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University teachers' learning paths during technological innovation in education

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ABSTRACT

Curriculum development initiatives, especially those involving educational technologies, provide a rich learning space for university teachers. In-depth interviews with teaching staff (n = 11) were qualitatively analysed to gain insight into the variety of individual learning paths and to identify potential relationships between learning paths, motivation, and conceptions of teaching and learning through educational technology. Three distinct learning paths relating to teachers' learning preferences and activities were identified: learning by performing daily teaching activities; deliberately experimenting with new teaching approaches; and reflecting on teaching experiences. The relationships between learning paths and relevant factors are described and implications for professional development practices are discussed.

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Conceptions of learning; educational technology; learning trajectories; professional development; teacher learning; workplace learning

Introduction

The implementation of new technologies is often challenging for teachers. It requires knowledge of the technological tools, in-depth knowledge of the subject matter, pedagogical knowledge, and pedagogical content knowledge (Lawless & Pellegrino, 2007; Van Driel & Berry, 2012). Therefore, staff development oriented towards improving the implementation of educational technologies should not only focus on the technological specifications of the tools, but also on the development of teachers' knowledge of how to use the tools effectively for the benefit of student learning. Training about the tool, however, is one of the more common types of professional development for teachers (Brand, 1998; Bybee & Loucks-Horsley, 2000). The success factors, challenges, and risks of some professional development initiatives which focus on strengthening teachers' ability to apply educational technologies effectively in their daily teaching have been described in the literature on technology enhanced learning (Ertmer, 2005; King, 2002). What has received less attention is the way teachers learn and develop professionally in their day-to-day work by participating in educational technology projects. However, in order to support teachers working in dynamic, technology-driven, and innovative projects, a deeper understanding is needed of how teachers learn and develop in these environments. Therefore, in this explorative study, we first identify distinct

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types of university teachers' learning paths while implementing educational technology, and then explore the influence of their motivation and conceptions of educational technology on their learning paths. If we know what motivates teachers to get involved in educational technology, and how they learn during educational innovation projects, then training and development programmes for teachers can be aligned with their preferred learning paths.

University teacher learning

The topic of staff learning in higher education is strongly connected to teacher professional development literature (Barrow & Grant, 2012; Blair, 2014). We define university teacher learning in this study as an active process in which teaching staff undertake learning activities that lead to a shift in their cognition and/or behaviour related to their teaching tasks (cf. Meirink, Meijer, & Verloop, 2007). Two dimensions of teacher learning can be distinguished (Bransford, Derry, Berliner, & Hammerness, 2005). The efficiency dimension involves the ability to perform certain tasks in a routine manner quickly and effectively. The innovative dimension requires teachers to give up old routines and change prior beliefs in order to learn to use new teaching strategies (Bransford et al., 2005). The focus of this study is related to teacher learning along the innovative dimension, as we studied university teachers who were implementing educational technologies that were new to them.

Teachers develop professionally in practice through experiences in their daily work (Meirink et al., 2007) and in particular by participating in collaborative group work (Sjoer & Meirink, 2016). This informal way of learning often remains unnoticed and undocumented. In order to uncover the informal ways of learning of employees, Poell and Van der Krogt (2010) applied the concept of learning paths. A learning path refers to 'a set of learning-relevant activities that are both coherent as a whole and meaningful to the employee' (Poell & Van der Krogt, 2010). Each individual teacher carves out his/her own particular route, using the existing opportunities and creating new ones along the way. Four aspects of learning paths of professionals can be distinguished:

- Learning themes: the subject of learning, the content of the learning path
- Learning activities: the activities that teachers do to learn
- Learning context: the social component of the learning path
- Learning facilities: the organisational aspects of the learning path

In this study, teachers' continuing professional development (i.e. learning path) is studied during educational technology projects in higher education contexts by qualitatively analysing their self-perceived learning paths. These learning paths are then related to their motivation and conceptions of teaching and learning through educational technology.

From previous studies, we know that teachers' conceptions of teaching and learning influence their approaches to teaching (Trigwell, Prosser, & Waterhouse, 1999), their way of acting in the learning environment (Pratt, 1992), and their learning from and in action (Meirink et al., 2007; Schön, 1983). This implies that conceptions not only influence the way teachers implement educational innovations, but also influence

their own learning. Based on these studies, we expect that teachers' conceptions of teaching through educational technology will influence their learning paths. Furthermore, the degree to which teachers implement educational technology, and their learning while implementing educational innovation, is influenced by their motivation (cf. Pynoo et al., 2012; Teo, 2011). Throughout the literature on technology use in education, teachers' conceptions and motivation are repeatedly discussed as relevant factors to understand the use of technology in education (Chai, Koh, & Tsai, 2013; Kim, Hannafin, & Bryan, 2007). Although other factors, such as social norms, expectations of department heads, and the need to make teaching more efficient and learning more engaging, might also influence teacher learning, in this article we focus on participants' motivation and conceptions in relation to their learning paths. To provide a framework for the analysis, we briefly explore below the concept of motivation for educational innovation, as well as the notion of teacher conceptions of technology in education.

Motivation for educational innovation

A determining factor in staff development is the extent to which teachers are motivated to participate in educational innovations. Intrinsically motivated teachers are likely to learn more effectively and perform better. Ryan and Deci (2000) described a motivational theory known as Self-Determination Theory (SDT), which provides an explanatory framework for understanding why individuals pursue specific goals and behaviours. SDT describes an individual's motivation on a dimension from amotivation along various types of extrinsic motivation to intrinsic motivation. Four externally regulated types of motivation are described, in decreasing degree of external regulation: 'full external regulation' ('This project gives me promotion'), 'introjected regulation' ('The head of the department told me to do this'), 'identified regulation' ('I do this project because it is part of my job as a teacher to innovate'), and 'integrated regulation' ('I work on this project because it is relevant to improve my teaching'). As is apparent from the foregoing, extrinsic regulators such as social norms, expectations from others, and personal values are all incorporated in the theory. The authors emphasise that motivation is a construct facilitated by three innate psychological needs. The first basic need is the feeling of autonomy, which represents an inherent desire to feel volitional in acting and to experience a sense of choice. The second is the need for relatedness, which is defined as an inherent propensity to feel related to the issue and to others. The need for relatedness will be satisfied if people experience a sense of value and belonging in a community around the topic of interest. Third is the need for competence, which is defined as an inherent desire to feel effective in interacting with the topic. Competence satisfaction allows individuals to efficiently adapt to complex and changing environments, whereas competence frustration is likely to result in helplessness and a lack of motivation. Satisfaction of the basic needs for autonomy, relatedness, and competence are considered conditions for individuals' motivation.

Conceptions of technology in education

Educational technology projects are characterised by a substantial amount of learning (Mishra & Koehler, 2006). Teachers give meaning to this multitude of learning activities

and experiences through their views on education. They differ in their conceptions of teaching and of learning, and these conceptions influence their perceptions of educational technologies. Chai et al. (2013) showed in their review of the literature on technology use in education that teachers' conceptions and technological skills are factors that influence the use of technology in education, which subsequently shape students' practice and perception (cf. Kim et al., 2007). In addition, they appealed for more studies on how teachers' conceptions shape technology use in education to clarify the relationships between beliefs, knowledge and skills, and contextual affordances and constraints (Chai et al., 2013).

In general, teachers' conceptions of teaching and learning can be placed on a continuum from teacher-centred/content-oriented to student-centred/learning-oriented (Kember, 1997). Their perceived valuation of educational technologies and their conceptions of teaching and learning are intertwined. Hooper and Rieber (1995) developed a categorisation of teachers' technology adoption into four phases. The familiarisation phase is concerned with teachers' initial exposure to technology. In this phase, the teacher simply becomes acquainted with a technology. The utilisation phase, in contrast, occurs when the teacher tries out the technology in the classroom. The integration phase represents the breakthrough. This occurs when a teacher consciously decides to designate certain tasks and responsibilities to the technology. In the reorientation phase, computer technology requires the teacher to reconsider the purpose and function of the classroom activities. In each of these phases, teachers' conceptions of the value of technology for teaching and learning are reconsidered and revised.

Research aims

Through this study, we aim to increase our understanding of university teachers' learning while implementing educational technology in their day-to-day teaching practice. Insights into teachers' learning during educational change projects can provide academic developers with the tools to support teachers, thereby assisting developers with the often challenging task of improving teaching and learning in higher education. The guiding research question therefore concerns the extent to which university teachers' individual learning paths in educational technology projects are influenced by their motivation, as well as their conceptions of teaching and learning through such technology.

Method

Data were collected using in-depth semi-structured interviews to capture the self-perceived learning paths, motivation for educational innovation, and conceptions of teaching and learning through educational technology of the participating teachers. Pre-structured questions focusing on participants' motives, intentions, and experiences in the use of technologies in educational contexts were used to stimulate the participants' reflective thoughts. The interviews were qualitatively analysed and emerging categories were used for the development of typologies of teachers' learning paths.

Participants

A purposeful sampling technique was used to represent the variation in participants' experiences and expertise. The participating teachers (n = 11) worked at four different higher education institutions. Background variables of the participants, such as age, gender, affiliation, and years of teaching experience, were collected with a short survey. Participants worked in a variety of disciplines: engineering (3), humanities (3), social sciences (2), and business studies (3). Four participants had received a PhD degree, six a master's degree, and one a bachelor's degree as highest educational background. Six participants were affiliated with a research-intensive university and five worked at universities of applied sciences, which are institutes for higher vocational education. Three women and eight men participated, ranging in age from 30 to 60 years. All participants had more than five years of teaching experience in higher education (see Table 1). The aims of the study were explained to the participants and they were asked for active consent. Participants could withdraw at any point during and after the interviews. In order to preserve the privacy of the participants, all names are fictitious.

All participants were involved in educational innovation projects with a specific focus on integration of technological tools in teaching and learning. Although these projects differed in focus, for example, peer assessment, digital feedback, video-lectures, or virtual research environments, all shared the common aim of improving the quality of the practice of teaching and to improve student learning. All of the projects were financed by the relevant institutes and the financial means were distributed through an open call for innovative projects. The participating teachers were awarded funds based on a competition, with criteria geared towards the innovative quality of the proposal and positive impact on the learning environments. Participants were invited to ask for support from academic developers within their institutions.

Qualitative analysis of interview data

The aim of the qualitative analysis of the interview data was to capture the variation in the academics' self-perceived motivation, learning paths, and conceptions of teaching and learning through educational technology. A qualitative interpretive approach, analogous to the procedures of a grounded theory approach (Charmaz, 2003), was followed when analysing the data. During the qualitative analysis, the interview data

Table 1. Descriptive characteristics of the participants.

Name	Gender	Discipline	Teaching experience (years)	Formal educational role
Nathan	Male	Engineering	5–10	Lecturer
Adam	Male	Business studies	10–15	Lecturer
Simon	Male	Humanities	5–10	Assistant professor
Edward	Male	Social sciences	5–10	Lecturer
Howard	Male	Humanities	5–10	Assistant professor
Celia	Female	Business studies	>15	Lecturer
Francisco	Male	Engineering	10–15	Assistant professor
Aisha	Female	Humanities	>15	Associate professor
Daniel	Male	Social sciences	>15	Associate professor
Sarah	Female	Business studies	5–10	Lecturer
Timothy	Male	Engineering	5–10	Assistant professor

were broken down into meaningful fragments, closely re-read, compared for differences and similarities, and re-interpreted in the context of the whole interview.

The first step in the analysis process was to select relevant, meaningful fragments about learning paths, motivation, and conceptions of teaching and learning through educational technology. Based on the literature, a list of relevant sensitising concepts was drafted to start the coding of the fragments (Charmaz, 2003). These sensitising concepts offered ways of organising and understanding the data and were embedded in our theoretical framework. For example, we used the four aspects of learning paths as a lens to organise participants' interview fragments about their learning.

Secondly, all fragments were labelled and similar labels were clustered, creating a list of meaningful descriptive categories. Labels which appeared to portray a new theme were assigned to new categories. Definitions and demarcation rules for each category were described based on the content of the underlying fragments.

In the third step, a research assistant (a graduate student in the social sciences) was involved to verify whether the meaningful descriptive categories could be applied by a person not familiar with the data. In an iterative dialogical process, all fragments were labelled by the research team and by the research assistant using the list of descriptive categories, definitions, and demarcation rules generated in the previous step. Categories, definitions, and demarcation rules were refined, based on negotiated consensus between assessors, creating the final list of meaningful descriptive categories, definitions, and demarcation rules (see Sandberg, 1997). In order to inform the dialogic process, three interviews were rated independently by a research team member and the research assistant using the final list of categories. The inter-rater reliability with two assessors was 0.66 (Cohen's κ) on the level of the sub-categories, and 0.91 (Cohen's κ) on the level of the main categories. This inter-rater agreement was based on 65 interview fragments and all sub-categories divided over three main categories (Learning path, Motivation, and Conceptions). The first and second assessors reached consensus on all labels and categories during the discussion and re-reading of interview fragments. Subsequently, description of the categories was adapted and descriptive categories were assigned to all interview fragments.

To study patterns within the distribution of categories among the participants in our sample, hierarchical cluster analyses (HCAs) were used to inform the qualitative recognition of patterns in the data (Everitt, Landau, & Leese, 2001). HCAs were carried out to explore whether relatively homogenous and stable sub-groups could be identified within the main categories of motivation, learning paths, and conceptions of teaching and learning through educational technology. By examining multiple clustering methods for binary data with different distance measures, reoccurring clusters provided additional input for the qualitative interpretation of the data. HCA results were only used as an inspiration to examine patterns in the interview data qualitatively. The analysis of patterns in the categories showed that many of the participants used phrases which could be identified as belonging to multiple clusters of motivation, learning paths, and conceptions of teaching and learning. However, for each participant a dominant cluster could be identified from the emphasis that the participants put in the interviews.

Results

The respondents experienced a high degree of autonomy and readiness for learning in the educational technology projects, since most teachers indicated that they voluntarily participated in the reform projects. Teachers could exert an influence on the direction of the reform and were self-confident towards their own competence, thus showing identified and integrated regulation of their motivation. Some teachers experienced limited time and a lack of support as constraining factors. In this section, we will qualitatively describe the patterns in learning paths, motivation, and conceptions of the participating teachers. In addition, we will describe a typology of teachers' learning based on the patterns in the data.

Learning paths

In the main category, the learning paths of teachers, three variations were identified. The first group (Path1) was identified by fragments on preferred learning through 'getting your work done' (Nathan and Adam). The second group (Path2) described their learning preference as 'experimenting' and 'collecting information' from other sources, such as literature and seminars (Celia, Howard, Francisco, Aisha, Simon, and Edward). The third group (Path3) often described their learning preferences in terms of 'reflecting' on their teaching (Daniel, Sarah, and Timothy). Almost every participant described that they learnt in collaboration with colleagues, more often than with external parties. Formal learning moments were rarely mentioned by the teachers in our sample.

In order to identify the learning paths of teachers, the respondents were asked about the elements of the learning paths. Fragments relating to teachers' learning paths were labelled based on the following categories: 'getting your work done', 'experimenting', 'collecting information', 'reflecting', 'formal learning', and 'social interaction'. The learning themes of the participating teachers were quite similar because all projects were geared towards the application of technological tools in education.

The fragments that were labelled as 'getting your work done' are characterised by a preference of teachers to do their work and learn from experiences. For instance, Adam mentioned 'I just have to get started in order to learn new things'.

Teachers who learn by 'experimenting' deliberately try out new teaching tools and formats, sometimes without thorough preparation. For instance, Simon likes to improvise: 'I like to try out that tool', and '[our academic developer] told us there is a programme available called Annotation-tool, which I had never heard of before. Then I simply click through the programme and I find out how the programme works.'

Teachers who learned through trying out new tools often also referred to collecting information. The category 'collecting information' is used for fragments emphasising teachers' preference to frequently inform themselves on education-related topics. For instance, Howard described the following process: 'We are in a stage now where we collect literature, we try to analyse, and where we try to gain a better image of what we know, what we don't know yet, so that we are able to ask people for specific advice at a later stage of the project'.

Learning by reflecting is characteristic of teachers who evaluate and consciously reflect on their own learning experiences so that they can improve themselves. Daniel repeatedly mentioned that he learned from reflecting: 'What we aimed for was a continuous feedback cycle and also because our starting point was that the student is the expert. So, we constantly have to listen to [our students]. […] That's what we steadily did. We had an idea, we started the process, we asked for feedback, and then we sharpened [our idea]'.

The category 'formal learning' includes learning moments during which teachers consciously learn at the workplace in a formal setting, such as mentoring, collegial consultation, or during formal training programmes and workshops. Finally, the category 'social interaction' is related to learning from others. This category was further divided into learning from students, academic developers, colleagues, support staff, and supervisors. Learning facilities as a theoretical part of teachers' learning paths were not often emphasised during the interviews, and when mentioned featured mainly as help from an academic developer and IT support staff. Both the category 'formal learning' and 'social interaction' were evenly distributed among the learning paths.

Motivation for implementing educational technology

Three qualitatively different clusters of teachers could be recognised, based on the categorisation of fragments about the motivation of the participants. A cluster of participants (Mot1) placed strong emphasis on their feeling of autonomy (Celia, Daniel, Timothy, and Adam). A second cluster of participants (Mot2) emphasised their involvement in teaching and learning from multiple perspectives and academic roles (Nathan and Edward), while a third cluster (Mot3) emphasised during the interviews their competence in working with educational technologies (Sarah, Timothy, Francisco, Aisha, and Simon). Almost all participants described their general enthusiasm for educational technology projects in which they could improve the student experience and student learning.

The fragments related to motivation were selected based on the sensitising concepts of 'autonomy', 'relatedness', and 'competence' (Ryan & Deci, 2000) in projects aimed at improving education with technologies. To illustrate participants' perception of autonomy, Daniel mentioned in the interview: 'I was asked to develop a course. They said: "Do whatever you want". For me as a teacher and innovator, that is heaven indeed'. Relatedness was divided into the sub-categories 'combination of roles', meaning that the fragment emphasised fulfilment of several roles in an academic community (e.g. being a teacher, a researcher, and/or a project leader), and 'enthusiasm', referring to the positive feelings of relatedness to the topic of the educational project. For example, Adam commented: 'I simply really like to work on that issue'. And Aisha mentioned: 'I love teaching, I really enjoy it. After teaching for thirty years, I really got interested in the topic […] so for me that is a kind of eagerness'. In order to identify participants who perceived difficulties in dealing with educational technologies, and those who did not experience any such difficulties, competence was divided into the sub-categories 'low self-confidence' and 'high self-confidence'. Sarah described that educational technologies are difficult to deal with: 'I have a kind of the struggle with the application of

educational technologies in education. I always use clips from YouTube and websites and so on, but really implementing technological applications is a serious job for me'. One of the fragments from Celia is categorised as 'high self-confidence': 'I think that I am a very good user of technological tools. And that is very closely related to which tools I grew up with and to what I already used it in my teaching'.

Conceptions of teaching and learning through educational technologies

Based on the sub-categories related to teachers' conceptions of educational technologies, teachers were clustered into three different groups. One was a group of teachers (Con1) who emphasise the unchanged role of the teacher throughout any educational reform. This group described educational technologies and innovations as having a role in supporting the work of the teacher (Timothy, Howard, Simon, and Edward). This could, for example, be that of making assessment of students less time-consuming, or making the student–teacher communications more convenient for the teacher. A second group of teachers (Con2) described their conceptions of educational technologies in terms of improving the curriculum for student learning, more possibilities to differentiate between student needs, and increasing the visibility of information for students. This group of teachers distinguished themselves by fragments explicating their 'expectations for student learning' (Celia, Nathan, and Adam). The third group (Con3) could be distinguished by fragments on the role of technology in education to 'inspire' and 'challenge' students. The teachers in this group emphasised their view that 'interactive learning', for example, in discussions with the students, is a positive component of educational technology because it challenges students to interact about the content of the courses (Daniel, Sarah, Francisco, and Aisha). In general, almost all teachers in this group (Con3) described their inclination for 'student-focused approaches to teaching and learning'.

To identify teachers' conceptions of teaching and learning through educational technologies, fragments were labelled as 'focus on student development', 'focus on content', and 'focus on student–teacher interaction' to distinguish between teachers' emphases in their approach to teaching with technologies. For instance, Celia emphasised a 'focus on student development': 'The main point is that the students learn to think critically and also to judge the value of sources, and do not follow thoughtlessly what someone else said'. Several other fragments were labelled as 'inspiring students', in order to identify teachers' aim to inspire students through the use of technology in education. As an example of this category, Daniel said in his interview: 'As a teacher I am [. . .] the guardian of curiosity. I think that's the most important task of a teacher, to motivate students'. The category 'remaining role of the teacher' refers to fragments in which teachers emphasise that they believe that the teacher will always be an essential part of the learning process and cannot, for instance, be replaced by any technological innovation. For instance, Aisha put it as follows: 'Intense face-to-face conversations between me and my students still remain essential. I organise them as much as possible'. Furthermore, 'resistance' referred to struggles and a negative attitude towards the use of more technology in education. Moreover, the participants were asked in what way they used educational technologies. The sub-categories 'increase learnability', 'challenge students', 'easily find information', 'repeating', 'support for the teacher', and 'communication' emerged from the data. Timothy, for instance, uses educational technologies to support himself in

daily teaching activities: 'I think that it [educational technologies] can be a good support. Some parts of my teaching are more or less the same and technologies can nicely support in doing these activities, so that I have my hands free to do other things'.

Relation between motivation, conceptions, and learning paths

Table 2 presents an overview of the main categories of teachers' learning paths that we could distinguish in terms of the three identified pathways: (1) 'getting your work done', (2) 'experimenting' and 'collecting information', and (3) 'reflecting' on own experiences. Furthermore, Table 2 shows participants' dominant clusters of motivation for implementing educational technology in their courses, and their conceptions of teaching and learning through educational technology. For all concepts, the main clusters are presented in Table 2. The underlying sub-categories, as described above, are left out in order to detect patterns in the relationships between the concepts in our data set.

Most participants (6 out of 11) preferred to experiment and find information about educational technologies during their projects. Those participants preferring this experimental learning path were spread across all three identified conceptions of teaching and learning through educational technology. In this group, no pattern can be distinguished between conceptions, motivation, and participants' learning paths.

Only two participants emphasised in their interviews that they preferred to learn through their day-to-day activities. In their interviews, they emphasised that their learning does not require deliberate action, but happens unnoticed during daily activities in their projects. Both participants advocating this learning path also described their conception of educational technology in terms of the benefit for differentiating student activities. The value of educational technologies lies in the wide variety of possible ways to present course content, and ways to foster students' learning, such as continuous feedback, discussion forums, and peer feedback.

Three participants advocated learning through reflection on their experiences. Reflection could consist of a variety of activities, such as deliberately asking for feedback

Table 2. Participants dominant cluster of motivation, conceptions of teaching through educational technology, and learning paths.

Name	Learning path[a]	Motivation for implementing educational technology[b]	Conception of teaching through educational technology[c]
Nathan	Path1	Mot2	Con2
Adam	Path1	Mot1	Con2
Simon	Path2	Mot3	Con1
Edward	Path2	Mot2	Con1
Howard	Path2	Mot3	Con1
Celia	Path2	Mot1	Con2
Francisco	Path2	Mot3	Con3
Aisha	Path2	Mot3	Con3
Daniel	Path3	Mot1	Con3
Sarah	Path3	Mot3	Con3
Timothy	Path3	Mot1	Con1

[a]Path1: get your work done; Path2: experimenting; Path3: reflecting.
[b]Mot1: strong feeling of autonomy; Mot2: involved from multiple perspectives; Mot3: limited competence.
[c]Con1: technology as support for teacher; Con2: differentiate between student needs; Con3: challenge and inspire students.

from students or colleagues, locating good practices in literature, and critical self-reflection on teaching practices. Two of these three participants who indicated preferring to learn through reflection conceived the value of educational technology in terms of challenging and inspiring students. Through educational technology, a wide range of new teaching approaches become available to assist teachers to challenge students.

Discussion and conclusions

Through the qualitative analysis of the interview data of the participating university teachers who were involved in educational technology projects, three distinct learning paths were identified. Teachers in the first learning path preferred to develop relevant competencies in the course of engaging in their day-to-day teaching activities. A second group of teachers preferred to learn through deliberately experimenting with new tools and teaching activities. This group of teachers also consciously sought information to innovate their teaching. The third group preferred to learn through reflection on their own teaching and the teaching activities of others. In all three these groups, the teachers described situations in which their learning took place in social contexts: with colleagues, students, or support staff. Colleagues were the most important resource for most participants. All of the educational technology projects of the participating teachers involved collaboration with multiple partners, often supported by academic developers and IT support staff. Almost none of the teachers referred to formal learning activities, such as professional development training, specialised courses, reading a guide, or conferences, as an important way of learning. In our sample, most teachers preferred to learn by experimenting and collecting information.

The learning activities of the teachers appeared to be distinctive to their preferred learning path. Other aspects of the learning path model (i.e. learning themes, learning context, and learning facilities) were not characteristic of the three learning paths identified in this study. This is likely to be related to the selection of the sample of participants. All participants were involved in educational technology projects. Although these projects differed in focus, for example, peer assessment, digital feedback, video-lectures, or virtual research environments, teachers' personal learning themes were similar in the sense that the teachers focused on learning about integrating technology in teaching practice. Therefore, learning themes in our sample were not distinctive for participants' learning paths. The learning contexts of these projects are also rather similar. Each project was to a greater or lesser extent a collaborative group effort towards curriculum innovation. The limited variation in the learning contexts reflects the contexts in which the teachers worked; the educational projects were funded by their institutions, and technological support was present during all projects. Consequently, the learning facilities did not become distinctive for teachers' learning paths in this study.

Only emerging relationships between learning paths and conceptions could be recognised in this study. Participants who preferred to learn through their daily teaching activities also expressed the conception that educational technology could assist in differentiating teaching activities for diverse learners. And most participants who preferred to learn through reflecting on teaching practice supported the conception that educational technology could help to inspire and challenge students. The

learning path categories and the identified pattern in our data provide hypotheses for further research into teacher learning in the context of the application of technologies in education.

Limitations, further research directions, and implications

Although we identified some patterns in the data, we have to be rather careful in drawing general conclusions. Given the small and local sample size, only hypotheses for further study can be drawn. Especially because the participants in our study worked on self-defined, small-scale curriculum innovations, the results cannot be transferred to situations in which teachers have to implement institution-wide curriculum changes. Future designs might enquire into diverse contexts, such as curriculum reform and regular teaching practices, in order to understand the variety in university teachers' learning paths in terms of learning theme, context, and facilities. In addition, more longitudinal designs in which teachers can be followed for a longer period of time could reveal not only teachers' self-perceived learning paths, but also the unnoticed aspects of teachers' learning. Longitudinal designs can also identify whether teachers' learning preferences are stable over time, related to specific teaching activities, and associated with teachers' conceptions of teaching and learning.

In this study, we did not find a relation between teachers' learning paths and their motivation for educational innovation. This might be caused by the similarity in degree of internalisation of their motivation. Participants' motivation could be classified as 'integrated regulation', in the sense that all teachers were aware of the relevance of the innovation for improving student learning. Therefore, we suggest, for future studies into university teachers' motivation to engage in educational change, purposefully selecting samples of teachers who differ in degree of external regulation of their motivation.

The identified learning paths and preferred learning activities provide academic developers with tools effectively to support university teachers in implementing educational technology in teaching practice. First, academic developers should be aware of the diversity of teachers' learning preferences and learning needs. Second, formal learning activities, such as training, workshops, and practical guides, although available, are not the most preferred way of learning how to implement educational technologies. University teachers learn through doing their teaching jobs, through experimenting, and through reflecting on their teaching. As academic developers, we should assist those ways of teacher learning much more than through designing new workshops and training sessions, for example, by co-creating student activities and co-designing assessment methods in collaborative groups of teaching staff and academic developers. Those collaborative groups or communities of professional practice provide academic developers with spaces to provide advice and feedback in-time and on-the-spot. Third, teachers' conceptions of educational technologies influence their way of implementing new tools, but will also influence the way teachers develop professionally. Explaining the variety of perspectives on teaching and learning to university teachers, while working collaboratively to improve teaching in university courses, is a sustainable way of academic development.

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