Adaptive Professional Development during the Pandemic

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COLLECTION:
REMEDIATION OF LEARNING

RESEARCH

ABSTRACT

In Sweden, upper secondary school teachers made a swift transition into emergency remote teaching in 2020 due to the outbreak of covid-19. This paper reports on a Design-Based Research intervention in which professional development was designed using the Blended Learning Adoption framework, to support teachers to develop their teaching practices online. Twenty-six teachers participated in the intervention which spanned six months. Data was analysed using thematic analysis. Key results revealed that the pandemic had become an impetus for change, for many teachers, but far from all. Emerging teaching practices in synchronous online learning included: inviting special needs pedagogues in parallel breakout rooms, and grouping and re-grouping students when facilitating varied collaboration. Apart from realising new potentials of online teaching and learning, teachers identified emerging challenges such as: new ways of cheating, ethical aspects of accessing students' private homes via cameras and a lack of guidelines on managing disengagement. Conclusively, teacher's professional development and new experiences elicit new practices that could benefit teachers after the pandemic. Professional development during uncertain times and design principles supporting intervention ownership transfer are discussed.

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KEYWORDS:
professional development; upper secondary; COVID-19; distance education; ERT

TO CITE THIS ARTICLE:
Bergdahl, N. (2022). Adaptive Professional Development during the Pandemic. *Designs for Learning,* 14(1), 1–13. DOI: *https://doi.org/10.16993/dfl.172*

INTRODUCTION

Even during a pandemic, the teachers are to design learning that is inclusive and engaging (Kirschner, 2015; Nortvig et al., 2018). However, research undertaken during the outbreak of covid-19 in March 2020 identified that teachers were left to their own devices in transforming in-person to online teaching (Bergdahl & Nouri, 2020), that many teachers were novices to online teaching and learning and faced new challenges (Bond et al. 2021; Lockee, 2020; Trikoilis & Papanastasiou, 2020), highlighting a heightened need for teachers' professional development (PD) during the pandemic. PD during the pandemic has had diverse foci. Although there have been several PD initiatives during the pandemic (e.g., Clausen et al., 2020; Schildkamp et al., 2020; Trikoilis & Papanastasiou, 2020), there are still some unsolved aspects concerning delivery and content. For example, focusing on PD for Higher Education, Schildkamp et al. (2020) concluded that effective PD during the pandemic should target technological and pedagogical skills and be conducted with teacher mentors. Others (e.g., Clausen et al., 2020) designed a PD intervention that focused on school routines for communication to ensure students are not falling behind. However, pandemic restrictions may hinder in-person PD. To solve this, one school distributed educational research to teachers' homes (Trikoilis et al., 2020). From this, it is clear that traditional delivery of PD may not always be possible during a pandemic. In addition to issues of PD delivery, local, national and international reports have identified that students experienced monotonous teaching, social isolation and unavailable teachers as a result of emergency remote teaching (ERT) (Bond et al., 2021; Department of upper secondary and adult education, 2020; Grönlund, 2020; Swedish Students Council, 2020). The aim of this PD intervention was thus to try to develop and deliver flexible and relevant PD. Informed by the above reports, this intervention focused on supporting teachers to develop their online teaching practices in relation to: variation, social presence and interaction. A second aim was to analyse emerging practices and persistent challenges a year into the pandemic. The following research questions were raised:

1. What emerging teaching practices are teachers reporting in one upper secondary school a year into the pandemic?
2. What persisting challenges are teachers facing in teaching and learning in one upper secondary school a year into the pandemic?
3. What design principles can be deduced from the intervention to enable adaptive professional development during pandemic times?

BACKGROUND

ONLINE AND BLENDED LEARNING DURING THE PANDEMIC

Traditionally Blended Learning (BL) has been defined as combining in-person and online learning (e.g., Boelens et al., 2017; Bubaš & Kermek, 2004; Garrison & Kanuka, 2004; Graham, 2006; Liao & Lu, 2008; Thorne, 2003). When such combinations translates to simultaneous teaching of in-person and online students, this has been referred to as hybrid learning (Raes et al., 2020). Pre-pandemic studies have shown that today's students are positive and comfortable with online learning (Cain et al., 2016; Dimitoglou, 2019). However, experiences of online and distance learning during pandemic and non-pandemic times are likely to differ, as reports reveal that social isolation may increase stress (Beam & Kim, 2020) and that teachers (and students) not used to distance education may face significant barriers (König et al., 2020). Swedish reports have explored upper secondary school students' perception and experiences of ERT (e.g., Åkerfeldt, 2020; Bergdahl & Nouri, 2020; Öckert, 2021). Some have identified positive aspects, such as good organisation (Åkerfeldt, 2020) and little fluctuation in student grades compared to previous years (Öckert, 2021). However, negative effects have also been reported: students have experienced a lower degree of cooperation, loneliness and monotonous approaches during the shift to ERT (Åkerfeldt, 2020; Bond et al., 2021), even though interaction, social presence, and variation have been highlighted as critical for learning (Akyol et al., 2009; Järvelä & Renninger, 2014; Järvenoja et al., 2015; Mun Ling & Marton, 2011; Richardson et al., 2017). On a positive note, the shift toward more digitalised learning is likely to contribute to the development of teaching practices even after the pandemic (Bond et al., 2021; Greener, 2021; Holmström, 2021).

PD TO ENHANCE VARIATION, INTERACTION, AND SOCIAL PRESENCE IN ONLINE LEARNING

Due to the shift into ERT, students reported a surge in monotonous online lectures and reduced interaction (Bond et al., 2021; Grönlund, 2020). Several studies suggest that teachers should offer a variety of learning activities to support active learning and social interaction (Babadjanova, 2020; Ekayati & Rahayu, 2019; Mantra et al., 2019), and use the potential of digital technologies to, for example, invite special needs teachers into the online class (Kaden, 2020). Research has shown that increased online interaction creates active learners and increases learner engagement (Nguyen et al., 2016; Nortvig et al., 2018). However, a lack of interaction in online learning is not pandemic-specific (e.g. Andriessen & Baker, 2016). Research during the pandemic has found that interactions online do not in themselves lead to the same degree of social presence as interactions in a physical classroom

but require an adapted and informed design of learning (Wut & Xu, 2021). While using videos for learning could increase students' social presence, students preferred experiencing the *teacher's* social presence (Borup et al., 2012). The important caring teacher-student relationship and emotional support are essential aspects of learning, but it may be challenging for teachers to convey their social presence online (Joksimovićet al., 2015; Tomas et al., 2015). Social presence has been described as the degree to which a person is perceived as 'real' in mediated communication (Gunawardena & Zittle, 1997) and defined as "the effectiveness and impact of person-to-person telecommunications" (Short et al., 1976: vi). Schultze and Brooks compare the phenomena of presence with an illusion of non-mediation, e.g., "being there," and suggests that social presence is "produced in and through situated interaction" (Schultze & Brooks, 2019: 708). Digital technologies may enable social presence in the form of interaction with teachers, peers and the learning content synchronously during an ongoing lesson (Crook & Sutherland, 2017) or a sensation within a virtual world (Schultze & Brooks, 2019). Social presence has been related to student satisfaction with learning (Akyol et al., 2009; Richardson et al., 2017). While a pandemic may place extra demand on teachers, it may also be an incentive for developing teaching practices.

DBR-INSPIRED PROFESSIONAL DEVELOPMENT THAT FOCUS ON IT RELATED TEACHING PRACTICES

The quality aspect of online education remains an aspect to tackle (Fernández-Batanero et al., 2020; Hodges et al., 2020; Lockee, 2020; Schildkamp et al., 2020). Teachers' digital competence is closely related to the design and quality when digital tools and resources are employed (Caena & Redecker, 2019; European Commission, 2013; Fernández-Batanero et al., 2020; Hodges et al., 2020; Lockee, 2020; Schildkamp et al., 2020). Often, PD is viewed as a solution. However, PD has been critiqued for not leading to expected results for all teachers (Hargreaves & O'Connor, 2018; Körkkö et al., 2020). It has been forwarded that to be an effective intervention, PD should enable teachers to explore innovative approaches together with other teachers (Becuwe et al., 2017; Hargreaves & O'Connor, 2018; Lidolf & Pasco, 2020; Schildkamp et al., 2020) empower teachers in viewing themselves as designers, engage leaders and allocate time, (Becuwe et al., 2017). Such ideas are compatible with the Design-Based Research (DBR) approach, which is often applied for "designing interventions and solving classroom problems in various contexts" (Getenet, 2019: 483). Anderson and Shattuck (2012) and The Design-based Research Collective (2003) have forwarded several critical ideas that underpin DBR. Four of them are adopted as guidelines and are referred to as guidelines A-D.

A. That the goal of designing learning (and related environments) and developing theories are intertwined.
B. That development and research overlap in continuous cycles where design, practice, analysis, and redesign, are essential.
C. That DBR should inform practitioners and the field, for example, by identifying theory or design principles.
D. That the intervention is conducted in situ to reflect an authentic setting and to "focus on interactions that refine our understanding of the learning issues involved".

(The Design-based Research Collective, 2003: 5).

The uses of learning technologies must be guided by the vision to develop teaching practices and raise the maturity (quality and effectiveness) of institutionalised adoption (Graham et al., 2013). To this mean, DBR is a stable foundation for interventions, as it allows for flexibility and values stakeholder initiative (Bjögvinsson et al., 2012).

METHOD

CONTEXT AND PARTICIPANTS

This study was conducted in an upper secondary school (year 10–12) in one of the larger cities in Sweden. Twenty-six teachers participated in the study. The classrooms were equipped with projectors, and teachers and students had their own laptops. While the school had used Google Suite for Education (later Google Workspace for Education) for some time, additional features such as breakout rooms, Google attendance and Jamboard, had only been made accessible to the school in November 2020 and was thus a new feature for teachers. Upper secondary schools in Sweden shifted into ERT in March 2020. Schools were re-opened in August, just to return to ERT again in December. The period was marked with uncertainty, as school restrictions depended on the on the spread of the Covid-19 virus.

DESIGN-BASED RESEARCH INSPIRED ADAPTIVE PROFESSIONAL DEVELOPMENT

To answer the research questions, a DBR intervention that focused on combining workshops (n = 2) and online webinars and seminars (n = 3) was conducted. The intervention spanned six months (September 2020 – February 2021), during which time data was collected through photos, dialogues and observations. Following the principles of DBR, school interventions should derive from existing school practices and should ensure that the ownership of the intervention remains at the school (Anderson & Shattuck, 2012). The researcher aligned ideas with the principal and deputy principal and collaborated with the lead teachers. A lead teacher is a teacher who

has extended responsibilities to develop teaching and who supports other teachers (e.g., Petrie & McGee, 2012).

Intervention design

The intervention followed four stages (see ***Figure 1***). Each stage contained an adaptation of content and delivery to meet the current conditions and expressed needs of the PD, elaborated on below.

Step-by-step design of Adaptive Professional Development

The intervention design combines DBR guidelines A-D (The Design-based Research Collective, 2003) with the BL adoption framework (Graham et al., 2013). Graham (ibid.). proposes that the initial awareness and exploration phase is characterised by individual teacher awareness. The intervention supports increased awareness and the development of support (stage 1). Second, the schools move into adoption and early implementation, characterised by experimentation and emerging support of teacher implementation. Here, the intervention is geared to scaffold teachers' experimentation (stages 2–4). The guidelines are realised as follows:

A. The goal of designing learning and developing theories are intertwined, as the aim is to identify design principles to support the development of ADP.
B. The development and research overlap and include design, practice, analysis, and redesign (stages 1–3 and ***Figure 1*** reflect the parallel process of research and redesigns of PD.
C. Being published, the DBR intervention will inform the field.
D. The intervention is conducted in situ and focuses on the emerging practices and challenges.

Stage 1 – Workshop – Two workshops were held with two different groups of teachers. The first one was an in-house workshop, and the second was offered as a hybrid workshop. In the hybrid workshop, some teachers participated in person and others online. The workshops sought to inspire the teachers to explore blended learning activities together with colleagues and shared these with the group.

Stage 2 – Adoption – Teachers were encouraged to apply their lesson designs in their actual teaching. Classroom observations were conducted (and reported on elsewhere: Bergdahl & Bond, 2021).

Stage 3 – Theory implementation, adoption and reflection -Stage 3 contained several elements: I) a webinar, II) a lead teacher online collaboration, III) an online seminar, and IV) teacher online collaboration.

I. A 2.5-hour online webinar that focused on teachers' social presence, variation of learning activities and interaction was offered in mid-January. All teachers (n = 35) participated (but 26 out of 35 agreed to participate in this study). The webinar also included breakout rooms for collegial reflections, such as: "What aspects are you considering when planning for distance and hybrid learning?" and "How does polysynchronous interaction manifest in your subject?". Teachers were then instructed that there would be a follow-up seminar.
II. In the lead teacher online collaboration, the researcher proposed two alternative exercises to link theory with practice. The lead teachers chose "Designing learning in BL and online settings with a special focus on variation, social presence, and interaction". This exercise prompted them to focus on and further explore peer-peer interaction, variation of learning activities and social presence in their online teaching. The teachers developed an idea of how they and their colleagues could collaborate online (see ***Appendix A***).

Between elements II and III, the lead teachers undertook the practice related PD.

III. During the online seminar, the lead teachers presented how they had engaged in PD collaboratively online and shared their experiences

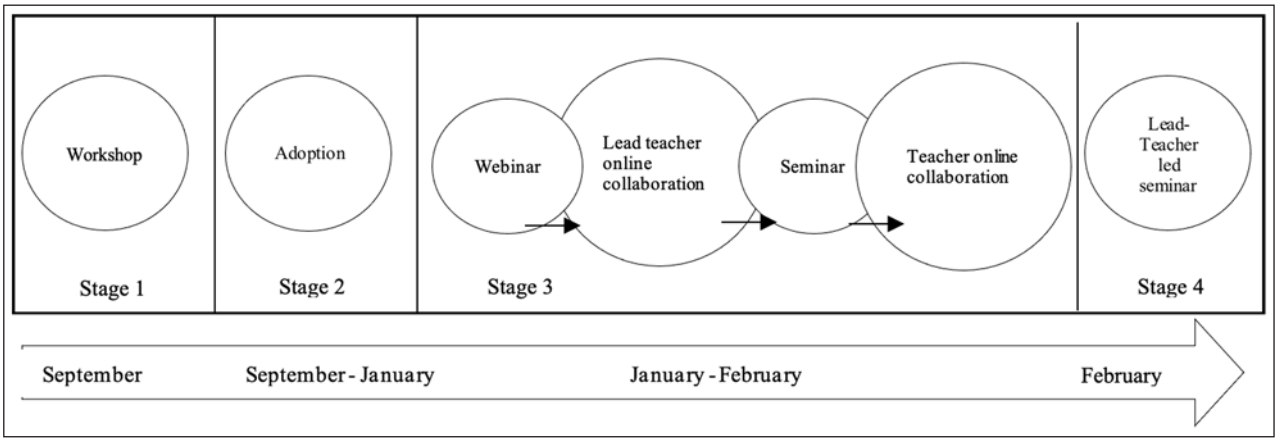

Figure 1 Intervention design.

(see ***Appendix A***). These were discussed in the group, were answers to questions were sought in research findings. This was done to validate and further nuance teacher reflections on conditions and other aspects related to online learning. Lead teacher reflections, ideas, revisions and plans for distributing the exercise (teacher online collaboration), as well as taking ownership of the PD to the rest of the teachers, were discussed. Stage 3 was thought to prepare the lead teachers to be able to answer similar questions when they, in turn, would run the online collaboration with the rest of the teachers at the school (stage 4).

Stage 4 – Lead teacher-led seminar –It was confirmed that all the school's teachers had connected the webinar ideas to their online teaching practices and discussed these using online groups as planned. No data was collected during stage 4 as the ownership of the PD had been transferred to the lead teachers. Here, a transfer of ownership is viewed as a success and means that the researcher no longer participates.

DATA ANALYSIS

To answer research questions one and two, workshop material (photos, field notes) and the online seminar (document and field notes) were analysed using thematic analysis (Braun & Clarke, 2012). The analysis was initiated adjacent to the data collection. Sequences of collected data that were meaningful to answer the research questions were coded using post-it notes. The post-it notes were then arranged to form themes. Single post-it notes were discarded. Emerging themes were checked against the data. A second analysis was conducted to answer the third research question. As design principles are "generated inductively from prior examples of success" (Bell et al., 2004: 83), each stage was approached using a reflective question: "What critical principle enabled ADP?". The initial principles were then abstracted to guiding principles that can be refined over time and transferred across settings (ibid.). This approach was guided by identifying the underlying principles that underpinned the intervention and may support PD during uncertain times and transfer of ownership (van den Akker et al., 2013).

ETHICAL CONSIDERATIONS

The principal provided consent to conduct the intervention series at the school. Subsequently, all teachers were invited to participate in the study. All participants signed the informed consent, in which they were informed of the purpose of the study, that they had the right to withdraw at any time without questions asked, and that data would be pseudonymised, which entailed replacing names with random letters blurring faces in photos.

RESULTS

THE WORKSHOP

The workshop was inspired by Arena Blended Connected Learning (ABC) (UCL, 2020) and focused on active and visible learning when using digital technologies. In the first workshop, all teachers were physically present. In the second, participation was hybrid: meaning that some teachers participated in person and others online. The instructions were to design a course and, within that course, design some lessons. The teachers collaborated in planning lessons and learning activities (see Photo 1–4). (See ***Appendix B*** for photo translation). Some groups focused on the variation of learning activities during introduction and laboratory demonstrations (see Photo 1).

Photo 1 Sample of design for variation

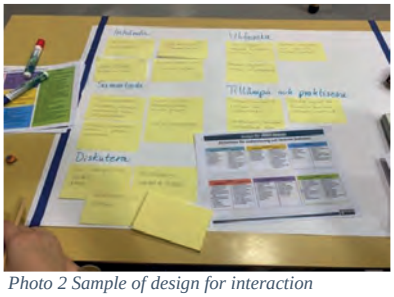

Photo 2 Sample of design for interaction

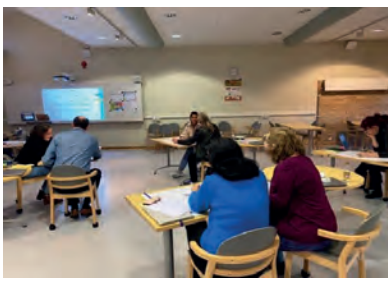

Photo 3 Workshop with teachers

Photo 4 Teachers collaborating

Teachers were instructed to focus on acquisition, collaboration, discussion, investigation, practice and production (see Photo 2) and explore innovative uses of digital technologies (and digital resources). The teachers were observed to plan for learning activities or a shared theme across several lessons and subjects. Classroom observations were conducted following the workshops between the workshops and the webinar (see Bergdahl & Bond, 2021). The "World Café" set-up scaffolded teacher interaction and sharing (Aldred, 2011). Teachers would mingle around and share their ideas and plans. Each participant was given stickers to vote for the best plan. A selection of the most high-ranked designs was shared with the whole group.

The results from the initial workshop were in line with Gudmundsdóttir et al. (2014) – results reveal that teaching practices could tend to remain traditional, with little innovation even though many teachers tried to increase their social presence, vary the lesson design and increase the online interaction. The actual shift in adoption was observed during the shift to ERT. Then teachers started to experiment with grouping students with different needs to offer more personalised learning, inviting special needs pedagogues for support, and 'walking' through the breakout rooms to engage with smaller groups of students.

THE ONLINE SEMINAR

In preparation for the online seminar, the five lead teachers were asked to try and develop their teaching practices by further exploring the teacher's social presence online, variation and interaction. Two weeks were allowed between the webinar and the final seminar to allow time for both implementation and reflection. During the online seminar, the five lead teachers individually presented their experiences, challenges, and emerging practices when developing 'teacher's social presence', 'variation of learning activities' and 'increased possibilities for student interaction' in online learning. At the end of the seminar, the lead teachers took ownership of the intervention and arranged for the same online collaborative learning and follow-up seminar with the other teachers at their school.

EMERGING PRACTICES AND PERSISTING CHALLENGES

Five themes were identified: 1. Exploring new features of digital technologies, 2. Enabling more individualised learning, 3. Supporting students online, 4. Change of conditions for teachers' classroom leadership and 5. Changed responses by students.

Exploring new features of digital technologies:

> "We tried to look at the variations that digital technologies could provide and include them in the learning activities". (Workshop 1, teacher A).

> "I tried to use Padlet to encourage interaction, but using plenty of different digital resources may confuse students. /.../ Google Drive documents and Google Quiz can be used to reach the same goal as Padlet [a shared space for student reflections and answers]." (Online seminar, teacher S).

Most teachers would *try to think* of variations when designing a lesson. Although encouraged, teachers did not have to adopt the lesson design they developed during their workshop. It was not until the actual shift into ERT that many of them shifted from tentative plans to describing actual innovative practices.

Enabling more individualised learning:

> "I created specific breakout rooms in Google Meet, based on [the teacher perception of] students' knowledge. That is how I divide them into groups for different exercises." (Online seminar, teacher C).

> "This virtual laboratory exceeded all my expectations. Students no longer need to take turns, but everyone can practise and try how it works, hands-on." (Online seminar, teacher E, when using an online virtual physical laboratory).

Acquiring experiences of student-teacher interaction, student digital skills, and ways for online communication, teachers started to realise the difference between teaching and learning in class instead of online. Real experiences triggered curiosity to experiment with variation online and how digital technologies change the conditions for learning.

Supporting students online:

> "The teacher later divided students into smaller groups, in which I could work more focused with the ones who needed more support. For some students, being allowed to participate online has been a positive experience. For example, for students with long-term illness, who otherwise had been excluded." (Online seminar, teacher G).

> "In my subject [Math], the interaction between students is hard to achieve as students rather work individually than engage in dialogues. That's why I introduced a general dialogue when starting the lesson, with questions relating to their everyday life. Using a randomising application, the student whose name turns up have to answer, and the student whose name turns up the second time has to comment." (Online seminar, teacher E).

Having two teachers meant that teachers could experiment with, for example, dividing students who need extra support. As any student could join the slower-paced group, there was no stigma surrounding

the need for help. These teachers were also more positive and identified applications to, for example, students who otherwise would not attend school. Teachers in some subjects (e.g., math) had to design an additional element of interaction and reported that interaction otherwise was not a natural element in their subject.

Change of conditions for teachers' classroom leadership

> "This particular class was rather fluent in their IT-actions, as they quickly shared their screens when asking the teacher for help so that it would be possible to see and understand what the students were struggling with." (Online seminar, teacher G).
>
> "One challenge is that we cannot control where the students are; if they are in bed, or at one time, the student was driving a car while attending the lesson. Second, our student group is highly disparate when it comes to using digital technologies. Third, we try to instruct the students to turn their cameras on to interact with them. However, by doing that, we enter into students' private homes. This affects the online experience for all, as we sometimes hear other people talking in the background, a mother passing with a basket of laundry or younger siblings. It may also invoke a sense of shame: many of our students may not have a normal standard home; they may or may not have their own rooms." (Online seminar, teacher D).

Teachers would build on their experiences and adopt a student-centred perspective. Here they would highlight positive aspects, like the usability of digital technologies for students to convey their need for help, but also a lack of control and concerns about student privacy, and guidelines to tackle disengagement.

Changed responses by students

> "Students complain that their digital tools are not working. Maybe this is an excuse for not participating in classroom activities." (Online seminar, teacher M).
>
> "I encouraged students to connect to a peer using their mobile phone. However, when I had an online test, I found that some test results were identical. Even if we can lock the screens in online exams, students have several devices they can use." (Online seminar, teacher E).

Teachers reported on both positive experiences and new challenges when shifting to online teaching. On the one hand, there were unexpected responses from students and new ways students might cheat or withdraw from learning, and a need to balance innovation and structure. On the other hand, students also evolved in their peer-to-peer interaction initiatives, which posed new challenges when not foreseen by the teacher.

DESIGN PRINCIPLES

One of the challenges with DBR is to transfer ownership (van den Akker et al., 2007). ADP is guided by the purpose of being flexible and relevant in terms of developing and aligning teaching practices during uncertain times. Three design principles that may support enabling PD and a transfer of ownership were identified: steering and letting go, enabling teacher autonomy and beneficial online collaboration.

Steering and letting go

The researcher was encouraged by the principal to work with the lead teachers in September. Even though DBR promotes inclusion, how, when and to what extent teachers are invited was found to be important. There is a need to establish relationships early, and ensure that the idea of the intervention aligns with the principal's. However, the researcher also need to steer the project in an intended direction to allow the (lead) teachers to 'grow into' the intervention. Through the many visits to the school during the six months, the researcher could build relationships with all teachers, not only the lead teachers.

Enabling teacher autonomy

In dialogue with the principal, it was agreed that the webinar would be held for all teachers, but that the researcher and lead teachers would conduct their separate final seminar, after which the lead teachers would repeat the process (collaborative online learning and seminar) with the rest of the teachers at the school. The principal then communicated this to the lead teachers.

The intervention applied a step-by-step approach where it was made a priority to:

- Establish ideas with the principal(s) allow them to involve (lead-)teachers
- Tap into current practices, needs and existing PD
- Conduct the first workshops to establish rapport
- Build relationships with teachers (consider balancing status)
- Be attentive and let go when (lead-)teachers indicate they accept ownership

Beneficial online collaboration

Online opportunities for learning must be beneficial to as many stakeholders as possible. Here, to be beneficial online collaboration was explored between I. the researcher and principal for alignment, II. the lead teachers for PD, practice, planning and execution, III. the

lead teachers – researcher for PD planning and executing. IV. the researcher to all teachers to distribute PD, both in hybrid form, fully online and asynchronously, as the 2.5-hour webinar was recorded and distributed to enable re-watching.

CONCLUSION

Conclusively, the answer to research question one, "What emerging teaching practices are teachers reporting in one upper secondary school a year into the pandemic?" is:

- Creative ways of using breakout rooms, resources for virtual learning and even new applications that they could have used in a BL setting
- Experimentation of digitalisation to increase individualisation and differentiation
- Special needs pedagogues work with all students in need in a breakout room without the stigma of being 'called out of the classroom.'

The answer to research question two: "What persisting challenges are teachers facing in teaching and learning in one upper secondary school a year into the pandemic?" is

- A reported lack of guidelines and consensus on how to handle emerging challenges
- That students may disengage undetected
- New ways of cheating
- Ethical aspects of accessing private homes via cameras

The answer to research question three, "What design principles can be deduced from the intervention to enable adaptive professional development during pandemic times?" is:

The identified design principles are:

- Steering and letting go
- Enabling teacher autonomy
- Beneficial online collaboration

Finally, the pandemic can be viewed as a vast school experiment, leading to increased discrepancies between teaching practices, with teachers in the forefront taking the opportunity to excel while teachers lacking digital skills are left struggling with designing basic learning activities. Experiences foreshadow educational development only if the momentum is regarded as an opportunity to seize by leaders. The broadened experiences and new practices may benefit teachers after the pandemic. While teachers would have developed their practices even without PD, such development is individual and unguided – and thus risk increasing uniformed and disparate practices. APD during uncertain and challenging times is critical. The above design principles were identified to support the distribution of flexible APD and a transfer of ownership.

DISCUSSION

Expanding the findings of Kaden (2020), teachers in this intervention also reported that breakout rooms were particularly useful and enhanced the learning experience in comparison to in-person teaching and learning. Such emerging practices included pedagogical changes (using breakout rooms to observe student dialogues or group students to individualise learning), which increased student focus, and administrative changes (not needing to find, book and transfer to a physical room). The teachers also explored virtual learning environments such as virtual labs and, expanding on the summary of benefits of virtual labs forwarded by (Heradio et al., 2016), which include availability and short notice access; the findings here revealed that all students could experiment without waiting for their turn, as opposed to in-person teaching. Teachers reported a range of new ways that digital technologies had enabled a more flexible way of working: with online PD, online teacher-parent meetings, a higher availability for one-to-one and small group interactions with students, which all saved the teachers' time. Importantly, teachers also emphasised increased possibilities for certain students with special needs and breakout rooms for slower paced instructions accessible to all, not just students with special needs. Such flexible solutions may remove the potential stigma of special needs, even during non-pandemic times.

König et al. (2020) also pointed out that many teachers "who had already software resources at their disposal and were familiar with their use in teaching were clearly advantaged when school closures began" (ibid: 617). In this study, teachers had the basic equipment but initially did not have access to breakout rooms and virtual laboratories. Interestingly, the teachers who reported insecurities, scepticism, or tech-aversion were the same who engaged little in the workshop and concluded that the adoption had not worked out well in their class(es). On the other hand, emerging ways of supporting students online that also reduced potential stigma was identified. This indicates that some teachers who experience aversion or insecurities toward digital technologies may need more hands-on support than the other teachers and that collegial support can boost development. Finally, as also indicated by (Holmström, 2021), the identified challenges included ethical aspects of student privacy, emerging ways of cheating and withdrawing from studies, and a lack of control of

student activities. Previous research (e.g., Körkkö et al., 2020) has noted that lack of support could negatively affect the PD initiative; the proposed design principles suggest an adaptation to the school's needs in terms of both content and delivery. Even though workplace support has been found to only account for a smaller part of teachers uptake of technologies (Instefjord & Munthe, 2017), the DBR approach includes a wider concept of stakeholder inclusion.

LIMITATIONS

As is the case with DBR interventions, they are highly context-dependent and conducted in situ. Thus, generalisations are highly limited. However, for the purpose of replicability, specific design principles were identified. As pointed out elsewhere (Anderson & Shattuck, 2012), DBR results should ensure a transfer of theory to practice, a requirement the presented data fulfils.

IMPLICATIONS

It is proposed that the DBR design principles align with school priorities and goals to enable acceptance and transfer of ownership. It is worth noting that with ownership transfer, the PD may no longer be driven nor accessible by the researcher. This is a paradox, as ownership shift should be desired (van den Akker et al., 2013). At the same time, it prevented further data collection, insight, and control. However, with that potential 'loss' comes potential 'gain'; in this intervention noticed as autonomy, initiative, and capacity to work without the researcher.

FUTURE RESEARCH

Online learning is indeed a new frontier in education, as neither virtual nor physical resources alone can provide the best teaching and learning environment. In the presented results, teachers reported on emerging practices; however, more research is needed on digital competence in education as a social practice that includes digital leadership, teacher self-efficacy and strategies to support special needs students in online learning. Moreover, traditional PD may not be enough to incentivise all teachers, thus not effective. It needs to be further considered how PD can be developed to meet individual digital scepticism if the schools wish to raise their lowest level of digital competence amongst personnel. Research exploring post-pandemic emerging practices and advanced lesson designs is critical to inform future practices, guidelines, and research.

Appendix A Adaptive professional development, online reflection log.

INTERACTION	SOCIAL PRESENCE	VARIATION	REFLECTION LOG
Presentations and lectures with the whole class. Students in small groups in Meet, based on their level of knowledge where collaboration is emphasised	Ask students to turn on the camera as much as possible. Alt. checking in using direct questions. Check-up tasks via Google Document and Padlet.	Work with Clio, use varying levels of difficulty. Distribute material using Google Classroom (GC). YouTube snippets to inform individual reflections and group discussions. Assignments via Google Drive (GD) and GC.	[...] student's claim technical issues cause absence. Copy/paste is used by some when submitting digital data. Technical support takes more time than expected and may be due to negligence. Try some new interactions in different subjects and groups, and reflect on whether/how it affected your social presence online.
Introduction to a lesson. Controlled interaction by asking each student how they were feeling. Review of the previous lesson. At the end of the lesson, I summarise what we have gone through.	The students had cameras on at the beginning of the lesson when I talked to them one by one. The students had cameras on at the beginning of the lesson when I talked to them one by one. Many of the students struggled with the new technology. (Emoji, survey)	The students were shown an emoji based on how they felt. I gave the students a survey question when we would finish the lesson.	[no additional reflection]
A lesson in Meet, where I support students and teachers. The teacher asks questions, the students "raise their hand" I distribute the word. [...] the students are divided into groups and work individually.	The camera is on at the beginning of the lesson when we meet and greet each other, and at the end when we say goodbye.	The lesson begins with teacher-led instruction; then, the students work in Nomp with similar tasks.	Several students did this without a reminder. Students are good at sharing screens with teachers when they want help. Like in the classroom, some of the students failed to raise their hands and just spoke.

(Contd.)

INTERACTION	SOCIAL PRESENCE	VARIATION	REFLECTION LOG
Discussions in breakout rooms (Meet). Controlled student-student interaction by inviting a student to comment on another student's comment or response (*https://wheeldecide.com/*). Solve tasks in math together	Encourage students to collaborate and discuss tasks in breakout rooms (Meet). The lesson begins with open-ended questions related to the lesson and the students' everyday lives. Small talk and positive comments welcome students at the beginning of the lesson.	Inläsningstjänst [Service which offers audio recordings of printed text]. Use quiz in the whole group. Work in virtual labs via: *https://phet.colorado.edu*, play a game (Kahoot).	[no additional reflection]
Individually, small groups, collaborative text construction. A) students who hide/their home conditions B) Good level of attendance/ability to participate in each module, c) the purpose is high-quality teaching, even if most of our students need teaching at school	The question in relation to general studies or the previous lessons	Oral group presentation Whole group, small group and individual work. Voting by show of hands, common text construction for youtube clips	[no additional reflection]

Appendix B Translation of text in photos.

Photo 1)

Reading up/lecture
(prior knowledge)

Hi- part 1
Facts
Timeline
I----------I [see below]
Killed enemies over the years! Mass death! 2 lessons

Animals in a well	Greek fire	Fire Oil Gunpowder	Industrialism Mass death	Mustard gas Machine guns	Mass death Concentration camps Lead bullets

Chem- part 1
I----------I
2 lessons

Photo 2)

Collect

1) Lecture, presentation
2) Active participation in demonstrations
3) Reading literature, books, articles
4) Digital books and similar web pages, YouTube

Explore

search/evaluate relevant information/facts
compare, analyse test – or number depending on content
use digital tools for evaluation

Collaborate

Small groups, discuss, co-write texts, presentations.
Active participation in demonstrations
Reading literature, books, articles

Apply and practice

search/evaluate relevant information/facts
Develop shared work in Google Classroom. Digitally: discuss peer work in small groups. Digital presentation.

Discuss

Pair – dialogue (IPA)
individually
group
Supervision
teacher – student dialogue

FUNDING INFORMATION

The study was partly funded by the city of Malmo, Sweden.

COMPETING INTERESTS

The authors have no competing interests to declare.

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TO CITE THIS ARTICLE:
Bergdahl, N. (2022). Adaptive Professional Development during the Pandemic. *Designs for Learning*, 14(1), 1–13. DOI: *https://doi.org/10.16993/dfl.172*

Submitted: 13 April 2021 Accepted: 17 October 2021 Published: 25 January 2022