Teachers' Design Processes: An Analysis of Teachers' Design Talk and Use of Pedagogical Patterns

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Abstract. Research on how teachers design to support learning and how teachers use different learning designs is still in its infancy. The explorative study reported here aims to approach an understanding of how teachers design learning activities by analysing upper secondary teachers' design work while using pedagogical patterns. Ten teachers working in pairs of two were invited to design and document learning activities based on pedagogical patterns. The findings reveal that (1) pedagogical patterns inspire teachers to embark on a design process that aligns with their own context, and (2) teachers' design processes share common general design characteristics and are, among other things, different, dynamic, unpredictable, and unsystematic. It is concluded that knowledge about teachers' design processes and the use of learning designs may inform researchers on how to develop design-supporting tools and resources.

Keywords*:* pedagogical patterns; learning design; designs for actual use; design work; design process; protocol analysis

1 Introduction

Since the introduction of technology in regular education, along with the rise of e-learning opportunities, researchers have extended their efforts in providing support for teachers' pedagogical use of technology. Valuable support for teachers' implementation of technology in their teaching has been provided by Technology-enhanced learning (TEL) research for several years [1], and Learning Design (LD) has emerged as a specific research field [2], [3], [4], [5] for tools [6] that support teachers to allow them to work as designers and as a whole regard teaching as design [7], [8].

LD encompasses web-based design support tools that allow teachers to create, communicate and share good ideas that support learning with technology [6], [9], [10]. Because the tools are intended to reach the teachers directly, without taking detours via instructional designers, they allow teachers to engage in communities in which they may share their knowledge [11] Currently, most LD tools are developed to enhance learning in any educational environment, be it face-to-face, online or blended [12]. (For a critical account of LD, see [13].)

Bennett, Lockyer and Agostinho [9] summarise what is known today concerning LD by the following (p. 1017):

1. Designs can be represented in systematic ways that formally document their pedagogic features.
2. Representations can be shared for other teachers to adopt and adapt to their contexts, to improve and share again.
3. Technology tools can be developed to support creation, representation, sharing and adaptation of designs.

The Learning Designer[1] is a prominent example of a free support-tool that boasts more that 590 public designs, hence "showing that teachers are willing to share their learning designs with their peers" [14, p.10]. The Integrated Learning Design Environment[2] (ILDE) integrates various tools and resources for the construction of learning tasks [15].

Pedagogical patterns is the LD tool that is the focus of our study. This design-supporting resource incorporates a design approach that emphasises descriptions of technology-related teaching problems and provides solutions to these problems [16]. The tool stems from a design pattern framework that was originally created for the proliferation of problems and solutions related to architecture [17]. Today, design patterns are used in human-computer interaction and interaction design [18], and the framework is equally useful for pedagogical purposes within the sphere of education: here, it is renamed pedagogical patterns. There are numerous pedagogical representations of teaching ideas in open repositories, books and articles on how technology may be used to promote learning in higher education, for example [19], [20], [21], [22], but pedagogical patterns have also been created at the compulsory school level [23], [24].

Different LD tools have been generated to support teachers' design efforts for learning. However, although knowledge of teachers' design activities would allow researchers to construct effective tools, what teachers do and think and say when designing learning tasks with or without LD tools is not sufficiently investigated [25], [26]. It has been strongly recommended to pursue such knowledge because "we are in need of conceptualisations of teacher design practice that can be further explored empirically to better understand the processes, influences and decisions involved in designing for learning and teaching" [9, p. 1019]. The descriptive study reported here seeks to contribute to the lack of research in this subject matter: it aims to increase the knowledge of the design processes of teachers and the design work that they do using pedagogical patterns. The research questions that guide the study are the following: (1) How do upper secondary teachers use pedagogical patterns? and (2) What characterises teachers' design processes when they use pedagogical patterns?

To accomplish this aim, a workshop was arranged in which participating teachers carried out design work in order to develop designs for actual use, a term borrowed from McKenny, Kali, Markauskatie and Voogt [27] that encompasses designs to be

[1] https://www.ucl.ac.uk/learning-designer/
[2] http://ilde.upf.edu

applied in ordinary teaching practice. The participants were instructed to use any of the pedagogical patterns from a collection that had previously been written by other upper secondary teachers [24]. A Teaching Activity Plan (TAP) provided a structure to articulate the designs in writing. Additionally, teachers' discussions and negotiations during the task were recorded. Document and protocol analysis [28] was used to analyse the teachers' design work.

Before we proceed, it is essential to clarify that *Learning Design (LD)* constitutes the tool or the framework that is developed by researchers. With an LD tool, a teacher creates a *learning design* that may be shared (for an account of the bewildering use of similar concepts, see [6]). Based on a learning design, a *design for actual use* is created by a teacher to be implemented in future teaching [27].

2 Background

Here, we will provide a brief introduction to pedagogical patterns, give an account of studies of design work in education and in a condensed form, describe common features of design processes.

2.1 Pedagogical Patterns

Because computer scientists in the nineties used design patterns, those researchers/teachers in higher education were already familiar with the framework at the time that technology was introduced to teaching. Design patterns were thus created for pedagogical motives and renamed pedagogical patterns [29]. The original design pattern concept as developed by Alexander in the seventies [30] has been criticised, among other things, for being pseudo-scientific [31]. However, scientific evidence and theory were stressed early on as prominent features for pedagogical patterns, for example [32]. By several iterations, it could be further ensured that the solutions could be validated to provide "a rationale which bridges between pedagogical philosophy, research-based evidence and experiential knowledge of design" [16, p. 92].

Specifically, writers of pedagogical patterns fill out an elaborated form that includes a set of sections. The original layout of design patterns graphically emphasised the "body" of the pattern, the problem and the solution section, by three diamonds [17, p. x-xi]:

A picture.
The context.
♦♦♦
The problem.
The solution.
♦♦♦
Related patterns.

This stylish way of representing good solutions to known problems has seldom been picked up by developers of patterns. Although the body of the pattern is kept, the

developers may add any other sections they consider relevant for a dissemination of the sound pedagogical use of technology [16], [32], [33]. In a previous study, a layout that was considered comprehensible enough for upper secondary teachers with no previous design experience was utilised [24]:

> Pattern name (title of the pedagogical pattern)
> Problem (a recurring problem encountered)
> Context (typical context of the problem)
> Solution (suggested solution to the problem)
> Maturity (the maturity of the pattern, in terms of how established the solution is)
> Miscellaneous (any other comment)
> The pattern creator's name and the date
> Pattern status (whether the pattern is currently in use or not)
> References to other patterns (that are necessary to accomplish the solution in the current pattern or that inform other patterns)

The original design patterns, as well as pedagogical patterns written by researchers, are often lengthy and may well cover a couple of pages, as in [19], [20], [22], for example. This is due to the demand that they must provide research-based evidence. Schoolteachers [23], [24], in contrast, tend to elaborate their writings less, and may express complex teaching ideas in just a single line. These designs are thus characterised as fragmented or incomplete [24], [34]. In addition, teachers that create pedagogical patterns do not use all of the sections that are provided by the format [24].

Pedagogical patterns are not recipes that the user is expected to follow exactly [35], [36], [37], [38]. Therefore, similar to any shared learning design, pedagogical patterns must always be modified by teachers in order to adapt them to the unique context of the actual teaching practice. However, as was noted many years ago, "attention has focused on generating patterns, rather than on using them" [39, p. 86].

We hope to provide some answers related to the use of pedagogical patterns by our analysis.

2.2 Knowledge about Teachers' Design Processes

The perception that teaching is related to design has been around for a long time (several examples are given by [40], but research conducted within TEL and LD give evidence of renewed interest in design issues for education [7], [8], [27]). There are several articles describing, for example, how teachers' design work is characterised in terms of the TPACK framework[3] [41], [42], [43]. Moreover, McKenny, Kali, Markauskaite and Voogt [27] propose an ecological framework for the support of research on different design issues. Svihla, Reeve, Sagy and Kali [44] suggest a "fingerprint pattern" in support of teachers' design efforts. However, detailed descriptions of how teachers

[3] TPACK is a resource for teachers that integrates seven aspects of teachers' knowledge about technology, pedagogy, and content to shape teachers' designs [15].

design for actual use are in their infancy [9], [25], [26], and hence, we were able to find only a few studies.

In two sub-studies, the design talk of kindergarten teacher teams while they designed learning material were examined. The first study [41] examined whether collective or individual activities predominated the design work. They found that collective brainstorming was frequently used. An analysis of the teachers' design talk also revealed that the designs were created according to their knowledge and beliefs, which are rooted in their experiences. Teachers' beliefs [45] are thus essential to the goal setting that "also calls into memory the kinds of activities that a teacher knows would work to achieve these goals" [41, p. 412]. Although the design process was mainly characterised as unsystematic, the teachers began the design work with problem framing, which was then followed by the creation of learning activities.

The minor, second study [46] investigated the contributions of individual participants. They found that teachers engaged in design work mainly contributed according to their different interests in either subject knowledge, beliefs or concern for practicalities. The results indicate that teachers' differences function as an asset that enriches discussions.

Bennett, Agostinho and Lockyer [12] interviewed university teachers with the aim of understanding how they design learning activities. The teachers were thus asked to explain their design process, and common strategies found in the teachers' design work displayed a structure in which "the macro features provided a scaffold for more detailed, micro-level design decisions" [12, p. 137]. Half of the teachers started with a focus on their subject's content, and the other half started by deciding on the learning outcomes. Both of these design approaches were then followed by a 'broad design', which included sketching out possible learning activities, learning outcomes, the scope of the content and assessments, which provided the teachers with a framework for their continued design work. Lastly, teachers specified the outlined details by, for example, choosing reading materials and deciding on assessment requirements. Similar to the Boschman, McKenny and Voogt study [41], the teachers' personal beliefs shaped the designs, and they preferred to be guided by what made sense to them instead of applying any particular learning theories. A conclusion drawn by the researchers is that teachers' design processes have similarities with general design, but they are not as systematic as the processes of instructional designers [12].

Thus, this article continues by giving a condensed overview of knowledge gathered about design processes done in traditional design environments. In this study, a mediating tool is introduced.

2.3 Characterisation of Design Processes

When it comes to defining design activity, Herbert Simon [47] is commonly referred to: "Everyone designs who devises courses of action aimed at changing existing situations into preferred ones" [47, p. 111]. Commonly, however, designers are those who create or improve artifacts (products, services and experiences) of various kinds.

Researchers find it difficult to agree on the methods designers apply when designing [28], and Stempfle and Badke-Schaub [48] explain that "empirical studies raise the question of whether designers follow any methodology at all" [48, p. 474]. Descriptions

of what designers do and how designers think are thus needed in order to understand the nature of designing. Because it is not optimal to ask designers about how they design [28], analyses of what innovative designers in fact do when designing has become the basis of the growing interest in design thinking.

A central element of design processes in general is problem-framing, which involves identification of the problem and the generation of solutions. The two activities are interdependent, like the two sides of a coin: "The designers select features of the problem space to which they choose to attend (naming) and identify areas of the solutions space in which they choose to explore (framing)" [28, p. 120]. The earlier in the process that designers can make priorities, the more likely it is that the final design is successful [28], [49].

Due to the complexity of the design processes, the description of these processes becomes extensive. Here is but a selection: A design process is *disciplined* [49], but is at the same time *exploratory*, as the stages of the design process alternate between unpredictability and control [28], [50]. It is not linear, but *unsystematic* [28], [49], [50]. The phases of the process influence each other during design work, and hence, the design process is *dynamic* [51]. The activity is *reflective*, as it requires the support of the designer's expert knowledge and previous experience [52]. Consequently, the activity involves *learning*, as it generates new knowledge and thus new meanings for the designer, which presumably may alter their guiding principles [50], [52]. Design practice is furthermore described as *situated* because the artifact is aimed to a certain context [50]. Design processes are *different* because the particular designer shapes the process [49], and according to Cross [28], individual preferences would explain why teams doing design work have difficulties in following prescribed processes. Because the preconditions for design work always change, design work is unique, and the process cannot be *predicted* [51].

Different aspects of the design process are reflected in the literature on teaching with use of technology and design. For example, Goodyear [7] and Laurillard [8] acknowledge that learning and reflection take place during teachers' design activities. Boschman, McKenney and Voogt [41] describe the design process as unsystematic. Guiding principles may, in the field of education, be equivalent to teachers' beliefs and are as such identified as an important factor for teachers' design decisions [12], [41], [45]. Also, there is a consensus among researchers that teachers' practice is situated. Incidentally, there are some aspects that may be further investigated, and not until research on teachers' design processes has expanded will it be possible to fully compare the general characteristics of design processes with those of teachers. The authors of this study can hopefully contribute to this research.

3 Method

An exploratory study of upper secondary teachers' design work while using pedagogical patterns was carried out. The overall research design was developed to facilitate the teachers' design work and to provide both oral and written data for the analyses carried out in the study. In the following sections, teachers, participants' tools and resources and the workshop design are presented, which includes how qualitative

data was collected. The section then moves on to describe the method applied for the analysis of teachers' design talk and for understanding their use of pedagogical patterns.

3.1 The Participants

Teachers at a small upper secondary school were invited to participate in a workshop to develop learning activities based on ideas about how to integrate technology in teaching. We considered interest in taking part in the study desirable, and ten teachers that represented different subject areas agreed to participate. The teachers themselves paired up to form five teams. This process was uncomplicated, since collaborative teams could be formed on the basis of shared teaching subject areas. Team 1 taught social study subjects, Team 2 taught mathematics, Team 3 taught social study subjects, Team 4 taught Swedish and Team 5 taught mathematics.

Teachers gave the researchers a written consent to participate and were informed about the study, about their right to leave the study for any reason, that data would be stored safely and that their identities would not be traceable.

3.2 Design Resource: Pedagogical Patterns

Twelve pedagogical patterns had been created in a previous study where teachers from other upper secondary schools collaborated in articulating their proven ideas on technology use in teaching [24] (Table 1).

The set of pedagogical patterns were presented to the participants as written by their unknown colleagues but were copied to separate papers of ordinary paper size and designed as exemplified by pedagogical pattern 1 (Fig. 1). Each of the proposed solutions for a problem are defined as sub-solutions.

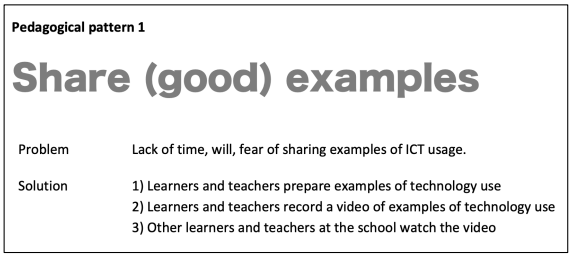

Fig. 1. Example of how pedagogical patterns were presented to the workshop participants.

The participants were not told how to use the pedagogical patterns; they were simply asked to choose a pedagogical pattern, or two, and to create a design for actual use based on it. The intention was to capture a relatively open-ended use of pedagogical patterns.

Table 1. Names, problems and solutions of the pedagogical patterns collection

Pattern name	Problem	Solutions and sub-solutions
1. Share (good) examples	1. Lack of time, will, fear of sharing examples of ICT usage	1. Learners and teachers prepare examples of technology use 2. Learners and teachers record a video of examples of technology use 3. Other learners and teachers at the school watch the video
2. The laptop is used only as a typewriter	2. N.A.	4. Encourage optional presentation alternatives 5. Use the tool to support a culture of sharing 6. Use the tool to support creativity
3. Internet source criticism	3. Learners do not reflect on the sender of sources of information	7. 'The Viral Eye' with examples of false sources 8. Wikipedia course 9. Reference guide for source criticism 10. Demand references—reflections in every part
4. Plagiarism, cheating	4. Learners hand in copy-pasted work. They are ignorant of the differences between writing a text in their own words, citing and plagiarising.	11. Make the learners show their work in progress 12. Demonstrate how to search and find the same material 13. Learn to referee—learn to reference
5. Invent pre-knowledge	5. The teacher is ignorant of the pre-knowledge or misconceptions of learners	14. Use a response app
6. A way to let everybody use their voice	6. Some learners do not want to speak up in class	15. Use digital and anonymous response apps such as Padlet, Kahoot, Socrative
7. Evaluating the lesson	7. The teacher does not know how much the learner has absorbed from a lesson	16. Use exit tickets at the end of the lesson, i.e., Padlet
8. Follow-up of previous lessons	8. Saved material in digital response apps can be used for future lessons	17. Students' earlier answers may be their new questions for later lessons. Ex. previous answers may recur as a question.
9. Learners work with concepts by flip	9. The learners need a basic knowledge of concepts, but their knowledge is at different levels	18. Give learners online access to all material (concepts, task, videos, links) and work at a preferred pace 19. The learners submit further questions via a form at the end of the lesson. 20. Learners take a digitalised mini-test after the lesson
10. Collaborative work by brainstorming	10. A group should be able to collect, think and brainstorm collaboratively in the cloud; all members should be able to edit; and nothing is linked to a user or screen. All learners do not need to be at the same place at the same time	21. Work in the cloud so that many learners can edit work, for example via Lucidchart or Padlet
11. Learners – collaborative work by brainstorming	11. Learners are not familiar with technology for sharing and editing	22. Learners work in a classroom with the teacher the first time using Padlet
12. Working anonymously on a group task	12. Social patterns in the classroom generate preconceptions about learners and what they can add to project work. Learners may therefore avoid working with classmates. This causes a problem, as the democratic values of the school support the development of confident learners that are able to cooperate with anyone in the classroom	23. Learners brainstorm together anonymously online in Padlet 24. Learners work anonymously in an online document for the creation of a presentation 25. Teach the learners how to use the applications

3.3 Data collection

How written and oral data was collected is described in the following.

Teaching activity plan. A teaching activity plan (TAP) was constructed beforehand by the authors to provide the teams with a common structure to use to articulate their designs for actual use. At the same time, what the teachers write in TAP constitutes qualitative data for analysis. The TAP focuses on central components for planning lessons, involving the subject matter of activities, why they are relevant for students and how they are to be carried out [53], [54]. The sections of the TAP are as follows:

Purpose: The aim of the learning activities.
Objective: What the students have achieved after completing the learning activities.
Steps of activities in writing: A detailed description of the learning activities.
Sketches or storyboarding of activities: Visualisation of the steps of the learning activities.
Tools and resources: The technology and other materials needed.
Preparation activities of the teacher: What teachers need to prepare to implement the learning activities.
Subsequent activities of the teacher: Work that needs to be done after the learning activities have been carried out by students.
Miscellaneous: Additional comments and reminders.

TAP was printed on large A0 paper to allow room to indicate any comments (Fig. 2). This paper size was chosen because we hoped that the unexpected size of the work material could invite creativity: for example, it could allow scribbles, the use of arrows to show connections or other tools often used when mind mapping.

Fig. 2. A team creatively uses the size of the workspace

Workshop design. Because we sought to arrange for an undramatic design environment, the workshop was held at the teachers' school in two ordinary but large classrooms after the end of the school day. The workshop lasted for two hours, which included an introduction by two of the authors who led the workshop. The introduction involved a presentation of the task and a description of the structure of the pedagogical

patterns. The task of creating a design for actual use was given as follows: “The task is to create learning activities based on one or more pedagogical patterns”. After pairing up, the teachers had an hour to complete their work. Although an hour time limit may seem to lead to stress, we considered the time reasonable and in line with the high work pace that teachers are used to. The design work could thus mimic the lack of time that teachers often mention. Each design team was given a large workspace with room for the TAP. During this time, the researchers worked as facilitators, which involved explaining the task or TAP when requested and sharing their thoughts and ideas, thus encouraging teachers’ design work.

Fig. 3. Participants amid design work.

The workshop ended with each team presenting their design for actual use to the other participants.

While the team worked on creating learning activities, the conversations were recorded and thus consisted of oral data for analysis.

3.4 The Analyses Carried Out

How the analyses were carried out on the basis of oral and written data is described in the following.

The use of pedagogical patterns. Quotes, or other explicit references of patterns that were used, were searched for in the design talk and writings in the TAP. In the case that the pattern involves a common concept that is much used by a team, the context helps us to understand if an utterance refers to the pattern or not. The most prominent example is “source criticism”. TAP sections relevant for comparisons with pedagogical patterns were limited mainly to three sections, namely the Purpose, Objective and Steps of the learning activity, since they best correspond with the content of the pedagogical patterns.

Quotes or explicit references to elements of pedagogical patterns would make it possible to examine the imprint that the pedagogical patterns made on teams’ designs

for actual use. In the case that the teams just mentioned pedagogical patterns without using them (which in fact was the case in a few instances), they were not noted.

For details, the use of the sections of the pedagogical patterns were examined, including the use of solutions, which together with the sub-solutions described in some patterns constitute twenty-one items. In addition, if whole sentences were not used, the elements used were noted.

The design talk. Verbal protocols were originally developed as a means to capture the problem-solving processes of individuals by asking them to think aloud during the performance of a task [55]. It is also used to capture dialog in teamwork in, for example, software design [56] and product design [48]. Examples of analyses of the verbalisation of P-12 students' cognitive processes are also to be found [57]. Recorded speech is transcribed, and segments of thoughts constitutes the transcribed protocol.

The purpose of the transcription made for this study was to maintain a flow of utterances that support an understanding of the teams' design work. Incomplete sentences and repetitions were omitted if they didn't add to the understanding of the design talk. Dialogues and remarks related to regulating the teamwork were excluded, as were team members' conversations with facilitators. Finally, segments were translated from Swedish to English by the authors.

The verbal protocol may be analysed by different methods. Christiaans and Almendra [56] used a decision-making framework that they have developed, and several different coding schemes have been identified by Grubbs, Strimel and Kim [57]. The inspiration for the analysis of the protocols of this study is the work by Stempfle and Badke-Schaub [48]. They suggest that the design process includes the following steps, but not necessarily in this order: Goal clarification, Solution generation, Analysis, Evaluation, Decision and Control (of facts and effects). These steps were applied as topics for analysis of design processes.

The topics for this study were adapted specifically to the design work of teachers (Table 2). The Problem definition is added to the framework: this involves the teams' description of the problem that the design for actual use is planned to deal with. Moreover, Previous experience is also added as a topic to include not only the teams' experiences but also ideas brought from others that would enable us to capture the extent to which designers take into account and articulate the competence of others during the design process. The original framework by Stempfle and Badke-Schaub [48] includes Analysis to cover utterances, which involves questions and answers about the solution and hypotheses. We have, however, considered this activity an integral part of Generation of learning activities. The original Control topic is, in our analysis, given the self-explanatory name Obstacles identification.

The authors first jointly decided on the topics and also discussed issues related to the transcription phase. In addition, the interpretation of the transcripts, that is, the analysis, was done iteratively and regularly discussed by the three authors, following suggestions described in [58], [59].

The results from the protocol analysis are presented through an illustration of the distribution of topics per team. As shown in the results section, each topic has been given a distinct colour in order to display the processes clearly, and the distribution of topics displayed is based on the number of words per topic. Time was opted out with

reference to the transcription method that omitted parts, as explained, of the teams' design talk.

Table 2. Topics, explanations and illustrative utterances retrieved from participating teachers' design talk.

Topic	Explanation	Utterances illustrating topics
Aim and goal clarification	The aim of the learning activities and what the students have achieved after completing the learning activities. (Identical to the TAP sections Purpose and Objective.)	"We will eventually use programming as a pedagogical tool that makes it easier for students to learn mathematics." (team 5) "It's really about understanding what you are experiencing." (team 3)
Problem definition	Conceptualisations of the problem.	"There are still relatively few who talk, so talk in front of the class." (team 2) "They are unaware of the difference between writing yourself and referencing, quoting." (team 4)
Generation of learning activities	Proposals, rejections, analysis associated with learning activities; the tools and resources selected; the teacher's preparation and subsequent activities.	"The student makes a presentation without a script and speaks freely, possibly with supporting words." (team 3) "Then we take all the examples as well. Plus the students' own ideas." (team 1)
Previous experiences	Teachers' own or others' experiences.	"My partner sits on a board of a sailing association and so they would do different things, scan in, sign papers." (team 1) "I posted a voluntary assignment in a class." (team 2)
Evaluation	Positive and negative statements regarding the suitability of the learning activities.	"It became much more advanced." (team 2) "to find 34 different math tasks …" (team 5)
Decision	Deliberations on the exact formulation of a learning activity to be written on TAP.	"You get a link, work two and two with it." (team 4) "Sign documents. Set up email accounts with names, etc." (team 1)
Obstacle identification	Perceived barriers to a successful implementation of the design or other problems that the teams find difficult to solve.	"I actually do not really know how it works." (team 5) "If they say they dare not stand there and record it." (team 2)

4 Results

An overview of the design work of the five teams introduces the result section. Please see Appendix 2 for reference. Next, teams' uses of pedagogical patterns are presented, which in turn is followed by findings that concern the teams' design processes.

4.1 Different Uses of Pedagogical Patterns

Overall findings concerning the use of pedagogical patterns are summarised in Table 3 and involve the pattern name and the body of a pattern, that is, the problem and the solution(s): (1) The teams were presented with 12 pedagogical patterns, and in total, seven of these were used by the teams, including a pattern that was used by two teams. (2) Two teams used two or three pedagogical patterns. (3) The problem sections of the seven used patterns were addressed by all teams. (4) Teams 2 and 3 did not use any of the solutions proposed in the pedagogical pattern. (5) Five solutions or sub-solutions were used in total by teams 1, 4 and 5. Although team 3 could have chosen to use any of seven solutions, none of them were used.

Table 3. The teams' use of pedagogical patterns.

	Team 1	Team 2	Team 3	Team 4	Team 5
Number of pedagogical patterns used	1	1	2	1	3
Problem description used	No	Yes	Yes	Yes	Yes
Solutions or sub-solutions used out of the total provided by the chosen pedagogical pattern(s)	2/3	0/1	0/7	2/3	1/5

A closer look at this use shows that in some cases the teams only select elements from the main sections of pedagogical patterns (Table 4). The use of a pattern's name, problem or solution(s) thus does not always apply to the original complete wording.

Table 4. Teams' use of elements from patterns' names, problems and solutions, highlighted in yellow.

Team	Pattern number and name	Problem	Solutions and sub-solutions
1	1. Share (good) examples	Lack of time, will, fear of sharing examples of ICT usage	• Learners and teachers prepare examples of technology use • Learners and teachers record a video of examples of technology use • Other learners and teachers at the school watch the video
2	6. A way to let everybody use their voice	Some learners do not want to speak up in class	Use digital and anonymous response apps such as Padlet, Kahoot, Socrative

3	3. Internet source criticism	Learners do not reflect on the sender of sources of information	• 'The Viral Eye' with examples of false sources • Wikipedia course • Reference guide for source criticism • Demand references—reflections in every part
3	4. Plagiarism, cheating	Learners hand in copy-pasted work. They are ignorant of the differences between writing a text in their own words, citing and plagiarising.	• Make the learners show their work in progress • Demonstrate how to search and find the same material • Learn to referee—learn to reference
4	4. Plagiarism, cheating	Learners hand in copy-pasted work. They are ignorant of the differences between writing a text in their own words, citing and plagiarising.	• Make the learners show their work in progress • Demonstrate how to search and find the same material • Learn to referee—learn to reference
5	9. Learners work with concepts by flip	The learners need a basic knowledge of concepts, but their knowledge is at different levels	• Give learners online access to all material (concepts, task, videos, links) and work at a preferred pace • The learners submit further questions via a form at the end of the lesson • Learners take a digitalised mini-test after the lesson
5	10. Collaborative work by brainstorming	A group should be able to collect, think and brainstorm collaboratively in the cloud; all members should be able to edit; and nothing is linked to a user or screen. All learners do not need to be at the same place at the same time.	Work in the cloud so that many learners can edit work, for example via Lucidchart or Padlet
5	11. Learners—collaborative work by brainstorming	Learners are not familiar with technology for sharing and editing	Learners work in a classroom with the teacher the first time using Padlet

4.2 Summary of Teams' Design Work

Not only are the teams' uses of pedagogical patterns different, so are the design processes of each team. To support the reader's ability to follow the presentation of results, a summary of the teams' design work is provided in this section. The outcome of the design work, which involves the TAP sections Purpose, Objective and Learning activities (Table 5), should further support the reader's understanding.

Team 1—social study subjects—was inspired by the prospect of having fun with their classes by allowing students to produce, in collaboration, video tutorials of software resources to give fellow students opportunities to develop digital competence. Hence, team 1 did not address negatively loaded words from the problem section, such as "lack" and "fear", but instead focused on the possibilities laid out by "sharing examples of ICT". The design for actual use describes learning activities as proposed in the first

and second sub-solutions, limited to learners' participation. The imprint of the pedagogical patterns is clear.

Team 2—mathematics—more or less kick-started their work by their choice of pedagogical pattern 6, as it inspired the teachers to generate an elaborated learning activity involving the introduction of quadratic functions to be launched in their respective classrooms the same week. The inspiration was the idea of letting every student speak, but as the teams' design work proceeded, they forgot about the pedagogical patterns. Thus, the pattern is not reflected in the design for actual use.

Team 3—social study subjects—worked on pedagogical patterns 3 and 4, concerning plagiarism, cheating and internet source criticism, which they perceived to be a severe problem. The team was thus able to find inspiration for their mutual understanding of problems described in the patterns. However, their main concern was found in a related problem about students reading from their manuscripts:

> *They should not stand and read beforehand. If they read from the manuscript, you do not know if they can possess the knowledge. I have asked afterwards but …*

They consider an oral presentation a learning activity, as it was written in the corresponding section of the TAP. However, we define it as an examination. What can be considered learning activities were found in the TAP section with the title "Preparation activities of the teacher". That came as a surprise to us, since their design talk revealed nothing about these activities. The imprint of pedagogical patterns is thus difficult to detect.

Team 4—Swedish—created a detailed design for actual use, based on pedagogical pattern 4, on how to help their students to understand how to write their own texts instead of just copying other texts. The imprint of the pattern is clear, as its sub-solutions are used. The team developed several learning activities that may train their students to be able to use their own words when describing phenomena found in other sources.

Table 5. Outcome of design work: purpose, objective and learning activity/activities according to TAP

Team 1	
Purpose: To give examples, train and discuss how to use ICT tools in a good way. **Learning activities:** • Review of materials. Students decide assignment • Execution • Presentation. 4 hrs.	**Objective:** The students have been trained to use and realized the benefits of a number of ICT tools for both computer and smartphone/tablet. Students find new and smart ways of working.
Team 2	
Purpose: Make the students more comfortable talking in the group. Have students discover the properties of second-degree functions. **Learning activities:**	**Objective:** Knowledge of second-order functions and the concepts that belong to it.
• Review of exercise (5 min) • Individually watch movies and ponder what they show (5 min) • Group breakdown (2 min) • The group discusses concepts/properties and correct terminology (10 min)	

- They prepare who says what (5 min)
- Practice on joint presentations and timing? (5 min)
- A group is selected to present to the class (5 min)
- Discussion on the concepts, positive response, suggest better concepts to allow as many as possible to speak (10 min)

Team 3	
Purpose: To help students to formulate their own words and thoughts as much as possible when presenting research in speech. Source-critical consciousness. **Learning activity:** About 10 min. Oral presentation with digital tools. The student speaks freely.	**Objective:** The student has developed the ability to: • Choose sources; • Evaluate sources; • Based on their own knowledge and information from sources, formulate with OWN words (Presentation based on speaker notes, i.e., without manuscript)
Team 4	
Purpose: Creating awareness of plagiarism • How do we borrow ideas? (From each other/by research/from others); • To cite sources	**Objective:** Students should be able to write texts "in their own words". Students should be able to refer to source material.
Learning activities: 1: Students write example sentences "with their own words". Then they can discuss. a) What have they done with the meaning? b) How was the meaning "yours"? c) Is the content/meaning the same? 2: Reference text. The teacher shows prepared papers together with the source. In full class. Students may discuss: a) What has been taken from the source? What is the idea? b) Who is the source? How does it look? The teacher can then graphically show how a paper works, with arrows, explanations and underlines showing what is what in the paper. (For example, source reference, summary markers, own words, etc.) 3: Students may try to write minutes. Students work in pairs with a link each. Now they have to write some longer texts.	
Team 5	
Purpose: That the students increase their mathematical knowledge through programming. To do so, they must be able to use the programming language used.	**Objective:** Students should have developed programming skills so that they can use this as a tool for mathematical problem solving.
Learning activity: The students work through a module in advance. During the lesson, they solve problems in groups. This takes place about once every two weeks and continues throughout the course.	

Team 5—mathematics—worked on a design that aimed to solve a major challenge for upper secondary school mathematics teachers. The new national curricula had recently introduced a requirement for programming in mathematics courses. The team initiated the design work by choosing pedagogical patterns 9, 10 and 11, as stated on the TAP. However, the basis for the problem was partly inspired by elements of two of the patterns, and the design for actual use is mainly based on the flipped classroom pattern. The imprint of the patterns on their design for actual use is considered low.

4.3 Different Design Processes

Figure 5 illustrates the distribution of topics for each team as captured by the protocol analysis. Although there are common features in the design work, it is visually possible to observe that no design process is identical to another. To identify the topics in the illustration, we refer to the following colours:

Aim and goal clarification, Problem definition, Previous experiences, Generation of learning activities, Evaluation, Decision, Obstacle identification.

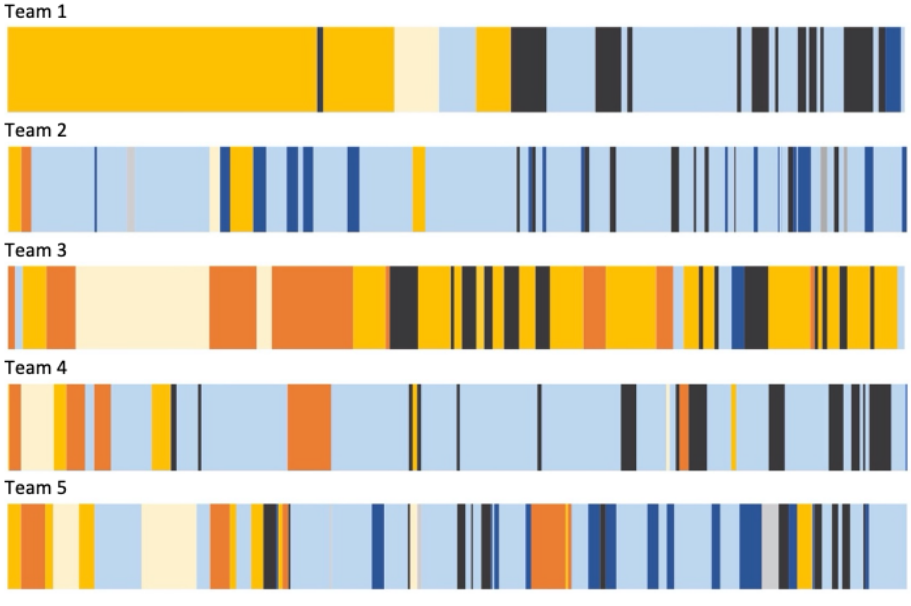

Fig. 5. The design process of five teams, illustrated by the topic distribution.

Key findings that can be discerned by Figure 5 about the design process include the following: (1) The design processes start by defining either the Problem or the Aim and goal. (2) Although all teams started similarly, the continuation of the process differed. (3) Decisions on Aim and goal are made later on in the process, and decisions are often clustered towards the second part of the design work. (4) Team 1 does not identify any problem to solve. (5) The design process after the first phase goes on to rotate between four topics, namely Generation of learning activities, Evaluation, Decision, and Obstacle definition. Shifts between these topics are a recurring feature. (6) Some teams return to the Problem or Aim and goal topics throughout the process. (7) The design work of team 3 is significantly different from the others, as Problem identification is a predominant topic of the teams' design talk.

Additional findings are revealed by a characterisation of each teams' design work (Table 6) per topic. The table also shows the proportion of each topic in the design process. We initially note that two teams addressed every topic, while the other three addressed five or six topics. Another finding concerns the Evaluation topic, which is mainly addressed by teams 2 and 5.

Table 6. Characterisation of the teams' design process per topic of the protocol analysis.

Topic	Team 1	Team 2	Team 3	Team 4	Team 5
Aim and goal clarification	Extensive negotiation 46%	Immediate agreement, later refined 6%	Recurrent 38%	Immediate agreement, later refined 5%	Repeatedly 9%
Problem definition	None	Immediate agreement 1%	Recurrent 24%	Repeatedly 11%	Repeatedly 10%
Previous experiences	Supports generation of aim and goal 5%	Supports the generation of learning activities 1%	Narratives confirm the problem 17%	Supports the problem definition 4%	Supports generation of course design 10%
Generation of learning activities	Extensive when focused 30%	Extensive throughout 73%	Limited 5%	Extensive throughout 66%	Extensive, but scattered 48%
Evaluation	Limited 2%	Limited, but recurrent 12%	Limited 1%	None	Recurrent 13%
Decision	Extensive, second half 17%	Few and precise 4%	Required efforts 15%	Concentrated to the end of the design work 14%	Recurrent 9%
Obstacle identification	None	Practical concerns 2%	None	None	Concerns about implement-ation 3%

An explanation of the results given by Table 6 can be supported by examples from the design talk.

Aim and goal clarification. As we have shown, collaboration may require extensive negotiations on what problem(s) to address but may also be a matter of instant agreement. Some groups reconsider the topic repeatedly, while some may be preoccupied with the issue throughout the entire design process. For example, team 3, building their design on pedagogical patterns 3 and 4, continue to clarify the aim and goal until the end of the design work:

> *If we are to include source criticism, then it must be clear how the work has been done. If the student says how he or she has worked, it is automatically an example of a source-critical consciousness.*

Problem definition. We also found extensive differences with regard to the problem discussions in the teams. It ranges from not being addressed at all to being a recurrent matter during the design work. The apparent absence of any problem as manifested by team 1 is worth highlighting:

> *I thought this one was fun. This, to work smart, to work with ICT as well. And besides, that 'b' I think is very fun. Record a movie… I think that is something you do a lot, in many contexts. It can be anything really.*

Previous experiences. This topic is generally not in focus; only team 3 refers to their own or others' experiences to some extent. What has been learned is that Previous experiences support any other topic involved in the design work. Team 1 finds arguments for the problem definition by referencing a previous experience:

> *I had that discussion with a student yesterday. He said it was just a sentence. "That's a good sentence." Yes, but that wasn't your words.*

Someone else's previous experience may also inform the design of learning activities, as exemplified by team 5:

> *I know [person's name] has been working a little like that. She had four classes in the same course. Then she made a lot of modules in Canvas and added recorded movies herself in her lessons and had a lot of tasks. I have not heard what the students thought about it. But she worked a lot that way. Instead of having four briefings on the same thing, she recorded one single briefing.*

Generation of learning activities. The efforts presented on this topic were different. Team 2 used 73% of their design talk on it, while team 3 used 5% on learning activities. A typical example of initial discussions related to the topic is given by team 4:

> *... then they get a reference text. Maybe with the source. Or first without the source. "What has been taken from the source?" Look at the source, compare the texts. "How did it become your own text? What was taken from the source?" It would have been nice if we then had it on the whiteboard. […] Here own words, here citation, here author …*

The Generation of learning activities by team 4 is described as scattered because they repeatedly tested their design proposals, that is, evaluated them, which is distinct from other teams.

Evaluation. This topic is related to the Generation of learning activities, but it is not much addressed by the teams, except for teams 2 and 5. Although the teachers of these teams have mathematics in common, we will not further develop this circumstance but are content with some teams regularly carrying out evaluations of ideas while others do not at all. A typical evaluative statement is represented by team 2:

> *I like the idea that we at school, with the help of the students, that the students make their own flipped classroom. That is, as there are lots of those movies, it is much more fun if the students do them as well.*

Decision. The search for a precise formulation of decisions that the teams felt they had to articulate on TAP was a recurring feature. In the following quote, team 1 struggles to formulate the goal:

> *Students have been training to use, and realised that … Using … experience realised … Using and experiencing the benefits of … Using and experiencing … Realised … the benefits of a number of ICT tools.*

Only limited references by team 3 to this topic are discerned in their design talk, which hence express an absence of mutual agreement of decisions.

Obstacle identification. Obstacles are identified by teams 2 and 5. The obstacle identified by team 5 was not resolved, and a consequence may be that only one of the group members can start the proposed programming course, which means that the design for actual use in fact may not be possible to implement:

> *… but I can barely program …*

The obstacles discussed by team 2 concern practical issues:

> *It gets very messy in the classroom if everyone is going to be there at the same time...*

5 Discussion

The design work was performed in teams with the support of pedagogical patterns and TAP. The disparate analyses of the teams' use of pedagogical patterns and design processes supports both together and separately the notion that design in pedagogical contexts exhibits characteristics that characterise design processes in general.

5.1 Use of pedagogical patterns and the design processes of teams

Concentrating first on use of pedagogical patterns, we have seen that no team did consider entire pedagogical patterns to be appropriate for the context of their teaching. Instead, they picked elements of the patterns according to their preference. Because pedagogical patterns will be reused only if the proposals are applicable in practice, the teams' different uses of pedagogical patterns underline *the situated character* of the design work carried out [7], [8], [28].

However, since all teams' design work was initiated either from a problem description or a suggested solution of the chosen pattern(s), pedagogical patterns seem to have the potential to spur a design process and inspire redesign [60]. Because redesign entails mindful choices and reflecting [52], the mere use of pedagogical patterns may steer design work towards an *exploration* of new ideas and alternatives [28], [47], [50], and to individual teachers' *learning* about different ways of combining, for example, different learning objects, technologies and activities [7], [8], [47], [50], [52].

During design work, some teams ignored the pedagogical patterns to the extent that the original pattern was not recognisable in the finished design. There were exceptions, however, in which both the problem and solutions proposed made a clear imprint on the design for actual use. The use of pedagogical patterns, involving a redesign of the original idea, is as a whole thus *unpredictable*, which also applies to design processes in general [51].

The design process in particular involve only a few similarities. Thus, it is characterised by *different* approaches to the design process which should be expected because different individuals shape different processes [28], [49]. The teams did not consistently complete one topic at a time but instead switched between topics [28], [41], [49], [50] in the pursuit of a design for actual use, thus characterising the process as *dynamic* [51]. The aims and goals originally agreed to were for example temporary and thus kept open for adjustments to ensure the effectiveness of the design for actual use.

Based on our findings, we consider difference a predominant feature of teachers' design processes [28], [49] and use of pedagogical patterns. For the understanding of the results, research in both TEL, LD and traditional design research can contribute to an integration of knowledge.

5.1 Future studies

The implications of this exploratory study clearly indicate a need to further reflect on and study how pedagogical patterns and other LD tools can be positioned in relation to teachers' intuitive design practices [9], [25], [26]. Such research is highly relevant, since LD tools are constructed to support the sharing and use of good ideas in teaching for the creation of designs for actual use [6], [9], [10], [11], [12]. When specific students' learning is the main goal, users/teachers will contextualise their design for actual use, and the use of elements of learning designs may be as limited as we have seen in this study. If the developers of LD tools are satisfied with such a narrow use, the structure of design support tools can work well. If not, a reassessment of LD is needed. In addition, if the developers of LD tools are satisfied with the characteristics of the design

work outlined in this study, including the uncertainty about how the design process will eventually go, LD tools will be able to support teachers as designers. Otherwise, the expected stimulating effect on technology-supported teaching may be moderate. Nevertheless, to further understand if other LD tools in general are reused or redesigned would shed important light on TEL and LD research.

In addition, we have noted similarities in the design work of teams 2 and 5 that were formed by mathematics teachers. They address the topics Evaluation and Obstacle identification more than the other teams. We believe that it would be interesting to further develop whether design processes for teachers in different subjects carry out different design processes.

5.2 Limitations

The results may, however, need to be interpreted with caution due to a set of limitations. First, the use of pedagogical patterns in this study may have been hampered by a feeling of respect for the researchers, a wish to comply with the task, as verbalised by team 5: "*I do not think at all that we have done what they thought we would do. It is very possible that we have floated away a bit.*" On the other hand, the same quote also makes it clear that the team was working on what they believed was relevant to their students. Another equivalent thought that could affect our results concerns the distinctive outcome of team 3. These two predicaments would perhaps have been explained by analysing group processes as well. However, the intention of the study was delimited to grasping the flow of topics during the design work of different teams using pedagogical patterns. Further studies that also involve group processes are considered an important asset for gathering deeper knowledge of the use of pedagogical patterns and teachers' design work.

Another aspect to address concerns the character of the pedagogical patterns that have been presented to the participants. Those patterns have previously been developed in a participatory design process [61] by upper secondary teachers [24] and are not as considerably elaborated as most of their academic counterparts [19], [20], [22]. Therefore, analyses of the use of extensive pedagogical patterns may come to other conclusions.

Because the analysis of design talk is dependent on the interpretation of transcripts, multiple iterations were made to ensure consistency, and we did not consider that an inter-reliability test would have achieved higher accuracy [59]. Despite the effort, our understanding of the design talk may not be replicable.

6 Conclusion

By integrating the use of pedagogical patterns with teacher teams' design work, we have been able to cautiously demonstrate that teacher design processes bear similarities with design processes in general. We have found indications that the design processes of teachers are different, explorative, reflective, situated, unsystematic, dynamic and unpredictable, and contribute to teachers' learning. Knowledge of teachers' design processes may inform and support researchers concerning how to develop design-

supporting tools and resources of various kinds. The findings, furthermore, may strengthen practice. Teachers, both in service and in training, can gain from understanding the planning process from a design perspective.

Pedagogical patterns, like other LD tools, aim at providing teachers with ideas that support their designs for actual use. This study shows that pedagogical patterns may provide inspiration for teachers, although the imprint of the pedagogical patterns was obscured due to an underuse of the available solutions given by the patterns. The prominent driving force for teachers' design work is the problem as defined in the framework, but the problem may prove to be neglected as the design process progresses. The consequence may be that teachers totally forget the inspiration for their work as the design evolves. We thus conclude that pedagogical patterns can inspire teachers to create designs for teaching.

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