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Article

Pedagogising Virtual Reality Technology — a New Perspective on the TPACK Framework

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Abstract

Digital technology has increasingly influenced all areas of education, including higher education, with subject-specific technologies developed for professional contexts alongside general communication and collaboration tools. This article draws on a case study conducted in a bachelor programme within building construction design in Denmark, tracking how teachers converted technical knowledge about virtual reality into teaching practice. This transformation process has crystallised different pedagogies, even within the same course. One pedagogical aim was for students to learn to use virtual reality (VR) as a professional competence, while another was to use VR as a tool for learning subject content (building design). This case study raises general issues regarding teachers' use of technology for teaching, addressed in the research tradition of technological, pedagogical and content knowledge (TPACK). However, to delve deeper into the educational transformation processes, this article adds an educational sociological perspective, including concepts from Legitimation Code Theory (LCT). With this background, this article raises new questions about the TPACK concept and discusses how the technological knowledge domains in the TPACK model can be differentiated to reflect various digital technologies and their functions, particularly in professional education.

Keywords: Digital technology, Virtual reality in education, TPACK theory, Specialisation codes, Pedagogical discourse

Introduction

In this section, I first describe the focus of this article and the background thereof. Secondly, I briefly outline the empirical context for the study on which the article is based.

Over the last three years, teachers from Danish higher education institutions employed in building construction programmes have participated in a course programme about digitisation in the construction industry (KUBU, 2022). Participants in this course should gain knowledge about digital technology and demonstrate application in teaching practice (Nielsen & Godsk, 2023). This article is based on a case study that I completed as one of several follow-up research projects associated with this course programme. In this case study, I specifically focused on how one of the participating teachers managed to transform knowledge of virtual reality (VR) technology into his teaching activities. The empirical context for this case was a bachelor programme in Architectural Technology and Construction Management (ATCM) at one of the five university colleges (UC) in Denmark. ATCM is a 3½-year bachelor programme. Inspired by a pedagogical planning model (Hiim & Hippe, 2013), the teacher designed the VR course over about three weeks for a group of 22 second-semester students to whom he was already assigned as a tutor in the subject 'Building Design'. All activities took place in the group's regular classroom, where VR equipment was set up (see Figure 1). This VR course was relevant because it aligned perfectly with the goals of the KUBU project and because the teacher in question had clear pedagogical intentions for incorporating VR technology. These will be discussed later.

What initially seemed relevant for this case study as a theoretical reference was the research tradition known as technological, pedagogical and content knowledge (TPACK). This tradition theorises about how teachers combine different forms of knowledge into pedagogical competence. However, the tradition has primarily been focusing on individual cognitive processes (Shulman, 2015), and has paid less attention to the sociological issues of knowledge concerning the underlying principles that regulate the transfer of knowledge between contexts. Data from the case study suggests that including such a sociological perspective would be beneficial. Therefore, the specific question addressed in this article is: How can the TPACK concept be merged with a sociological perspective on education to better understand the pedagogical transformation of digital technological knowledge?

First, I introduce the theoretical framework and the key concepts employed in this article. I then describe the case design and the empirical methods used for data generating and the analysing process. Next, I present the analytical results. In the section "Teaching in and with VR" I outline the content and flow of the course, the key arguments with which the teacher substantiated his choices and, in addition, the students' responses to the course. In the following section, "Codes, focus and priority", I argue how concepts from educational sociology (Legitimation Code Theory – LCT) may enhance the teacher's formation of pedagogical discourse and thus supplement the TPACK concept. Finally, in "TPACK variants - a differentiation", I discuss the analytical findings concerning a possible differentiation of the knowledge domains of the TPACK model.

Theoretical framework

In this section, I start by first presenting an outline of the TPACK framework. I then introduce specialisation codes from the educational sociology tradition, namely LCT, and specifically explain how the latter can supplement the former.

The TPACK framework

Data from the case study has crystallised some pedagogical issues which revolve around how teachers combine knowledge from different content areas, to make this knowledge suitable for teaching. A theory that specifically addresses these issues is the TPACK tradition[1] (Mishra & Koehler, 2006). It has received a relatively large amount of attention in educational research since Shulman (1986) introduced it, though then without the technological dimension, i.e., as pedagogical content knowledge (PCK). As the term suggests, knowledge is brought together, which combines pedagogical content with subject-specific content. Both the PCK and the TPACK tradition have mostly targeted primary school teachers but have also appealed to higher education (Jaikaran-Doe et al., 2016). The TPACK tradition has thus been an obvious theoretical starting point for the case study analyses.

However, what still seems to be more clearly explained in TPACK is the issue of transformation between domains, i.e., what regulates these processes. Since the emergence of TPACK and PCK, slightly different perspectives have been taken over time regarding ontological and epistemological questions on knowledge (Chan & Hume, 2019), but both traditions have a fundamentally cognitive basis. I propose to employ a perspective from the sociology of education on the concept of transformation and domain. In this perspective, knowledge transformation is seen as embedded in social practices, in which case it is possible to analyse underlying principles that regulate transformations. I will therefore point out how this perspective of conversion of knowledge can further illuminate the concept of transformation.

As expressed above, Shulman (1986) laid the foundation for the thinking underlying TPACK with his original PCK model. An important innovation was the research by Mishra and Koehler (2006), where the technological domain was added, thereby forming a new hybrid of technological, pedagogical, and content knowledge. In their 2006 article, the authors summarise a range of research contributions and argue that knowledge of technology in education has been under-theorised. They, therefore, suggested an expansion of the concept, with technology as a new domain of knowledge resulting in the hybrid form designated as TPACK (Mishra & Koehler, 2006). The authors subscribe to Shulman's basic argument that different domains are integrated and form hybrids or intersections but argue that technology can be separated as a new domain of knowledge with an independent analytical category because modern technologies have

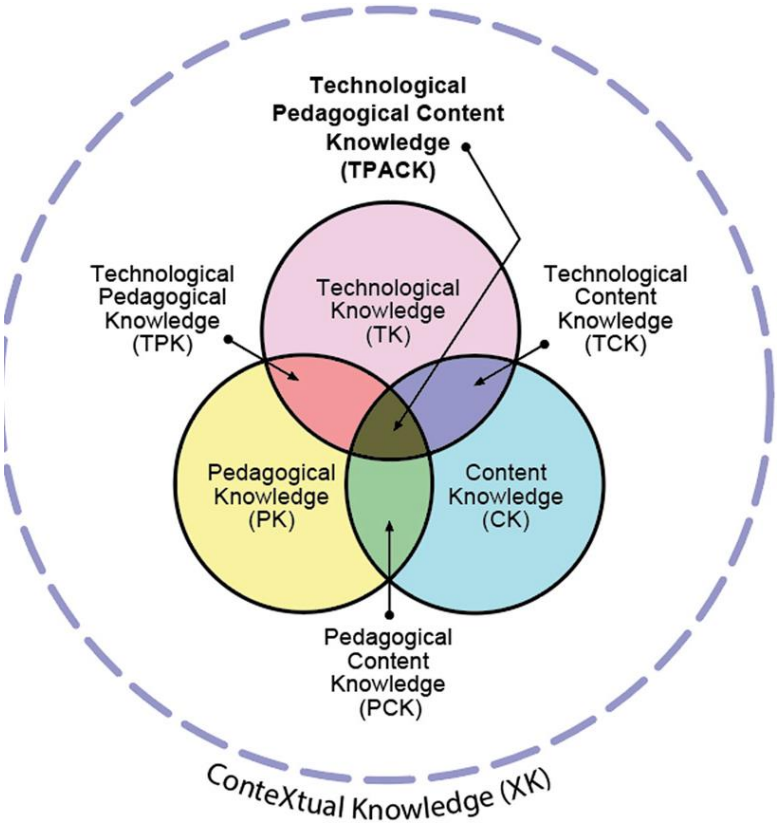
[1] The authors have later commented on the A in TPACK. It must serve to emphasise the totality of technology, Pedagogical AND Content Knowledge (Thompson & Mishra, 2007).

come to be "in the forefront of the classroom" (p. 1023). The authors argue that it is not enough to know how to use new technologies. The development, scope and nature of technologies allegedly make it meaningful to separate technological knowledge as a distinct area. Previously, technologies such as blackboards, overhead projectors and books were more stable and static, and these were integrated into PCK. The impact and rapid change of technologies allegedly increased the need for technology to be added to the hybrid of PCK as a particular form of emerging knowledge. The authors, therefore, summarise TPACK as follows:

> Technological pedagogical content knowledge (TPCK) is an emergent form of knowledge that goes beyond all three components (content, pedagogy, and technology). This knowledge is different from knowledge of a disciplinary or technology expert and also from the general pedagogical knowledge shared by teachers across disciplines. (p. 1027)

Figure 1 illustrates the three domains:

Figure 1. The TPACK model.



Source: Mishra, 2019

Mishra and Koehler (2006) conclude that as a new hybrid analytical model, TPACK enables a more differentiated view of contemporary teacher knowledge. Additionally, they argue that the TPACK framework can be used in the design of pedagogical strategies and can serve as an analytical lens to

broadly demonstrate changes in educational knowledge. However, the concept of transformation is not addressed in the 2006 article. It is Shulman, the originator of the PCK theory, who in his early texts from 1986 and 1987 works with the concept of transformation as one of several subcategories in what he calls 'pedagogical reasoning' (Shulman, 1987). Regarding transformation, he writes that:

> Comprehended ideas must be transformed in some manner if they are to be taught. [….] Transformations, therefore, require some combination or ordering of the following processes, each of which employs a kind of repertoire. (1) preparation (of the given text materials) including the process of critical interpretation, (2) representation of the ideas in the form of new analogies, metaphors, and so forth, (3) instructional selections from among an array of teaching methods and models, and (4) adaptation of these representations to the general characteristics of the children to be taught, as well as (5) tailoring the adaptations to the specific youngsters in the classroom (p. 16).

In other words, the five points relate to pedagogical organisation. In a summarised form, Shulman (1987) expresses transformation as how "one scrutinises the teaching material in light of one's own comprehension and asks whether it is 'fit to be taught'" (p. 16). Shulman thus outlines some important features that characterise transformation within each domain, but the issue of which underlying principles regulate transformation between knowledge practices is not immediately addressed.

Magnusson et al. (1999) later addressed the concept of transformation and, regarding pedagogical content knowledge, state that "it is the result of transforming knowledge from other domains" (p. 2–4). Magnusson and colleagues identify several subareas of knowledge beyond the three areas shown in Figure 1 and emphasises the “mutual interaction” between them (p.3–4). The issue of transformation was later raised by Kind (2015) and Angeli et al. (2016). Both sources reflect on the debate over whether knowledge domains should be understood as integrative, that is, as separate accumulated "bodies of knowledge" (Angeli et al., 2016, p. 21), or as a transformation into something new and unique. Angeli et al. (2016) refer to empirical studies that have shown that if teachers simply acquire knowledge from the individual domains/bases, it does not automatically lead to growth in TPACK competence. Therefore, the authors conclude that TPACK knowledge is transformative; it is "a unique body of knowledge [...] that needs to be explicitly taught" (p. 25–26).

Both the domain and transformation concepts remain within a cognitive understanding framework, as inner subjective processes which have some limitations. Even Shulman (2015) points out the challenges of defining a domain, by posing the question:

> What counts as a domain: Is it a discipline, specific topics or problems within a traditional discipline, a broad hybrid space that encompasses several disciplines, a field of practice or policy? (Shulman, 2015, p. 8)

In these formulations, Shulman suggests some sociological terms such as "space" and "field of practice or policy", but does not delve deeper into this discussion, which ultimately has to do with the ontological basis for knowledge (p. 9). The ambiguity surrounding this is also reflected in works by Abell (2008), who

introduces the debate of whether PCK/TPACK should be understood as an individual matter or something that is distributed collectively (Ellebæk & Nielsen, 2016).

Some recent research in the area has focused even more on individualistic dimensions, such as the PEAT model. Here, emphasis is placed on ethical and attitudinal aspects (McDonagh et al., 2021). Overall, there is much to suggest that a sociological perspective could promote the conceptualisation of knowledge in the TPACK framework.

Principles for the formation of pedagogical discourse

By including a sociological perspective on education, knowledge is viewed as something that occurs in social practices, rather than something that resides within individuals. Here, Bernstein's concepts of recontextualisation and pedagogical discourse can serve as a relevant starting point (Bernstein, 2001). The concept of recontextualisation is based on the premise that knowledge in education is a result of transfer/transformation from fields or arenas outside of educational practices and is therefore produced according to logic other than those that apply in the pedagogical world that education represents. Knowledge must therefore be recontextualised through a transformation, which is where pedagogical discourse is formed (Bernstein, 2000, p. 31).

A contribution from educational sociology that relates to research on TPACK, while also addressing the recontextualisation issue, can be found in Howard and Maton (2011). They recognise TPACK as an important step in examining distinct areas. They also present an explicit critique of TPACK's theoretical foundation.

According to Howard and Maton, the TPACK model lacks a conceptual framework with which to systematically analyse similarities (ibid. p. 194). However, it is considered to be limited to empirical differences and therefore requires underlying principles that describe the forms knowledge takes, beyond the academic areas it pertains to. They write that:

> while highlighting different contents or foci of knowledge, this does not provide a means of theorising the forms that knowledge takes, whether it's three constituent kinds (the three circles in Figure 1), their hybrids (the three elliptical unions) or TPCK itself (the centre). (p. 194)

The authors argue that the areas that appear in TPACK, both the circles and the overlaps, do not contribute to a theory of the forms that knowledge takes. Howard and Maton (2011) thus offer their contribution to the theoretical concept of LCT.

Fundamentally, the LCT concept is about what counts as the basis for legitimate knowledge and thus which recontextualisation principles regulate the formation of pedagogical discourse. The specialisation codes are one of several dimensions in the LCT complex that draw inspiration from the theories of Bernstein, Bourdieu and others. Specialisation codes highlight that any practice, belief or knowledge claim is always

oriented towards something and by someone. Therefore, one can analytically distinguish between

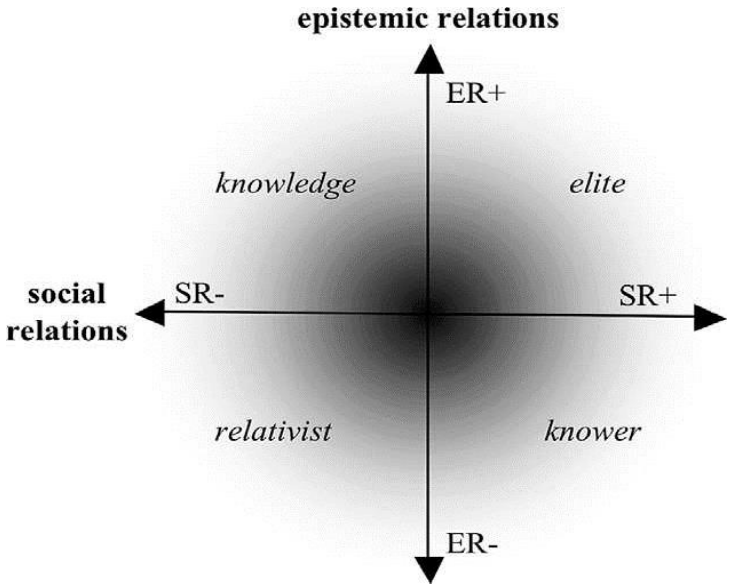
a. 'Epistemic relations' (ER): the relationship between the knowledge practice and the knowledge object and

b. 'Social relations' (SR): between the knowledge practice and the knowledge subject.

Each of these relations can be emphasised as a legitimate basis for achievement to a greater or lesser extent. Together, they form a diagram with four modalities (p. 196):

- a *knowledge code*, where possession of specialised knowledge, principles or procedures are emphasised as the basis of achievement, and the attributes of actors are downplayed;
- a *knower code*, where specialist knowledge is less significant and instead the attributes of actors as knowers are emphasised as the measure of achievement. Thus, these attributes are viewed as born (e.g., 'natural talent'), cultivated (e.g., artistic gaze or 'taste') or socially based (e.g. gendered gaze in feminist standpoint theory);
- an *elite code*, where legitimacy is based on both possessing specialist knowledge and being the right kind of knower. In this case, the term 'elite' does not indicate social exclusivity, but rather the significance of possessing *both* legitimate knowledge *and* legitimate dispositions;
- a *relativist code*, where legitimacy is determined by neither specialist knowledge nor knower attributes – a form of 'anything goes'.

Figure 2. Specialisation codes



In other words, specialisation codes are an expression of the strength of classification and framing carried out by different relations. A knowledge code is an expression of emphasis on what is to be learned and which methods should be used. A knower code emphasises the characteristics and traits of the learning subject. With specialisation codes, it becomes possible to say something about the principles that regulate teachers' recontextualisation and thus the properties of the pedagogical discourse that is formed.

The similarity between pedagogical discourse and a hybrid of the three domains in the TPACK model is that

knowledge about the subject matter, the technological content and the pedagogical content are combined in different complex combinations (Koh, 2019). The difference, as Howard and Maton (2011) point out, is that the focus of the TPACK model is on *content* while pedagogical discourse is an expression of underlying principles by which knowledge is made suitable for teaching. Therefore, the specialisation codes in LCT provide a deeper understanding of the transformation aspect.

In summary, the TPACK model is well suited for analysing the relationships between different areas of knowledge in teaching. It treats the introduction of digital technology as a special area that has gained wide acceptance in education. Integration and transformation aspects are addressed in TPACK research, but ontological and epistemological questions regarding knowledge appear to some extent to be unresolved. This leaves questions about the principles according to which transformations between domains and contexts occur and thus for the formation of pedagogical discourse. The specialisation codes from the LCT complex become an analytical contribution to illustrate some features of recontextualisation, namely in the form of codes that reveal the teacher's classifications and framings of ER and SR. Therefore, it is relevant to include these concepts in the further analysis of the empirical case but also to discuss what the analysis points to in terms of differentiating the TPACK model.

Design, data generation and analytical process

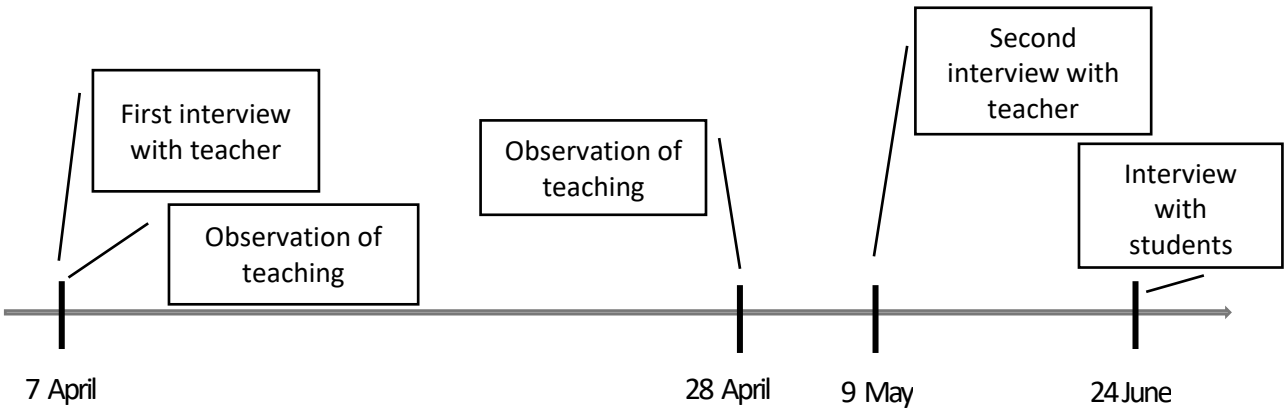
To generate diverse data, the case study included several methods and tools, such as a documentary study, three observations and three interviews.

The documentary study involved analysing the teacher's PowerPoint material to gain insight into his initial pedagogical considerations. One observation was made of an initial meeting where the teacher received guidance from a colleague concerning technical issues. Two observations were made with respect to classroom interactions in the VR course. Observations were performed unstructured and with a low degree of participation from the observer. They all involved:

- Audio recordings of all speech and conversation,
- Still photos and video clips of actions that appeared important to visualise,
- Hand-written notes of important actions and my ongoing interpretive reflections (Kristiansen & Krogstrup, 1999, p. 48, p. 127).

To get deeper into the teacher's pedagogical reasoning and the students' experiences, semi-structured in-depth interviews were conducted with these informants. Two interviews with the teacher were carried out, one before the first lesson and one after the last lesson. One and a half months after the end of the course, interviews were conducted with a group of students. All interviews were audio recorded and fully transcribed according to guidelines by Kvale and Brinkmann (2009). Sequences of the data generation are shown in the timeline below.

Figure 3. Data generation in the VR case, spring 2022: Timeline**.**



The analysis process began with the initial processing of observational data into a video, which included photos, video clips and notes synchronised with the sound. The resulting edited videos were shared with the informants for validation, which informed the guide for the follow-up interviews with both the teacher and the students. The interview transcripts were then coded inductively (Kvale & Brinkmann, 2009, p. 223), starting from the informants' perspectives and setting aside the initial theoretical framework outlined in the project description. Meaningful units were condensed into themes and categories, which were then compared across interviews and observations to identify similarities and differences and to refine the categories. Based on this analytical material, the original theoretical framework was reconsidered and expanded with theories from educational sociology that were found to be relevant to the areas highlighted by the data (Maton, 2014).

Ethical considerations

Informant consent was obtained following the research institution's rules through a written request. First, an email was sent to the teacher in question, informing them about the purpose and content of the case study. Attached was the research institution's formal information letter. The lecturer then contacted the student group via the students' IT platform with a notification to read the information letter. Immediately before the first observation, the participants were asked for approval of audio and video recordings, where anonymisation of these was guaranteed.

Results

In the following sections, the analytical results are presented. First, I focus on the teacher’s design of the VR course, including his reasoning and the student’s response. This forms the basis for the next section, where I identify and conceptualise the various pedagogical discourses enacted in the VR course. In the last section,

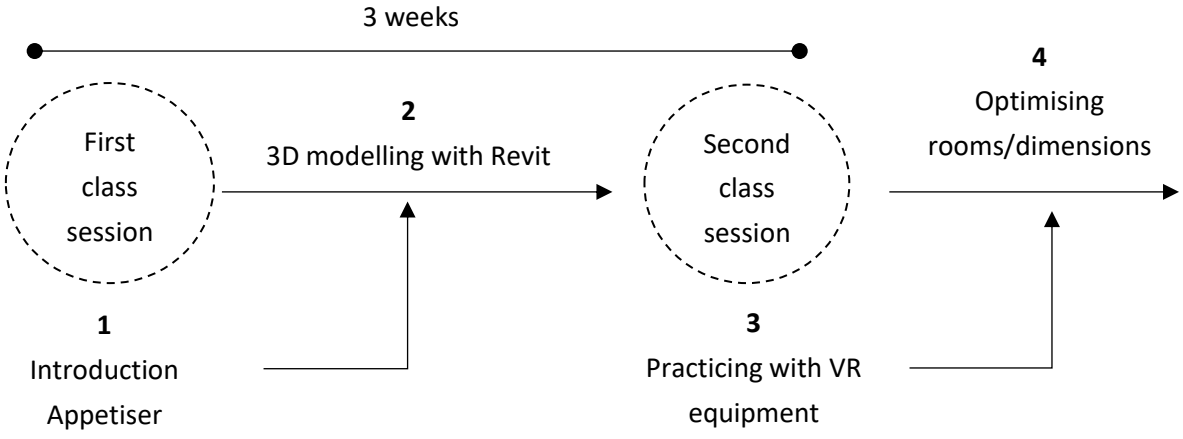
I discuss the pedagogical discourses against the TPACK model and suggest further differentiation.

Teaching in and with VR

The first lecture of the VR course was a short introduction where the teacher emphasised the purpose of VR but without actually trying out the equipment. Instead, the teacher showed a short video about VR which was intended to serve as an "appetiser". The teacher then thoroughly explained what the students should do in the following period of about three weeks. During this period, they were to prepare for the last instruction session by modelling their house using their usual design software, Revit 3D Section, so that they were ready to walk around the house virtually with the VR equipment in the final session. The equipment would include a powerful computer, the software program Enscape and a VR headset. Not all of the students' computers would have the necessary capacity, so the teacher planned the testing so that the students – in turn – could try the equipment (see Picture 1).

The final instruction session lasted an afternoon, and the teacher first demonstrated the equipment in the classroom, where the images from the VR headset were also shown on the large projector screen so that all the students could follow along. After the demonstration, the students could take turns trying out the equipment that was set up. Finally, the teacher suggested that the students could borrow the equipment at a later point in the semester if they wished, or simply use the Enscape program on their PC without the headset. This would still generate a 3D experience, but it would lack the authentic dimension that the headset could provide.

Figure 4. VR course in CTAM programme, second semester: Sequences.



The content and the form of the VR course together indicate that the main goal for the students was to gain a realistic spatial sense by virtually wandering around their designed houses and thereby assessing space, furniture placement, height above stairs, etc. This should then lead to the optimisation of the

house's functionality.

> It is one of the things they can do by using VR, that they get focus and a sense of standing one-to-one and feeling the height of different things, which means that VR can help students gain a better spatial understanding of their designs. (Interview with teacher)

The teacher repeatedly mentioned "aha-moments", "spatial awareness", and "spatial understanding" as intermediate goals on the way to ultimately identifying any errors and ineffective layouts.

The students' experience with VR confirmed this primary goal of VR as a learning tool. One student expressed it this way: "There isn't so much a product to it, but more of a tool to check what you've done." From the students' perspective, the aha-moment was the feeling of their design becoming real, which again led to the discovery of errors or inappropriate placements:

> We found out that our kitchen was perhaps placed inappropriately when entering. We could see that things were too crowded. I don't think we would have seen that if we hadn't been inside to look. So it gave such an "aha". (Interview with students)

In terms of how VR can help students with different backgrounds, a carpentry student said:

> So, I think it helps people with a non-technical background to understand the sizes inside the house. It helped me a lot to understand the actual heights of the different rooms that you work on. That was the big thing for me. (Interview with students)

Some students, however, expressed that there were technical challenges and issues. These included the lack of PC capacity, which potentially made it difficult for them to prioritise using VR as much during the semester as they otherwise would have done.

In summary, the VR course design illustrates how the teacher tried to integrate the technology into the students' design process for a building. He did not particularly think of the VR course as teaching how to use VR as a separate tool, after which the students should be able to use it in their studies. Rather, he considered VR as something which should be embedded in the building construction subject, justified by the ultimate goal of optimising the design process. The research case thus represents an example of how VR technology was made subject-specific by combining the VR headset with the Enscape program and using it as an extension of Revit's 3D functions in the design phase. The case also demonstrates that VR as a subject-specific digital technology primarily served as a learning tool.

While the teacher tightly controlled the building design content of the course, he made available to the students many different opportunities regarding the use of VR equipment. They could choose to borrow the equipment or to use the Enscape program alone, without the VR headset.

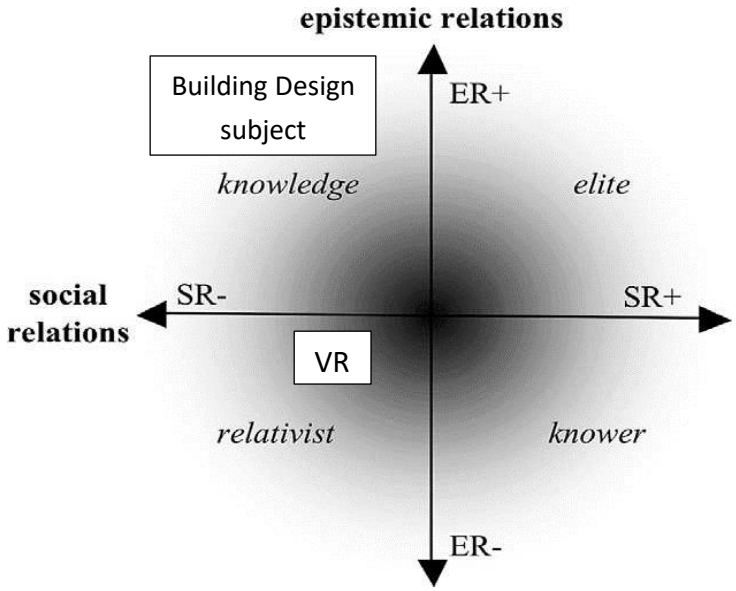
Picture 1. A student tries out the VR tools assisted by the teacher.

A student practices Virtual Reality on his own project using two joy-sticks to navigate. The images are shown on a screen so the other students in the class can watch. The teacher is sitting next to the PC ready to assist.

Codes, focus and priority

From the previous analytical points, different pedagogical discourses with different coding can be identified. As mentioned previously, the teacher exerted strong control over the content of the Building Design subject. Students should learn certain professional disciplines where individual dispositions counted for less. What regulated the formation of the pedagogical discourse in this context were therefore strong ER and weak SR, i.e., a knowledge code (see Fig. 6). This is also in line with previous studies of the ATCM programme (Larsen, 2018). Regarding teaching in VR specifically, the ER turned out weak. The goal was for the students to know something about VR because it is used in the industry: "They should know about VR, but they should not be experts." Therefore, there were no explicit performance requirements for evaluating such VR skills, and there were no progressions in training these. It was up to the students how to engage with VR. There was a high degree of voluntariness. Thus, the students could choose between using the entire set of equipment available or only making use of the Escape program on their own PC without a headset. No special individual traits and characteristics appeared to count significantly for becoming a privileged knowing subject in the field (knower-code). The code that regulated the formation of the pedagogical discourse for the VR course can therefore be described as relativistic, i.e., weak ER and weak SR. However, the VR course was embedded in a larger pedagogical discourse that applied to the subject of Building Design, which is regulated via a knowledge code. The relativist code for VR thus seems to be a logical consequence of the fact that VR was still peripheral to other curriculum content, such as using the drawing program Revit.

Figure 5. Different codes for the Building Design subject and the embedded VR course.



The relativist code thus controlled the recontextualisation of knowledge about VR, but the teacher still had two different goals with VR. One concerned the students' development of a professional VR competence. The other considered the students' ability to use VR as a learning tool. Thus, the same relativist code followed two different focus areas regarding learning content and thus represented two different pedagogical discourses. In this case, their basis for achievement – the structuring principles for acquisition – was the same, i.e., the relativist code. On the other hand, the focus, i.e., the content of the learning, was different (Maton, 2014, p. 31). What the relativist code does not express, but which was a significant difference between the two discourses, was not only the focus but also the priority. From the given resources, the teacher needed to prioritise one focus area over the other. The teacher's priority of the students' development of VR as a professional competence was very low compared to the priority of the students' use of VR as a learning tool, which, in turn, was high. During the interview, the teacher stated what the students should learn about VR as a professional competence, but this competence goal was not visible in the observations of pedagogical practice. In contrast, learning how to use VR as a learning tool was at the forefront.

With a higher prioritisation of VR as a professional discipline, the code might have moved towards a knowledge code. Only the pedagogical discourse about VR as a learning tool was enacted in classroom practice, while VR as a professional discipline was difficult to discern.

If the priority of VR as a professional discipline had been high, the pedagogical practice would have been aimed at teaching different up-to-date VR techniques from the industry. However, while the teacher considered the equipment used in the experiment to be outdated, he still considered it fully applicable for serving as a learning tool.

Table 1. Pedagogical discourses, codes and priority.

Pedagogical discourses	**Focus**	**Code**	**Priority**		**Enacted in classroom practice**
			Low	**High**	
Building Design subject (BD)	Acquiring professional competence in subject matter	Knowledge code (ER+/SR-)		X	Yes
Virtual Reality (PD1) (embedded in BD)	Acquiring professional competence in VR	Relativist code (ER-/SR-)	X		No
Virtual Reality (PD2) (embedded in BD)	Using VR as a learning tool	Relativist code (ER-/SR-)		X	Yes

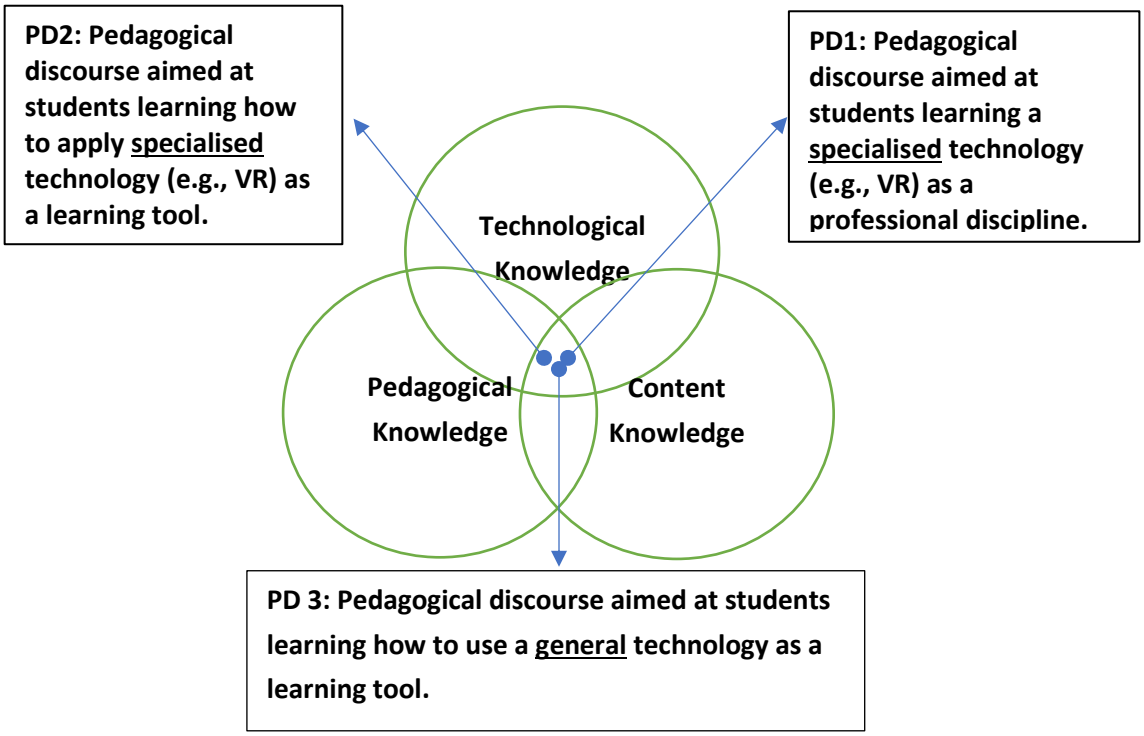
The above table presents the three different pedagogical discourses, including their focus, code, priority and possible enactment in classroom practice. The left column shows the pedagogical discourses embedded in the construction subject. The purpose of this information in the figure is to distinguish between what was the basis of achievement (the code) and what was the focus and priority. To make an important point clear: both PD1 and PD2 operated from a relativist code, but they were embedded in the construction subject, which was regulated through a knowledge code. However, the relativist code does not necessarily mean a low priority for the teacher. In comparison with PD1, the teacher gave high priority to PD2 (VR as a learning tool), although much was left to the students to control. The risk could be, of course, that the students would choose to use VR on and off as they please, as no evaluation criteria were defined. Thus, a more general point seems to be that if a pedagogical discourse exhibits a relativist code as a basis for achievement and at the same time is given low priority, the discourse will primarily appear as ideas and intentions, but will only be realised through pedagogical actions in practice to a small extent (Kemmis et al., 2014).

TPACK variants – a differentiation

The analytical distinction between VR as a professional discipline and VR as a learning tool provides an opportunity to revisit the TPACK model. Based on the case study, I will discuss a possible differentiation of the model more generally, particularly the overlap between the three areas. In the TPACK model, the overlap/hybrid between the three domains represent the integration or transformation of knowledge, which means that this overlap expresses pedagogical processing. The hybrid can also be seen as an expression of the *content* of the pedagogical discourse (Bernstein, 2000, p. 36). However, what the hybrid does not show is any further differentiations, which I have identified in the case as two different pedagogical discourses, made possible by incorporating education sociological concepts into the analysis. In

Figure 6, the two discourses from the above table (PD1 and PD2) are presented, and the difference between them is explained earlier. As for focus, the use of technology in PD1 is a goal in itself, because the goal is students' professional competence in using technology, while the focus for PD2 becomes learning specialised technology as *a means* to support learning construction issues. The code that indicates the basis for acquisition is the same for the two, though in principle they can be different. Thus, PD1 and PD2 deal with practices where there is a specific digital technology for a subject. If Figure 6 is considered as being a generic model, a third variant of pedagogical discourse, PD3, may emerge. It will arise in cases where teaching involves general communication technology, such as a new system for online communication, the use of video technology or other subject-independent technologies. Here, the teacher, like with PD2, must recontextualise knowledge with a focus on technology as a method to support learning and learning situations. However, this process will differ from the other two in the sense that such general digital technologies are freed from a specific professional context. Therefore, teachers can draw on a greater reservoir of knowledge about the pedagogical use of digital technology because such knowledge is more developed than it can possibly be in highly specialised professional contexts involving specific digital technologies, such as with Revit and VR in a building design context (Paulsen & Tække, 2018; Bang-Larsen & Qvortrup, 2021). This type of pedagogical discourse is yet another variant of the TPACK hybrid (PD3). It should be emphasised that pedagogical discourses necessarily only point to the inner hybrid of the TPACK model. Any other overlapping area will lack one of the components and will therefore only represent a partial process in the development of a pedagogical discourse.

Figure 6. TPACK model with different pedagogical discourses.



Conclusion and perspectives

In this article, I have presented analyses from a single-case study, in which I have examined how VR technology was introduced in a semester of an ATCM programme within a specific field. The theoretical framework for the analysis has partly drawn on the TPACK research tradition as well as on a newer research tradition within educational sociology referred to as LCT. TPACK thinking is mainly cognitively oriented and deals with the various forms of knowledge that the teaching competence is composed of. The specialisation codes from the educational sociological tradition, namely LCT, have been included to expand the analytical perspective and make it possible to conceptualise the underlying principles of what shapes knowledge.

At first glance, the VR course may seem to be tightly controlled by the teacher, because he has defined quite precisely what the students should do in terms of the Building Design subject. However, by searching for the underlying codes in the VR course, it can be seen that two pedagogical discourses about VR are formed and embedded in the Building Design subject. One discourse is intended to convey learning about VR as *a competence* that can be used in the professional world. The other discourse is intended to convey learning about VR with a focus on using it as *a tool* to learn other building-related content. The latter is intended to strengthen students' spatial understanding so that they can discover inappropriate heights and distances in room layout and optimise their 3D modelling.

In this particular case, *both* discourses exhibit a relativist code, because it is up to the students to decide

how they will avail themselves of the VR equipment, as long as they solve the design-related task. The fact that the relativist code with its high degree of voluntariness and independence became dominant may be because, in this first course, the teacher did not want to set too many requirements and evaluation criteria. If the basis of achievement for VR as a professional discipline has been to emphasise specific techniques and skills to be mastered, the pedagogical discourse would probably have exhibited a knowledge code. A more comprehensive empirical study with more cases could have shown such a code, thus strengthening this argument. Therefore, in this regard, it can be said that this single case study has its limitation.

However, the codes that regulate the formation of pedagogical discourses do not reveal everything about how they are enacted in practice. The case shows that *priority* plays a significant role, which particularly concerns resources of time and energy, and here VR as a learning tool is given the highest priority. The teacher did talk about the importance of the students having some basic VR skills in relation to professional performance, but classroom practice shows that this part was downplayed.

By identifying the different discourses and their properties, the case study provides a background for a discussion of the TPACK domains and distinctions, especially the overlap/hybrid between the three areas of content knowledge, pedagogical knowledge and technological knowledge. Though the LCT and the TPACK frameworks are based on very different ontologies, I have argued that the innermost hybrid between the three areas can be equated with the concept of pedagogical discourse, as both represent pedagogical processing. Therefore, the two discourses PD1 and PD2 refer to the hybrid in the middle of the model in Figure 6.

However, if the model were considered at a more generic level, I would argue that a third variant, PD3, could also potentially emerge. Instead of knowledge about specific technologies in a certain field, this third discourse concerns knowledge about general digital technologies such as online systems and Learning Management platforms. On another note, what sets PD3 apart as a third variant is that educators who need to learn about these technologies will be able to draw on pedagogical knowledge which is developed within a relatively large pedagogical research field on learning and media. With very specific digital technologies like in PD1 and PD2, such as Revit and VR, access to pedagogical knowledge will be much more limited due to the highly specialised technologies and contexts. In such cases, we must assume that educators must piece together their knowledge as required and according to the opportunities that arise, which was also the case with this particular VR course.

Such a pedagogy of a specialised technology will therefore more likely be developed by the educator as tacit/implicit competence that is difficult to explicitly separate due to its significant context sensitivity and arbitrary nature. This brings us to what has been discussed in the TPACK community regarding ways in

which educators acquire and synthesise various forms of knowledge into competencies (Angeli et al., 2016). Hopefully, the distinctions between pedagogical discourses argued for in the article can inform this discussion as well as instigate further research in the area.

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