning. Participating teachers in Sweden experienced tensions and contradictions within the activity and the specific design challenge turned into a challenge on systemic levels. For a more detailed description of the design process, see Augustsson, 2016. A workshop using CHAT was conducted and became the starting point for a CL intervention to explore new strategies in the process together with teachers from the Swedish school. The aim was to address issues of video production as a curricular activity on a more general level and to feed the design process for the international collaboration. The CL was designed with five sessions following the CHAT workshop, which was initially planned as a single session to evaluate the first iteration of the collaboration. A summary of the sessions and their purposes can be found in Table 1. During the process there were 2-3 teachers and a researcher participating. The role of the researcher was to prepare and present the mirror materials for the sessions and to moderate the discussions as well as to carry out analyses of the outcomes in between sessions. Participating teachers

worked with the ideation of new learning designs in between sessions during the whole process which created a mix of discussions and occasionally deviations from the prepared script.

	Date	Purpose of the session	Mirror materials
1	17-05-31	Presentation of the CHAT model Analysis of the design process and results	The CHAT model
2	17-11-17	Presentation and analysis of a four-field representation of contradictions and a Zone of Proximal Development (ZPD)	The CHAT model Excerpts from interviews with participants Four field model of ZPD (see below)
3	18-03-06	Reworking the ZPD. Historical analysis of the activity systems. Ideation process of possible new designs	Four field model of ZPD (see below) Policy documents
4	18-05-23	Development of new ideas and their relation to contradictions in the activity system	Results from the ideation process Four field model of ZPD (see below)
5	18-05-30	Development of concrete learning designs	Policy documents
6	18-11-06	Follow-up session. Consolidating and preparing dissemination activities	A graphic representation of the new concept

Table 1: Summary of the Change Laboratory sessions

4.0 Data and method of post analysis

The raw data in this study consists of video recordings of the six CL sessions. The total length of the recorded material was 418 minutes. The video material was transcribed verbatim by the researcher and then analysed to identify five key characteristics of CL intervention connected to the epistemological principles: *contradictions*, *conflicts of motives*, *first and second stimuli*, *zone of proximal development*, and *germ cell and emerging concept* (Sannino & Engeström, 2017). The identification of these characteristics in the CL discourse helps us to understand how the epistemological principles operate in the process. *Contradictions* refers to the tensions and contradictions identified in the activity system by the researcher and participants. *Conflict of motives* refers to the conflicts as they were articulated by the participants. The first stimulus refers to the main problems, presented to the participants and the second stimulus refers to the artefact or model used by participants to design their future activity. *The zone of proximal development* refers to the way alternative directions for the activity were represented and discussed. *Germ cell* refers to an initial idea for the

future and *emerging concepts* to concrete designs possibly emerging as an outcome of the CL.

The transcript was analysed by discerning episodes based on their substantive contents. Analysis of the conversations within each episode was performed to formulate and mark preliminary connections to the epistemological principles. Using the definition of the key characteristics described above, manifestations of the epistemological principles were identified. This process was done, iteratively, three times for a finalized categorization used for identification and further analysis. A summary of the results is presented in Table 2. In the result section, a thick description with excerpts from the transcripts are presented and discussed, divided into subsections for the key characteristics.

5.0 Results: Empirical manifestations of the epistemological principles

Contradiction	Conflict of motives	First and second stimuli	Zone of proximal development	Germ cell and emerging concepts
Curricular demands on both specific content matter and the development of 21 st century skills	Working with 21 st century skills vs. specific subject matters Promote learning and assessing results	1 st stimulus: Experiences from the design process analysed and represented in the CHAT model 2 nd stimulus: The ZPD model	Media production as a learning process and documentation of experiments. Complementary assignments for differentiation of assessment and deeper knowledge of subject specific content	The abstract video Hybrids: Media production as vehicle of learning and representation of knowledge sufficient for a passing grade mixed with individual reports

Table 2: Epistemological principles as manifested in the CL process

5.1 Contradictions and conflict of motives – tangible through shift in representation

In the first session, the teachers were presented with a blank CHAT model which was filled with content using post-it notes. They were asked to identify categories on the different nodes of the triangular model and to discuss the relation between the different categories. This process made it possible to map several tensions and contradictions in the activity, such as issues between cross-curricular activities and the school's organization of schedules and allocation of resources. The time-consuming process of media production raised the question of whether it is worth it in relation to traditional studies of specific subject matter and curricular demands on individual assessment. Promoting learning activities with a focus on social skills, collaboration and media literacy, described as 21st century skills, was in conflict with the need to focus on specific subject matter, easy to measure outcomes, and individual assessment. The most urgent issues were formulated by the dimensions of learning vs. assessment and 21st century

skills vs. specific subject matter (represented by the red text in Figure 2). This was described as a contradiction between rules (curricular demands) and the object of the activity (An international, Cross-curricular collaboration on Marine Biology with Video production) represented as the red bolt in Figure 2.

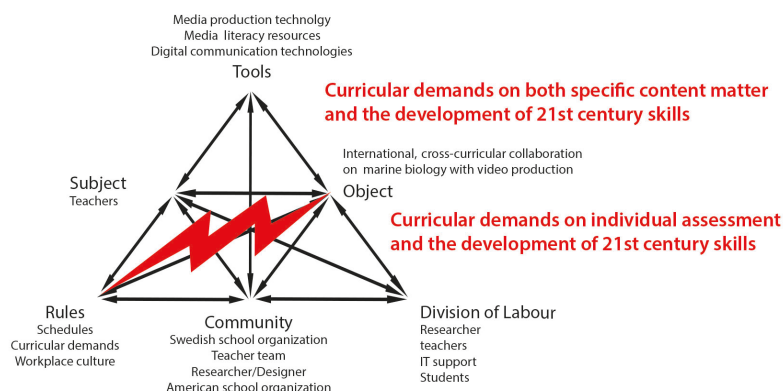


Figure 2: The most urgent contradiction in the activity system

In session 2 the researcher presented a four-field model of these dimensions and a zone of proximal development based on the researcher's analysis of session 1. They were represented on two axes where traditional practices were placed in the bottom left corner and a zone of proximal development towards more learning activities promoting 21st century skills in the upper right corner. Possible directions or spearheads into this ZPD were taken from session 1 and the design process. This four-field model is part of the CL toolbox to represent the contradictions and tensions to be resolved and charting the zone of proximal development that needs to be traversed in order to move beyond the existing contradictions (Engeström & Sannino, 2010). The upper left corner and lower right corners are used to represent the conflicting interests in the activity.

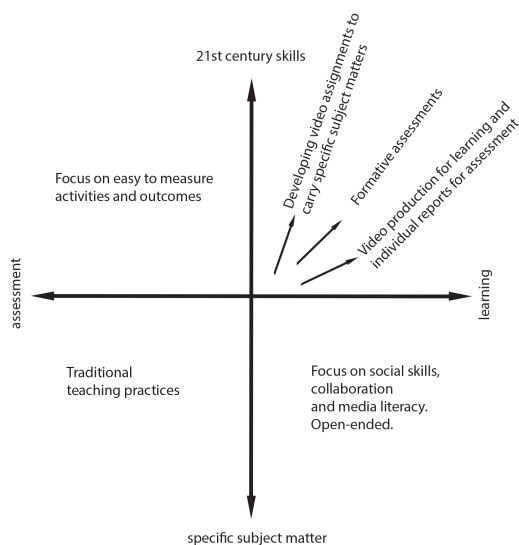


Figure 3: The four-field model from session 2

When introduced to this model, the teacher reacted with some resistance. The new representation of the contradictions from earlier sessions triggered a discussion as the model suggested abandoning 'traditional teaching' which caused some resistance and questioning of the relevance of the model by the teachers:

Excerpt from session 2:

T1: But...but... do you mean that 21st century skills are in opposition to the curriculum? R: No, both (21st century skills and Specific subject matter) are part of the curriculum, are they not?

T2: Yes, but these media skills that are written in the curriculum can sometimes be hard to connect to...

T1: (interrupting) But what I mean is... I automatically think that... the scale here... that they are opposites... they are not!

R: Well, perhaps not opposites, but contradictory...We are actually bound to do both.

T1: That's what I mean, they are not opposite...

This is an example of conflicting motives expressed by the participants and identified in the analysis. The shift of representation from the Activity triangle model to the four-field model of the ZPD was productive for the collective analysis as it provoked a discussion on the tensions in the curricular demands. The contradictions experienced in the curriculum cannot be avoided but are necessary to address, and when they were represented on opposite sides in the model, the dilemma became very visible and tangible. On one level, the curriculum prescribes both collaborative skills and different forms of representation and on another level, it demands individual assessment of specific content matter. This discussion continued:

T1: But... you can't put these things against each other... you need both learning and assessment. Traditional teaching doesn't mean we don't have learning? I feel like you are excluding things. It does take a lot of time and energy to experiment with these new ways of teaching, but I still have to assess the students individually on the learning outcomes and it's not easy to do.

T2: But with the new curriculum and all the new stuff, that's what we have to do.

The excerpt above also illustrates a movement from a dilemma experienced on a personal level (T1: but / still have to) to a need for collective action (T2: That's what we have to do). According to CHAT, this movement is important for a collective analysis and development of new practices (Engeström & Sannino, 2011). A collaborative articulation of the issues at hand is a first step towards agency and collective action in the design process.

5.2 Double stimulation – imagining a future state and visualizing change

The design process before the CL intervention made use of different tools such as interviews, SWOT-analysis, affinity diagrams and mind mapping methods. These external artefacts and resources were used as stimuli for participating teachers in the process, but it was not until the workshop in session 1, using the CHAT model, that tensions on a systemic level were expressed and made explicit. Using the principle of double stimulation, this workshop and the CHAT model must be understood as the first stimuli since they made the tensions and contradictions visible and tangible, based on participants' collective analysis of their process. An important feature of CHAT and CL is the cultural and historical context of an activity system, which aids in understanding the origin of the contradictions and problems. This is an essential step in the process of ascending from the abstract to the concrete (Davydov, 1990). In session 3 the model was re-examined and remodelled together with historical analysis of the development of curricular demands and the teachers' personal journey to their present situation. Participating teachers discussed how their profession traditionally had been focused on individual learning and written exams and as part of the historical analysis they were presented with a blank version of the four-field model used in session 2 (Figure 4).

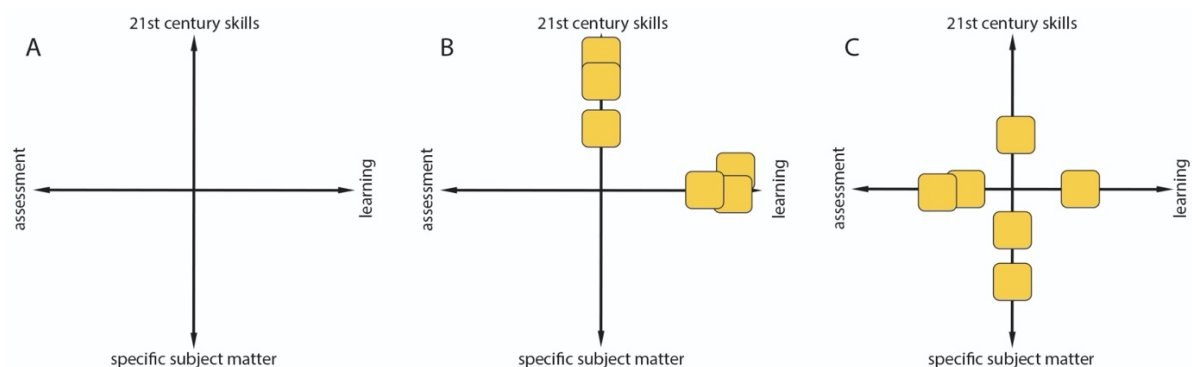


Figure 4: A: The blank model B: The most important (for the future) C: Contemporary practices

They were asked to put a post-it note in the axis that they thought was most important (B). Then they were asked to put the same note where they thought their current practice was situated (C). Their perception and representation of the past, present and future made it clear that the current practice needed to move towards the field of proximal development and that the concepts there had to be made concrete to overcome the experienced conflict of motives. To actively and tacitly engage in the model created an awareness and agency different from the prepared model done by the researcher.

5.3 Zone of proximal development – designing with contradictions

Sessions 4 and 5 were dedicated to working with the development of ideas and concrete learning designs that could solve the contradictions. Before and in between sessions participants were working on their own to formulate and experiment with new designs. Participants first started to explore ways to develop collaborative video assignments to carry specific subject matter in English and Marine Biology, but it was difficult to find ways to square the needs of assessment and the time and resources needed to accomplish them. Manifestations of the conflict of motives appeared again at these points in the process, what Nummijoki et al. (2017) call smaller cycles of defensive learning, in which participants go back to the state of the dominant activity, struggling between existing routines and the possible new practice.

Excerpt from session 4 using the ZPD model as mirror material:

T1: That's the problem with the school system, that we have to assess and grade things. We don't want to be teaching to assess, we want to teach and do good things, but our hands are a bit tied up.

R: The experiment with this model (ZPD) was interesting in that aspect. We say that we want to do this (focus on learning), that it is what is most important, but that's not what we are doing...

T1: If we didn't that would be malpractice...

T2: No, it's just that we are stuck and can't see...

T1: But I mean that we can't just ignore assessment.

T1: No, but it can be done in many ways, different ways, that we haven't done yet.

There is a difference in the way this resistance is represented in this session. There are fewer manifestations of personal dilemmas and rhetorical questions. The problem and the possible solutions are here articulated as a joint concern and formulated in terms of necessary actions, being part of their collective process (we are, we have to...). This indicates an important connection between resistance and agency as it moved participants closer to collective actions (T2...it can be done in many ways, different ways, that we haven't done yet). After this, the exploration of how to solve the contradictions in the curricular demands resulted in the design of a hybrid format where video production was combined with individual written reports.

Excerpt from session 5:

T1: An Abstract movie – I like that – it's an abstract but on video and it's the same level... You can assess that in the same way as an (written) abstract!

T2: Like we did last time?

T1: Yes, but they were a bit sloppy because they didn't know it would be assessed like a written abstract. We have to be clearer on that next time... and then... if they do a lab report... It really doesn't state in the

curriculum that you have to write a lab report – it states that the students have to be able to ask questions and motivate a hypothesis... we can pick out parts...not making a whole film of the experiment, but for example that they show the method in a video and analyse and evaluate the results in written form – that you don't do the whole report in written form but some parts with video.

R: Like a hybrid?

T1: Yes! It (the curriculum) states that you must have scientific communication; it can be what words you are using but also this way (video production).

T1: We have a lot of students that have problems with written reports, to them we can say: You know what – Now you will conduct your experiments, you will make a film on what you have done, showing the results and trying to explain. That's the level for passing. Then you can develop this with an individual report to show the different grading scale. A multistage rocket where the passing level could be the collaboration where they make a summary.

Here, the teachers reinterpreted the content of the curricular demands in ways that opened up for the creation of a hybrid form of activity to meet the demands of both 21st century skills (social skills, collaboration and media literacy) and subject matter knowledge. (T1: ...you must have scientific communication; it can be what words you are using but also this way). Retaining parts of both traditional writing and video production enabled both collaborative learning and individual assessment. This also created solutions for other problems like the possibilities for students with writing problems to work with video and still get a passing grade (T1: A multistage rocket where the passing level could be the collaboration where they make a summary). Figure 5 is a graphical representation of this hybridity created in the last session and Figure 6 is a collection of screencaps from student videos produced to illustrate the results.

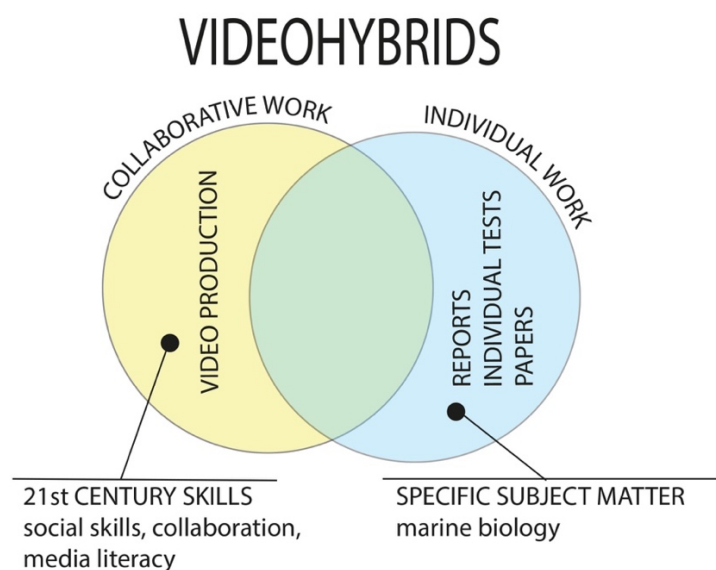


Figure 5: Graphical representation of the hybrid concept from session 6

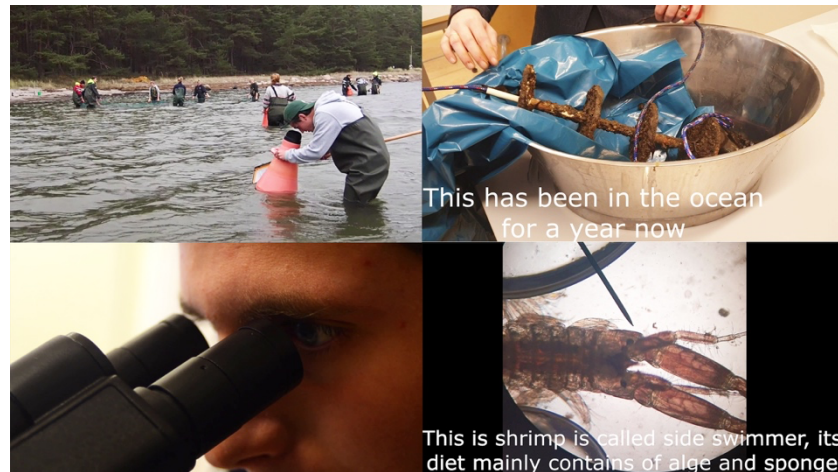


Figure 6: Screensaps from student video production

5.4 Germ cell and emerging concept

At the analytical level, we can follow how the theoretical models became a vehicle for joint formulations that have clear potential for moving the group to action. The abstract movie was a design that was used frequently to describe the concept of different hybrid forms of activity. From that experiment several new ideas for tasks involving video production emerged. It was a concrete learning design developed in the process, but also a model to explain and expand the use of video production in more instructional designs. Engeström and Sannino describe the hallmark of a germ cell as ‘...its generative potential that stems from its dynamic character as a unity of opposing forces or tendencies’ (Sannino & Engeström, 2017, p. 94). The opposing forces united here were the conflicts experienced in the curricular demands. The idea of hybridity, to mix different forms of activity and representation (collaborative video production and individual writing), can be interpreted as the unifying concept, but the abstract movie embodied this concept in a simple and concrete way. Its explanatory and transformational power makes it a good candidate for a germ cell in the process of ascending from the abstract to the concrete. The generative power of a germ cell can only be examined in the long term, but in the last follow up session, six months after the previous one, the number of learning designs with video production had increased from one subject and six videos made in the first iteration in 2016 to four subjects and 64 videos produced at the time of the evaluation in 2018. This indicates a development of a fairly stable, new practice through the co-design process.

6.0 Discussion and conclusion

The problems experienced by teachers in the face of challenging new curricular demands are known from earlier research in educational settings (Voogt et al., 2015; Kyza & Nicolaidou, 2016). In this design process, CHAT models and CL methodology became productive as they

enabled teachers to grasp the complexity and transform a conflicted activity into new forms of practice. The first question posed for this study concerned the empirical manifestations of the epistemological principles of a CL in the design process. The epistemological principles were used to script the intervention and the key characteristics were identified in the post analysis of the data, indicating a successful cycle of expansive learning. The steps taken by participating teachers to analyse their activities and develop new practices is an example of the process of ascending from the abstract to the concrete. The theoretical framework enabled tools for an important collective analysis by remediating and bringing the origin and development of systemic tensions and contradictions to the surface. The ZPD, represented as a visual and tangible model, promoted the collective analysis, and resistance must be seen as an agentive aspect of the process as it pushed the teachers to collaboratively articulate joint concerns and the need for collective actions. The design of the abstract movie was a result of this process and functioned as a germ cell, capturing the problem and its solution in a simple idea. It is an example of what Van Amstel (2015) calls designing with contradictions but must be understood as a process that not only produces innovative learning designs but changes the activity system in which they are implemented.

This intervention was not carried out in an activity system in acute crises but was conducted with a small group of teachers. There is a limitation in this approach and changes were not visible on an organizational level which is usually the case with CL interventions. The term intervention is perhaps misleading when describing the process. In a CL, the aim is to transform the activity system. Created models and germ cells function as vehicles for change; they are not the end game of the process. In this PD project with teachers, the activity system was limited to the small workgroup and the primary aim was to create new curricular units. As CL are normally used for activities in acute crises, the conflicts are pushing the process:

In transformations induced by CLs, contradiction and conflict may be seen as acute push and the future-oriented concept as gradually emerging pull, with the change actions of the local practitioners in the middle. (Sannino & Engeström, 2017, p. 80)

The design process presented in this study could be described as entering from the other direction. The tensions and contradictions on systemic levels that emerged in the co-design process had to be made explicit, analysed, and addressed. The design of the new curricular units acted here as a push revealing contradictions and conflicts that called for participants' collective actions. The desired outcome is the same. In this case, it was a change in the local practice as well as new, innovative curricular units. There is a limitation of the analytical depth in this study. To further explore and validate the use of CL methodology in the design process, a more systematic analysis of participants' discourse is needed. This would reveal how learning and design developed in the process at the level of interaction between participants more in detail.

The second question posed for this study concerns the combination of traditions from PD and CL. The most demanding challenges described by Sannino and Engeström for a CL is the construction and modelling of concrete concepts:

Constructing a germ cell and eventually an expanded concrete concept based on it are the most demanding challenges for CL interventions. (Sannino & Engeström, 2017, p. 80)

The innovation process could perhaps be less demanding if it were using methods and tools from the field of PD. The combination of PD and CL can be a way forward to develop both. CL comes from an academic field and the traditional setup is constructed as a seminar, in which participants are facing a stage where the interventionists are leading the sessions in a conference-like process (Virkkunen and Newnham, 2013). Mirror materials are predominantly used as tools for theoretical, analytical reflections. A PD process entails a more tacit and tangible engagement with the materials (Löwgren et al., 2013), and CHAT concepts can be turned into concrete tools for engagement (Van Anselm, 2015). The collaborative analysis in this study created a better understanding and agency in participants as mirror materials were treated as canvases on which participants could actively and tangibly engage with complex models and concepts. The use of the models as tangible interactive representations must be understood as an important part of the development of agency and volition. Participating teachers were introduced to the models without in-depth explanation of the theoretical framework but successfully used the tools and models with their own references and experiences. A similar observation was made by Bødker and Klokmoose when using activity-theoretical models with interaction design students (Bødker & Klokmoose, 2012).

The researcher carried out in-between analyses to interpret data and insert feedback into the process in which the models and mirror materials could function as a *boundary object* between design, research and professional discourse (Star, 1989). A key to understand the CL models as boundary objects is the concept of remediation. Shifting between different representations remediates the problems of an activity and creates tools of agency for the participants by establishing new relationships and meaning (Virkkunen & Schaupp, 2011). By mapping and remediating the already known, teachers in this study created a vehicle to envision an unknown future. The CL methodology is usually more focused on a theoretical analysis of complex phenomena, but in this study it was tweaked into a design tool in the process for practical solutions as well as addressing the complex, situated practice of the educational activity. CHAT provided a framework as a descriptive, explanatory, and generative theory for the design process based on research from developmental psychology and the models functioned as concrete tools for design. Reversed, the CL tradition could benefit from the adaption of tools and processes from the PD tradition for a more studio-based engagement in the process of ideation and development of new concepts and curricular designs.

Engeström used the notion of expansive design to connect the field of interaction design and the concept of expansive learning (Engeström,

2006) and from my perspective it is a term well suited to describe the combination of CL and PD efforts with teachers. Engeström summarized five arguments for the combination of interaction design and CHAT. These are listed below, adapted to design research in educational settings based on the experiences from the research presented in this paper.

1. Design research in educational settings needs to be embedded, integrated, and made visible in the activity systems within which the targeted learning designs are produced and used.
2. Design research in educational settings needs to be directed not only at curricular units and technical innovations but also at relations, processes, services, organizations, and, most importantly, at “germ-cell” concepts or visions of the future activity.
3. Expansive design for teachers creates integrated instrumentalities, not only isolated products. It operates by anchoring its ideas and outcomes upward, downward, and sideways.
4. Expansive design for teachers is best performed jointly by teachers, students and key staff members, supported by interventionists. This requires special reflective intervention methods, “microcosms” which combine joint negotiated decision making, joint future-oriented envisioning, and simulation of future modes of interaction across boundaries.
5. Expanded in these ways, design research in educational settings tends to merge with implementation and learning; expansive design, expansive implementation, and expansive learning are (so to speak) three sides of the same coin (adapted from Engeström, 2006, p. 3).

The case in this study is an example of such an effort in a small-scale project with teachers, struggling with their needs and the demands of new curricular units.

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