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10 Orchestrating Invention Activities through Teacher's Multilayered Work

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Introduction

The classroom conditions based on the invention pedagogy assume that the design processes are based on collaboration and anchored on students' ideas, questions, and current skills. It follows that the invention processes are often nonlinear, emergent, and open-ended in nature (see Chapter 2 of this book). In the pedagogical settings, aiming to develop the process and the object of the design process with the students, the outcomes, the content, or the process phases cannot be entirely known beforehand. The classroom discussion carried on by all participants, and based on collaboration and shared expertise, is described as improvisational (Sawyer, 2004, 2019). The individual members bring their contributions to the process by discussing and trying to build on the process turn by turn. Thus, the participants complement each other's skills and orientations. Working in such diverse groups offers several options for differently oriented students. On the one hand, the talented students can be inspired to take on more challenging tasks in the group, and on the other hand, working in cognitively diverse groups provides an encouraging example to those students who struggle with their learning for different reasons (Sormunen et al., 2020).

Despite the teachers' growing understanding of the student-driven design learning or inquiry processes, the ideal ways to support student participation or create compatible classroom activities may be challenging (Bielaczyc, 2013). In addition, a major challenge is the organization of collaborative and nonlinear activities with different kinds of learners. Even though collaboration relies on positive interdependence, peer support is often insufficient for struggling students. On the one hand, students need support and advice to function as active participants in the invention process. In contrast, too much structuring and direction may diminish their initiatives or ideation. The teachers need to accept openness, but at the same time provide sufficient structuring and scaffolding for the process (Jenkins et al., 2003; Viilo et al., 2018). These open-ended settings require creativeness in orchestration and teaching (Hämäläinen & Vähäsantanen, 2011; Sawyer, 2019). The concept of orchestration is used for describing the teacher's efforts in organizing and supporting the students' processes in individual, social, tool-mediated, and changing learning situations (Littleton et al., 2012).

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This chapter offers a perspective on orchestrating that can aid in understanding the organization or the procedural and timely guidance needed in the design, making, and invention activities. In these settings, the processes are open-ended, and the working methods are based on collaboration. First, we offer an overview of the elements within orchestration and distinguish between orchestration design and dynamic orchestration. Second, we illustrate the orchestration solutions in four different invention pedagogy settings with a lot of student diversity. Examining cognitively diverse classes provides an overall understanding of the intensity of orchestration in relation to the need for student support. Finally, we discuss the experiences learned from the settings.

Elements of Orchestrating Invention Process

When implementing the ideas of invention pedagogy and designing, the teacher's challenge is to engage all students in learning. In collaborative efforts, the teachers' primary aim is to sustain the practices that involve the students using their own ideas and organizing their collaborative process (Hakkarainen, 2009). In cognitively diverse classes, the need for differentiation is necessary because "one-size-fits-all" education must be changed to methods that support and inspire all students learning. Orchestration-minded invention pedagogy is convenient in cognitively diverse inclusive classes because invention activities are adaptable to various kinds of learners (e.g., Sinervo et al., 2021). To succeed, cognitively diverse student teams need support to participate in and develop the shared community. Overall, it requires orchestrating and promoting the collective pedagogical settings in which idea improvement is the central focus rather than a separate learning task or activity (Zhang et al., 2018).

Effective participation in design-oriented approaches to learning requires teachers' timely guidance in several layers of ongoing team, personal, and tool-mediated processes in changing situations. When describing this multilayered work, the concept of orchestration has frequently been used as a metaphor. It involves managing the collaborative processes within several ongoing trajectories in complex learning settings where the tools, materials, and supportive learning technologies are all connected and mediate the collective process (Littleton et al., 2012). Significantly, the concept captures the unplanned aspects of the enacted situations and therefore is well placed in the context of nonlinear settings (Hämäläinen & Vähäsantanen, 2011; Seitamaa-Hakkarainen & Hakkarainen, 2017).

On the other hand, the orchestrated settings can be positioned along a line between research perspectives highlighting the importance of structuring and scripting the processes of learning beforehand and perspectives emphasizing the emerging need for activities (Hämäläinen & Vähäsantanen, 2011; Prieto et al., 2011; Viilo et al., 2018). At one extreme, within a classroom based on pre-given and scripted procedures, the teacher often controls learning despite the student-centered aims (e.g., Kirschner et al., 2006). At the other extreme, there is a need to highlight the principle-based emergent knowledge practices that emphasize student and teacher invention and ownership (Sawyer, 2004; Zhang et al., 2018). Therefore, the success of invention pedagogy requires the right amount of structure and flexibility, with the teacher balancing between them. Only the teacher, who is familiar with the students and their needs, can define the suitable higher-level objectives and apply the strategic guidance of the process based on contextual knowledge.

When defining the elements of orchestration, it is helpful to distinguish the two meanings of orchestration, *orchestration design* and *dynamic orchestration*, as suggested by Sharples and Anastopoulou (2012). Designing of orchestration covers the previous arrangement of the learning setting. Dynamic management defines regulating and adapting the plans in unfolding activities and enacted practice to achieve productive results (Prieto et al., 2011; Sharples & Anastopoulou, 2012). Whether the aim is to create a structured or open-ended setting, both orchestration phases are present. However, the desired setting and the local context strongly affect how the orchestration design or the dynamic orchestration is created.

Creating Orchestration Design

When creating the design for inventory activities, it is essential to plan for improvisation and open spaces where teachers can support the students' ideas and lines of inquiry. However, sometimes designing orchestration has been associated with instructional planning (Prieto et al., 2011). The design can model learning activities, sequencing their time, event, and participant perspectives (Dillenbourg, 2015). It may include flexible macro scripting that supports the educational practices and actions of the proposed invention process and a collection of micro scripts to help the participants perform them. For instance, the invention pedagogy process models may be considered macro scripts (see Chapter 9 of this book). Nonetheless, the more explicit and rigid the educational structure or script, the less opportunity exists for flexible adaptation and improvising and spontaneous solutions present in genuine invention processes (Sharples & Anastopoulou, 2012). On the other hand, the teacher must work out beforehand how to help students with different learning orientations to be active participants in emerging processes. Especially in cognitively diverse classes, the students who struggle with their learning may benefit from well-designed learning tasks and adaptable approaches to fit different learners (Norwich & Lewis, 2001; Sormunen et al., 2020).

The overall orchestration design for implementing inventory and emerging activities can also be approached with the help of the pedagogical infrastructure framework (Lakkala et al., 2008). The framework suggests four supportive infrastructures: technical, social, epistemic, and cognitive, designed when creating student-centered pedagogical settings. The perspectives are partly overlapping in practice, but a teacher may use the framework as a thinking tool when creating the learning setting. In the context of invention pedagogy, the pedagogical infrastructures framework has also been applied in makerspace studies (e.g., Riikonen et al., 2020; Chapter 14 of this book).

In the infrastructure framework, the technological arrangements include the affordances of the tools for promoting design activity and the arrangements for providing access to and guidance for using the technology and tools (technical infrastructure). For example, the purposeful usage of technology embedded in students' practices mediates the participants' ideas and processes to team members or the whole learning collective. It makes the process stages or planning visible (Littleton et al., 2012; Viilo et al., 2011). Digital technology can also be viewed as a mechanism for inclusive, differentiated pedagogy that enables the use of multimodal learning materials, provides access to information and resources, and enhances function without stigmatizing any student (e.g., Cumming & Draper Rodríguez, 2017). It can be beneficial to struggling students, helping them to meet their curricular goals and to assist them in gaining social and functional skills (Sormunen et al., 2019).

In invention pedagogy, the social arrangements should entice the participants to collaborate and create a common ground (social infrastructure). The solutions to be made include how to foster interaction and collaborative action. Productive collaboration may require, for example, explicit rules, agreements, and organizational structures (Lakkala et al., 2008). Typically, a task that leads to productive interaction requires cognitive diversity and heterogeneous group structures (Hämäläinen & Vähäsantanen, 2011). Teachers can also support the collaborative process through flexible grouping in various forms, such as learning with a partner or in small groups (e.g., van de Pol et al., 2014). However, cognitively diverse groups often require teachers' support when preparing and implementing a project. Also, the learning task can be designed according to individual students' differentiation needs, such as integrating the differentiated academic content (e.g., more demanding aims for the more talented) into a student's group role (Sormunen et al., 2020).

In the spirit of design learning and invention activities, learners must treat ideas, plans, and prototypes as epistemic objects (see Chapter 3 of this book) that can be shared and jointly developed (epistemological infrastructure). In addition, educators should facilitate the participants' understanding and reflection on practices and processes to organize their developmental process (cognitive infrastructure). Students' self-regulative competencies and meta-skills for planning, monitoring, and reflecting on their work should be supported; this could take place through providing conceptual tools such as guidelines, models, or templates. When creating orchestration design, the infrastructure framework helps prepare the task structures, beneficial ways to interact, and other resources to support the process in well-working combinations. However, defining the best solution of task structuring between open-ended or structured tasks without contextual knowledge is not possible. Both ends may develop a sound basis for collaboration and invention (Hämäläinen & Vähäsantanen, 2011).

Dynamic Orchestration during the Invention Process

Hämäläinen and Vähäsantanen (2011) have pointed out that the main idea of orchestration is to combine design and improvisation; this means considering the unplanned aspects of the ongoing nonlinear invention processes. Dynamic orchestration focuses on the need for teachers to maintain the simultaneous ongoing activities on different planes: personal, group, and class (Sharples & Anastopoulou, 2012). When the orchestration design has been adapted to the local context, and the emerging occurrences in practice, the teachers' assessment provides insight into the progress and adequate adjustment (Prieto et al., 2011). Therefore, the teacher and students must iteratively reflect on learning and advancement of invention activity. However, in a well-orchestrated process, the teacher regulates the various aspects of the learning situation across multiple time scales: First, longitudinally from stage to stage adjusting the support as the process develops, and second, in real-time, during the enacted moments (Prieto et al., 2011;Viilo et al., 2018).

During the dynamic orchestration of the longitudinal invention process, the teachers cannot concentrate only on what any student or team requires at the moment, but also on what they believe the collective invention project and attaining its objectives require (Puntambekar & Kolodner, 2005;Viilo et al., 2018). It means supporting the long-standing efforts to create conditions for advancing the invention process such as guiding participants to document the advancement of inquiry, organizing, and planning the design process further (Hakkarainen, 2009; Seitamaa-Hakkarainen & Hakkarainen, 2017). It also means that the teachers must follow and reflect on the process in the background, and design the support needed based on the participants' achievements (Viilo et al., 2018).

The dynamic orchestration in real-time involves the features of improvisational teaching (Sawyer, 2004). The invention pedagogy that aims to support students' self-regulation, invention, and design activities, entails emergent and improvisational aspects during the process due to its nonlinear nature. In creative improvisational teaching, the teacher works with a unique group of students responding to their emergent needs (Sawyer, 2004). The processes need to be constructed as a shared social activity in which the students and the teacher manage and participate in the collective process together (Sawyer, 2004). However, improvisation in teaching should not be associated with unconstrained creativity and personal expression. The researchers who call for creativeness or improvisation in teaching also call for purposeful structures (Parker & Borko, 2011; Sawyer, 2019). To succeed, teaching needs to be anchored on disciplined or guided improvisation that gives students the freedom to build and create their knowledge while shifting between carefully chosen elements of structure (Sawyer, 2004, 2019).

The invention process based on students' plans and designing creates genuine opportunities and a need for collaboration and sustains collective object-oriented classroom discourses. However, the emerging classroom collaboration may require the management of the participatory aspects of social interaction that help participants contribute so that everyone in the team is participating and listening. The teacher also must observe and comment on students' reciprocal interlinkages and their relations to the materials and objects of inquiry. The genuine need for collaboration provides support for practicing collaboration skills through differently supported learning tasks (Hämäläinen & Vähäsantanen, 2011). Participants also need to have enough common ground and an emotionally safe atmosphere in which diverging beliefs and disagreements are critically examined, but not in a disputational way (Hämäläinen & Vähäsantanen, 2011).

The following sections illustrate four cases of orchestrating invention pedagogy in which the decisions involving the differently balanced structures and freedom varied. We concentrate on cognitively diverse classes, especially the student teams including struggling students. The purpose is to recognize the ways of working that may help all kinds of students' participation in invention pedagogy processes.

Context and Analysis

Orchestration of invention activities varies in cognitively diverse classes. We followed four invention projects in four classes using a multiple case study method (Stake, 2005) (Table 10.1). The classes had a similar variation of gender and ethnicity, and some of the participating students had been identified as struggling learners. In *Classes 1 and 3*, the struggling students worked among cognitively diverse teams during the projects. In *Class 2*, struggling students worked alone or with a pair and in *Class 4* in cognitively similar teams. We only followed a few teams in each class, although there were many more.

The aim of all projects was to design and invent an intellectually challenging, aesthetically appealing, and personally meaningful complex artifact that integrated physical and digital elements. The project name and learning objectives varied within projects. In *Class 1*, the student team's challenge was narrower than others focusing on a similar output, a scale model house. Other projects sought to find diverse, inventive solutions to everyday problems. The duration of the projects ranged from 11 to 14 weekly lessons (90 minutes per lesson).

The data were collected from teachers' project plans, researcher's observation notes, and students' portfolios. All teachers made detailed project plans in which they set the learning objectives. One of the authors participated actively in planning all the projects. During the project, she created detailed observation notes from each lesson. The researcher's role is significant, especially in cognitively diverse classes, in which the researcher must have participants' complete trust (Stake, 2005). The observation notes were compared to project plans and students' portfolios. The data was systematically investigated through theory-guided content analysis (Stake, 2005) grounding it on previous studies presented at the theoretical background. The pedagogical infrastructure framework (Lakkala et al., 2008) and the improvisational teaching (Sawyer, 2004) served us as the thinking tools when defining how orchestration design and dynamic orchestration were formed within the cases (Tables 10.2 and 10.3, first column). The primary aim was to illustrate how the enacted process took its form into practice by elaborating on the teacher's

Table 10.1 Background information and data collection of participating classes

Project	*Grade*	*Number of students (struggling students)*	*Teachers (assisting staff)*	*Number of co-inventions (personal inventions)*
Class 1: Scale model house	6 (ages 12–13)	44 (10)	3 (1)	4 (–)
Class 2: My invention	7 (ages 13–14)	6 (6)	3 (2-3)	1 (3)
Class 3: Everyday challenges	6 (ages 12–13)	47 (9)	3 (1)	13 (–)
Class 4: Smart product	7 (ages 13–14)	7 (7)	1 (1)	4 (–)

background organization and guidance during the unfolding activities. Our previous analyses have defined similar elements (Sinervo et al., 2021; Sormunen et al., 2020;Viilo et al., 2011, 2018).

Findings

The nature of orchestration varied from highly structured (*Class 2*) to highly flexible implementation (*Class 3*), providing information on effective orchestration practices. In what follows, we describe the main elements affecting the orchestration design and then elaborate dynamic orchestration of the invention projects through the teachers' organization before the lessons and teachers' guidance during the unfolding activities.

Orchestration Design

The orchestration design varied in different class settings according to learning design and support for active student collaboration (Table 10.2).

Learning Design

All projects were pedagogically anchored and were planned to begin with teacher-led ideation activities and continue through sketching to the production of functional prototypes. *Class 1*'s project design was based on maker-centered project-based learning, unlike the others (Sormunen et al., 2020), following a relatively linear and structured process from beginning to end. In *Classes 2*, *3*, and *4*, teaching and learning were based on nonlinear invention pedagogy. They followed the invention pedagogy process model as presented in Chapter 9 of this book.

Teachers in all classes set transdisciplinary learning objectives for the project, integrating science and mathematics, crafts, and visual arts, and four or five transversal competence objectives, depending on the project (Finnish National Agency of Education [FNAE], 2016). Two projects (*Classes 1 and 3*) included also Finnish language objectives, meaning that all students practiced reading, writing, or listening skills during the process. Unlike in other classes, in *Class 1*, the teachers had already considered the students' learning needs at the design stage. They set differentiated learning objectives for each student, especially for struggling students and talented students.

The projects' learning objectives also highlighted socio-digital (information and communications technology, ICT) competence as an object or tool for learning and technology-enriched materials were essential parts of all projects. In the Finnish curriculum (FNAE, 2016), technology education is a multidisciplinary and cross-curricular entity that is practiced in science (e.g., engineering), mathematics (e.g., programming), and crafts (e.g., designing and manual and digital crafting). Teachers included crafting and engineering elements in their project design, but more specific technology content was unclear during the orchestration design phase. However, programming was considered initially because some or many of

Table 10.2 Elements of orchestration design in four different invention projects

Elements	Class 1: Scale model house *Structured orchestration*	Class 2: My invention *Highly structured orchestration*	Class 3: Everyday challenges *Highly flexible orchestration*	Class 4: Smart product *Flexible orchestration*
Learning design	*Pedagogy* Maker-centered project-based learning *Learning objectives* Differentiated content of science and mathematics, crafts and visual arts, Finnish, and transversal competencies. Technology enrichened learning materials: crafting tools, electronics, multimodal learning materials, and digital portfolio.	*Pedagogy* Invention pedagogy *Learning objectives* Integrated into the invention/ design challenge: science and mathematics, crafts and visual arts, and transversal competencies. Technology enrichened learning materials: crafting tools, electronics, robotics, and electronic and maker kits.	*Pedagogy* Invention pedagogy *Learning objectives* Integrated into the invention/ design challenge: science and mathematics, crafts and visual arts, and transversal competencies. Technology enrichened learning materials: crafting tools, electronics, 3D designing, robotics, electronic and maker kits, and digital portfolio	*Pedagogy* Invention pedagogy *Learning objectives* Integrated into the invention/ design challenge: science and mathematics, crafts and visual arts, Finnish, and transversal competencies. Technology enrichened learning materials: crafting tools, electronics, 3D designing, electronic and maker kits, and digital portfolio.
Support for active student collaboration	*Engagement* Possibility to choose an engaging learning task and make a wish for group members *Grouping* Interest-, student- and teacher-led grouping based on students' wishes and intensive teacher-support for teams with struggling students	*Engagement* Possibility to choose an engaging learning task and work independently or collaborate *Grouping* Teacher-led grouping based on students' wishes and teachers' knowledge of students	*Engagement* Possibility to choose an engaging learning task *Grouping* Interest- and student-led grouping based on students' wishes	*Engagement* Possibility to choose an engaging learning task *Grouping* Interest-, student- and teacher-led grouping based on students' wishes and teachers' knowledge of students

the programmable devices were new to the students. In *Classes 2*, *3*, and *4*, the invention challenge directed students to use programmable devices. The teachers designed two to four lessons where students learned the basic skills of these tools. For example, teachers designed the programming lessons at the beginning of the project (*Classes 2 and 3*) or just after students had finished their initial ideation (*Class 4*).

Technology was also designed as a tool for process organizing. The digital learning environment (Office 365) was set up to mediate the process and achievements between students by organizing the process, giving guidelines and setting tasks (*Class 1*), and for reporting the progress of the process after every lesson and sharing it in the digital learning environment (*Classes 1*, *3*, and *4*). In *Class 2*, teachers chose not to use process portfolios. Teachers felt that the students should focus more on practical skills than academic ones to build the invention rather than getting frustrated with academic writing.

Support for Active Student Collaboration

Teachers designed support for active student collaboration by focusing on student engagement, giving them authority over their own learning, and using different grouping methods. In *Classes 1*, *3*, and *4*, the students were required to cooperate, and most of the students worked in pairs or small groups based on an interest-led, student-led, and/or teacher-led grouping. In *Class 1*, before the project, students completed an initial survey that mapped students' interests and asked them to assess which students in the class supported their learning best. Teachers grouped students according to their interests, but they also considered students' personal needs. Teachers planned struggling students' grouping especially carefully because research shows that careful grouping promotes student collaboration during the project and supports the development of social skills (e.g., Jenkins et al., 2003). In *Class 1*, the teachers also agreed on how to support every student team's work.

In *Classes 3* and *4*, teachers supported active student collaboration through interest- and student-led grouping, which took place after the first ideation session. In *Class 3*, the students were allowed to choose the most engaging invention idea and form teams and select team members by themselves. Also in *Class 4*, the students formed teams based on their interests, but the teacher made the final decision on each team's combination. She assessed what would be the team's chances of succeeding, reflecting on previous collaborative learning tasks. After teacher-student negotiation, some students changed teams.

In *Class 2*, the teachers encouraged students to collaborate, but also allowed them to work alone. Teachers based their decision on the fact that working with another student was particularly challenging for some students. Some students' participation was influenced by self-regulatory, socio-emotional, and other skills needed in peer collaboration. The teachers listened to students' perceptions and evaluated the meaningfulness of cooperation based on student knowledge.

Dynamic Orchestration

The teachers' dynamic orchestration that maintained the unfolding process was identified as teachers' organizing and guidance activities (Table 10.3). Each teacher's organizing included work and support prepared for the lessons. This support was based on the students' ongoing process achievements. The maintenance of the process during the lessons was the teacher's guidance. It involved flexible responses to the students' unfolding work and discussion.

The Teacher's Background Organization

In each class, teachers planned how best to support the students' invention process advancement during each lesson. Except in *Class 2*, teachers supported teamwork between lessons in a digital learning environment, in which they could provide multimodal learning materials (*Class 1*). The classes primarily used the digital learning environment to pursue and share student teams' process portfolios (*Classes 1*, *3*, and *4*). After each lesson, teachers went through each team's portfolios (*Classes 1* and *4*) and provided written feedback regularly (*Class 1*) or a few times during the project (*Class 3*). Teachers gave feedback on the content and quality of the process logs. The process portfolio helped teachers

Table 10.3 Elements of dynamic orchestration in four invention projects

Elements	Class 1: Scale model house *Structured orchestration*	Class 2: My invention *Highly structured orchestration*	Class 3: Everyday challenges *Highly flexible orchestration*	Class 4: Smart product *Flexible orchestration*
Teachers' background organization	*Digital learning environment* Checking teams' process portfolios and providing written feedback after each lesson and giving general or detailed instructions to teams for the next lesson. *Physical learning environment* Not addressed *Teacher resources* Dividing guiding responsibilities with teachers. Recognizing certain teams that need intensive support.	*Digital learning environment* Not used *Physical learning environment* Preparing the class with required materials and tools before a lesson. *Teacher resources* Planning how to place students based on previous lesson's student interaction. Dividing guiding responsibilities with teachers.	*Digital learning environment* Checking teams' process portfolios and providing written feedback a few times during the project. *Physical learning environment* Making the scripts for beginning and ending routines. *Teacher resources* Dividing guiding responsibilities with teachers.	*Digital learning environment* Checking teams' process portfolios and anticipating the teams' support needs for the next lesson. *Physical learning environment* Preparing for the next lesson with required materials and tools. *Teacher resources* Not addressed

(Continued)

Table 10.3 (Continued)

Elements	Class 1: Scale model house *Structured orchestration*	Class 2: My invention *Highly structured orchestration*	Class 3: Everyday challenges *Highly flexible orchestration*	Class 4: Smart product *Flexible orchestration*
Teachers' guidance during lessons	*General guidelines* Reminding to check portfolio feedback and to fill process portfolio at the end of the lesson. Following actively and scaffolding teams' work. *Personalized guidelines* Supporting some of the teams to organize their work at the beginning of the lesson. Leading reflective discussion after each lesson to guide students' collaboration skills and promote self-organization at the next lesson.	*General guidelines* Following actively and scaffolding students' and teams' work. *Highly personalized guidelines* Seating students in their places when they enter class. Starting the lesson with general instructions and helping them to organize their work at the beginning of the lesson. Modeling working if needed.	*General guidelines* Starting the lesson by reminding students of the routines and reminding them to fill process portfolio at the end of the lesson. Following actively and scaffolding teams' work. *Personalized guidelines* Supporting some of the teams to organize their work at the beginning of the lesson.	*General guidelines* Starting the lesson by reminding students of the routines. Reminding to take photos during the lesson for the process portfolio. Following actively and scaffolding teams' work. *Personalized guidelines* Helping students organize their work at the beginning of the lesson.

predict what the invention teams would do in the next lesson, what challenges they might encounter, and the kind of support they might need during the next lesson (*Class 4*).

The preparation of the learning space (physical learning environment) and the teaching team's division of labor (teacher resources) were also acknowledged as the teacher's background organization. Teachers supported the independent work of the intervention team by creating posters on the classroom walls that included step-by-step routines for starting and ending group work (*Class 3*). In some classes, teachers brought out the necessary materials just before the class (*Classes 2* and *4*) and arranged workplaces for the teams (*Class 2*) to ensure that students began to work immediately. In this way, teachers could prevent conflicts between students when setting up work (*Class 2*). Also, it was beneficial that teachers discussed each team's need for support and agreed on which of them was responsible for guiding each team before each lesson (*Classes 1*, *2*, and *3*). It also seemed appropriate to anticipatively consider what to do if a student fails to collaborate or make progress (*Class 2*).

Teacher's Guidance during the Lessons

Depending on the class setting, the teacher's guidance between the structured instruction and flexible guidelines varied. The lessons always had a similar start in all classes, and teachers gave explicit instructions for working during the lesson. Teachers also made sure that all students' and teams' work started. If the students had difficulties concentrating or regulating their behavior, the teacher moved on to work with them. In *Class 2*, it was often the case that teachers' support was identified as highly personalized. Typically, a struggling student had challenges, so the teacher worked side by side with a student doing the same task and modeling the desired activity. In *Class 2*, the teaching staff resources were considerable, with three teachers leading the project and another two or three assistants to support the students in each lesson.

In other classes, the organization of work was more flexible, and the goal was to reduce personalized support gradually. Teachers reminded invention teams about the posters on the classroom wall (*Class 3*) or commonly agreed (*Class 4*) routines, to review feedback or instructions that teacher had written on portfolios (*Class 1*), and to work on the portfolio during and at the end of the lesson (*Classes 1*, *3*, and *4*). Particularly in *Classes 1 and 3*, when mainstream students supported the work of struggling students, teachers emphasized the independence of student teams. They sought to personalize the work organization only for some groups by helping them get started at the beginning of the lesson (*Classes 1*, *3*, and *4*). Efforts were also made to increase the independence of the teams through reflective discussions at the end of each lesson (*Class 1*). In these discussions, the teacher aimed to guide students' collaborative skills and promote self-organization in the next lesson. When all invention teams were ready to work, the teachers followed their work and provided scaffolding if necessary. The independent student teams checked the teachers' feedback and instructions from the digital learning environment (*Class 1*). They could plan the lesson (*Classes 1* and *3*), divide tasks (*Classes 1* and *3*), and complete process portfolios (*Classes 1* and *3*) without teachers' support.

Concluding Remarks

This chapter defines the elements present in orchestration when implementing invention pedagogy in classrooms. We focused on the cognitively diverse classrooms, including students who struggle with their learning, to raise attention to the ways of working that help all students' participation. Figure 10.1 summarizes the appropriate orchestration design and dynamic orchestration that teaching teams should implement when guiding and scaffolding the co-invention processes of diverse students. We illustrated how the invention projects orchestration designs were created in different cases by setting learning design and support for active student collaboration. We also defined how the teacher's organizing and guidance activities maintained the processes in practice.

The case examples presented show that orchestration design has a significant impact on the success of a nonlinear invention project. The more diverse student

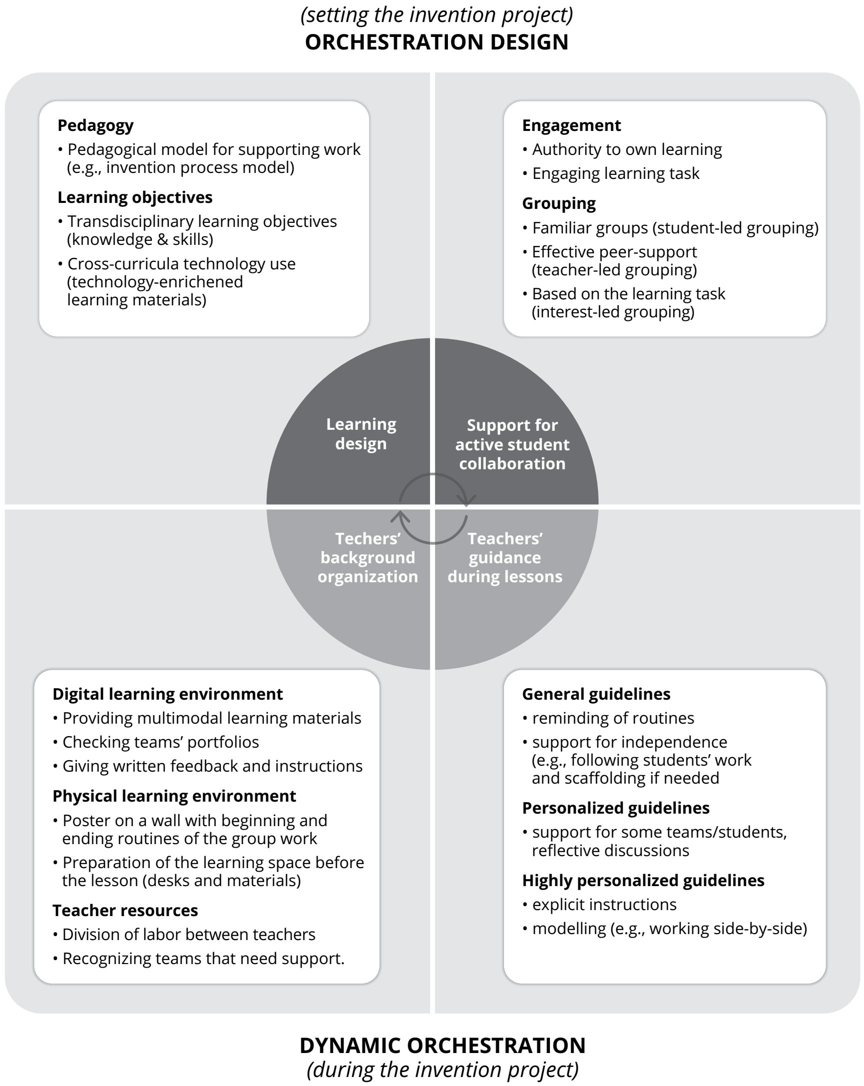

Figure 10.1 Model for orchestrating invention project.

teams are, the more carefully the teacher must plan for orchestration. The projects were settled by defining the transdisciplinary learning objectives raised from the curriculum and formed the content area with which the students worked during the invention process. The pedagogical models and the ideas of invention pedagogy supported the unfolding activities when developing the objects of the participants' processes. It is often perceived that struggling students benefit from a highly structured learning environment. However, our cases show that inventing exercises do not need to follow any strict order. The developing object determines the stages of the process and directs both the activities of the student teams and the guidance of the teacher. Carefully planned but adaptable orchestration design supports not only struggling but all students learning in nonlinear settings where invention activities unfold.

The orchestration design also considered students' participatory roles among the community and teams. The invention processes challenge participants to engage in collaborative discussions and designing. Collaboration and reaching mutual understanding require the skills to negotiate, build further on the discussions and the process, reflect on the process achievements, and make decisions together based on the current status of the invention process. All these skills and processes must be supported. In the present processes, the process design involved engaging learning tasks that gave students authority over their own learning. In addition, the well-planned and familiar groups and effectively constructed peer support helped the students collaborate and design their processes further.

Dynamic orchestration plays a vital role in the success of heterogeneous group invention projects. In the background, the teachers do well when arranging phases of the process, providing tools, and preparing the learning space for the coming lessons. It is also fruitful to comment on the student's processes in the digital learning environment, offer feedback, and provide additional materials to help their work. In most cases, organizing an invention project requires close cooperation between subjects and teachers and collective following of the ongoing process. In this way, different perspectives and a wide range of expertise are included. During the project, the presence of several teachers enables the implementation of flexible and creative teaching arrangements and solutions (see Chapter 11 of this book). However, dynamic orchestration must be planned between the teachers taking part in the project.

During the invention activities, it is helpful to rely on the plans created before the lesson and adapt them according to situational demands. The teachers' role is paramount in cognitively diverse classes for providing support and guidance throughout the process, responding to and sustaining the students' ideas, and advancing the design practices. The teachers should promote the groups' independence and interdependence and provide only as much support and structuring as the students' learning process and inventing requires. In most of the present classes, the students could affect their own learning processes, take responsibility for the process with teachers' help, and let go of it when the work proceeded. The teachers' support varied between the highly personalized guidelines to students' independent work. Some students were able to assume more responsibility earlier than others.

The purpose of this chapter has been to recognize the ways of working that may help the participation of all kinds of students in nonlinear invention pedagogy processes. To conclude, when orchestration works, students can assume more responsibility for their own actions. In successful orchestration, the support responds to emerging needs helping participants feel how their initiatives are highly valued. It creates ownership of the collective process and supports all students' belief in their own strengths.

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