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Teaching Smart with Podcasts

DORINA GNAUR
Department of Learning and Philosophy, Aalborg University, Denmark. E-mail: dg@learning.aau.dk

JOHAN CLAUSEN
Department of Civil Engineering, Aalborg University, Denmark. E-mail: jc@civil.aau.dk

The purpose of this paper is to explore the potential of digital technology, such as podcasts, to stimulate the learning environment in engineering education by advancing student learning from a focus on fixed disciplinary content and habitual examples towards higher procedural and conceptual knowledge forms. The paper examines how a pedagogically aligned use of podcasts can support deeper and more integrative learning in an engineering course. The findings reveal the importance of planned pedagogic alignment between content knowledge and the use of technology, and expose the role of a qualitatively enhanced student–teacher interaction in re-centering teaching on active learning and on problem-oriented, functional knowledge. It shows how minor alterations in teaching design caused by the integration of digital tools, in this case the use of podcasts, can enhance student learning. However, in order to extend beyond reproductive learning, podcasts have to be part of an engaging pedagogic design involving active learning and provide a privileged space to stimulate inquiry and encourage multiple perspectives. Informal access to teacher/expert facilitation in small study groups can provide a less intimidating support to help navigate the troublesome realms of disciplinary advancement and prepare for future challenges.

Keywords: podcasts; pedagogic design; thresholds concepts; problem based learning

1. Introduction

Engineering education lies at the intersection between practical skills and advanced abstract calculus and science. On the one hand, industry demands graduates with strong technical skills and indeed: "[the preparation] of students for professional competence has always been the ultimate goal of engineering curricula" [1, p. 45]. On the other hand, the rapid technological development and globalization puts new demands on engineering graduates in terms of higher-order, flexible thinking and problem solving skills. In order to form engineers who can work effectively and competitively, engineering education has to see to the continual renewal of its underlying paradigms that are required to adapt to change in a world of growing complexity [2]. This perspective resonates with deep, rather than surface, approaches to learning [3]. Surface approaches aim at the memorization of information to be retrieved in exam situations and are generally detached from the context of use. Deep conceptual approaches seek relationships between learning tasks and underlying concepts or theory, preferably by working through problems. Learning approaches are context-dependent, and this induces discipline specific adaptations for how students seek a deeper understanding of the subject matter. The course context (aims and tasks) as perceived by students is decisive for their choice of approach.

With reference to engineering programs, Case and Marshall [4] suggest a continuum rather than a polarized surface–deep perspective, including a procedural surface and a procedural deep approach, aimed at application and problem solving. The latter often acts as a precursor to the conceptual deep approach resulting in deep learning. Students elect their learning approaches on the basis of perceived learning aims, and thus the learning context has to be explicitly aligned with the intended learning outcomes of a course. As suggested by the theory of constructive alignment [5], there must be alignment between teaching methods and assessments and the learning outcomes stated in the objectives, the purpose of teaching being to support student learning towards higher taxonomic levels. These unfold very much in line with the suggested surface-deep continuum, from uni- to multi-structural levels: from declarative (descriptive) and procedural knowledge (performing sequences and skill learning), towards conditional (problem solving: what to do and why) and functional knowledge (a dynamic level of know-how, phronesis).

2. Integrating learning and technology

The students' perception of the course context manifests itself as a distinct combination of intention and strategy: the type of knowledge they choose to pursue and the associated strategies that they will apply to reach that level. Meanwhile, the learning path is thrown with obstacles and the inability to achieve set objectives, which can lead to 'mimicry' or other simulation strategies that keep the learner

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stuck within a surface approach. The notion of a threshold concept captures the idea of a portal that needs to open up in order for learners to grasp a conceptual domain that was previously inaccessible and troublesome to the individual student [6]. Threshold concepts are irreversible, transformative and integrative in nature in that they involve a leap into the distinct ways of disciplinary thinking and practicing, repositioning and empowering the self within the disciplinary discourse, while exposing earlier hidden connections between things. Threshold concepts can be very specific or more overarching in nature, the know-how of engineering is also a threshold concept: "Such a transformed view or landscape may represent how people 'think' in a particular discipline, or how they perceive, apprehend, or experience particular phenomena within the discipline" (id.). This marks the initiation into the 'thinking like an engineer'—domain through the creation of troublesome and sometimes even counter-intuitive knowledge. The task for teachers is to support such complex processes by identifying, through observation and dialogic processes, the cognitive obstacles, and aligning teaching methods with course aims in such ways as to unlock blocked areas. This requires an ongoing exploration of new teaching approaches, including resources and technologies that allow for recursiveness as well the provision of a 'holding environment' including a qualitatively enhanced student–teacher interaction.

The increasing impact of technology in society carries the risk of viewing technology as a goal in itself to the extent that educators have to ensure "that pedagogy exploits the technology, and not vice versa" [7, p. 2]. Thus, educators must identify pedagogic principles that inform the learning design in order to make qualified use of technology evolving and not reproducing conventional learning. Designing for learning involves a consideration of the pedagogical content knowledge, which is the result of combining one's knowledge of the subject matter with knowledge about the pedagogical organization that supports the learning process of that subject, which can be viewed as a discipline-based pedagogy. It comprises "the ways of representing and formulating the subject that make it comprehensible to others" including "an understanding of what makes the learning of specific topics easy or difficult" [8]. Designing instruction with technology requires the ability to flexibly draw on and integrate pedagogical content knowledge with knowledge of technology into the teaching practices [9]. Figure 1 shows the interplay between the three domains of knowledge, i.e. subject specific, pedagogic and technology related, and the types of knowledge emerging at the intersection of each two domains, i.e. the technological content knowledge, where technology meets the requirements of the subject, e.g. dynamic representations of a worked example; and the technological pedagogical knowledge, where technology fulfils pedagogic requirements, e.g. making the material accessible on demand, at the learner's own pace. Technology enhanced learning designs are created where knowledge about content, pedagogy, and technology overlap and are subject to the dynamic interplay of these three domains, amounting to Technological Pedagogical Content Knowledge (Fig. 1), that is how technology supports the discipline specific pedagogy, e.g. the rehearsability option that allows intricate formulae to be easily identified and replayed as needed. Educators can thus make best use of new technologies to frame the pedagogical approaches associated with the content objectives and so promote student learning.

Our study focuses on the use of video podcasts, shortly referred to as podcasts (portable on demand), which are audio-visual files distributed in digital format through the internet and accessed through personal computers or mobile devices. Three main uses of podcasts are distinguished in

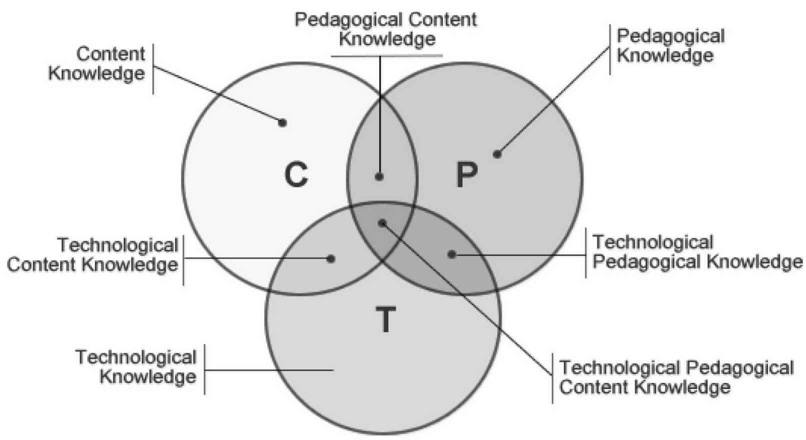

Fig. 1. Technological pedagogical content knowledge (http://tpack.org).

higher education: the receptive viewing and problem based format are both teacher created; the creative production use is student driven. Receptive viewing is the most common [10, 11] and is further subdivided in either substitutional, these are lecture recordings, supporting (additional video based information), or enhanced video representations (Power Point presentations with audio explanation) [12, 13]. All three types are generally met with a positive attitude by the students for the advantage of being used on demand, and are thus conducive to learning [11–13]. The problem based podcasts or worked examples are less common. They provide explanations to specific procedural problems following a clear structure and a solving method to be imitated actively by the students. Podcasts are successful in conveying a variety of knowledge representations by experts in any field, affording enhanced flexibility regarding accessibility: anytime, anywhere, at any-pace; as well as unlimited training opportunities in terms of repeated access in order to review difficult concepts, clarify erroneous perceptions and rehearse for exams, which have been found to increase student understanding [13].

3. Objectives of the investigation and methodological considerations

The objective of this investigation is to go into a detailed consideration of what might be some guiding principles for integrating technology in engineering courses based on the feedback from students, as well as on a renewed focus on aligning learning objectives with teaching design in view of expected outcomes. The main contribution of this study is that it reveals the importance of planned pedagogic alignment between the content knowledge on the one hand and the technology on the other. The research question is:

> In which ways can a pedagogically aligned use of digital content formats, such as podcasts, support deeper and more integrative learning for engineering courses?

Methodological considerations involve the researchers' own ontological and epistemological stances on the nature of knowledge and how it can be known. The authors of this paper represent distinct paradigms of research related respectively to the natural and the social fields of science. The present investigation is related to learning processes and how teaching can support those, in this case, by integrating technology. The knowledge we aim at is thus not precise, quantifiable or generalizable, but rather contextualized knowledge, for which a number of methods for data collection and analysis are available within an overall qualitative approach. The knowledge we obtain through qualitative research is local and aims at accessing and interpreting data in ways that are validated by the subjects' own perceptions as well as by existing theory; it can then be extrapolated to similar situations. Both quantitative (questionnaire) and qualitative (group interviews, observations) methods were used and linked in a triangulation process to increase the reliability of the findings in that the research object was approached through various channels so that the various types of data support and inform one another. Questions such as: What is the situation? What is the individual perspective on the situation? What are the naturally confluent points?—were asked. The questionnaire data was informative on the altered learning situation and the overall perceptions of the individuals. In the semi-structured interviews, the same issues were addressed more in depth, and other emerging issues were uncovered. The interviews were transcribed and coded as per the strong points within each group as well as the salient issues across the groups. The interpretative analysis had the emphasis on the ways a phenomenon seemed to make sense to the individual students involved in the concrete situation [14]. After having established the local meaning of a phenomenon, the primary preoccupation of the researcher is to look for "concrete universals" [14, p. 143], in this case, aspects related to technologically supported learning in an engineering context that might apply, and could therefore be extrapolated to similar situations.

4. Empirical evidence: What say the students?

This study is empirically anchored in an intervention involving the integrated use of podcasts on a graduate course in structural engineering, i.e. on the finite element method for plane finite elements for stress and strain analysis. The course was run by the second author of this paper, the pedagogic counterpart acting as observer and collecting data. Each lecture was sequenced in 4–6 video clips on specific subtopics, 10–14 minutes long, in order to make it easier for students to navigate the content. They were available on the course LMS in two digital formats: ppt. and video. The podcasts consist of PowerPoint presentations with audio explanation and playback of curser pointer movement (called "Laser Pen" movements in Power Point). Thus, the podcasts can be categorized as enhanced video representations (see above). As the learning objectives are aimed at functional knowledge, i.e. the students should be able to program their own 2D finite element code using simple elements, the receptive viewing mode is supplemented by procedural elucidations or solving methods to specific proce-

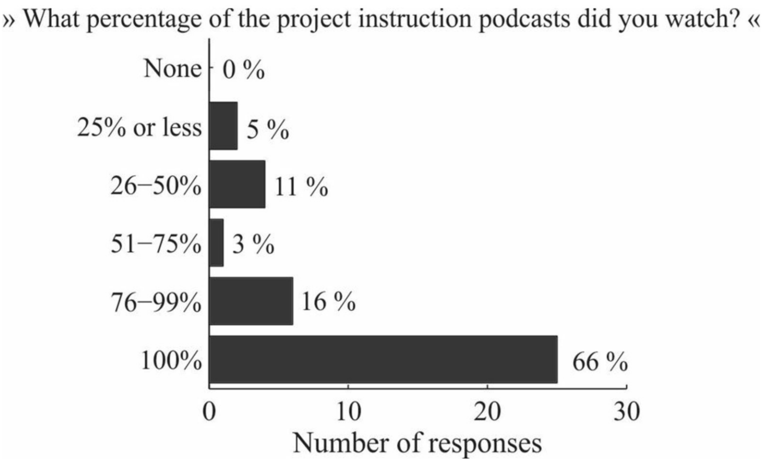

Fig. 1. Technological pedagogical content knowledge (http://tpack.org).

dural problems, which approach the problem based podcasts in their pedagogical intent. The podcasts were offered optionally, in addition to the original soundless ppt. slides and readings and literature references.

The findings are based on three types of data, combining quantitative and qualitative approaches: an online questionnaire completed by 79% of the class (38 of 48 students), followed up by four group interviews with 4–6 students in each group. This was supplemented by structured observation by the first author of the teacher–student interaction in class and in the study groups. The main features emerging from the overall consideration of the data are as follows. All students watched most (82%) of the podcasts before the class (Fig. 2).

Part of the students watched the entire podcasts once (21%) or more than once (11%). Most chose the option of watching the entire podcast once and reviewing difficult sequences several times (66%) (Fig. 3).

Few or no questions were asked during the brief initial class meetings, which were therefore abolished in favor of extended small group tuition. It was observed that although there were no questions during the initial large class meetings, there were plenty of questions asked, related to both content and use, anytime the teacher entered the small group rooms where the students were working with the problem solving exercises. The teaching format was thus altered from 2 hr lectures followed by 2 hr practical sessions to converting the lectures into digital content to be viewed before the class. Classes consisted instead of 4 hr practical sessions, i.e. active learning in groups, with the teacher circulating and offering assistance on demand. Most groups stayed for the entire duration of the extended practical sessions. This approach has been called the 'flipped classroom' in that it shifts the focus from a teacher-centered, 'sage on the stage' to a student activating, teacher assisted role as 'guide on the side'. This is easily recognizable in the renewed teaching design,

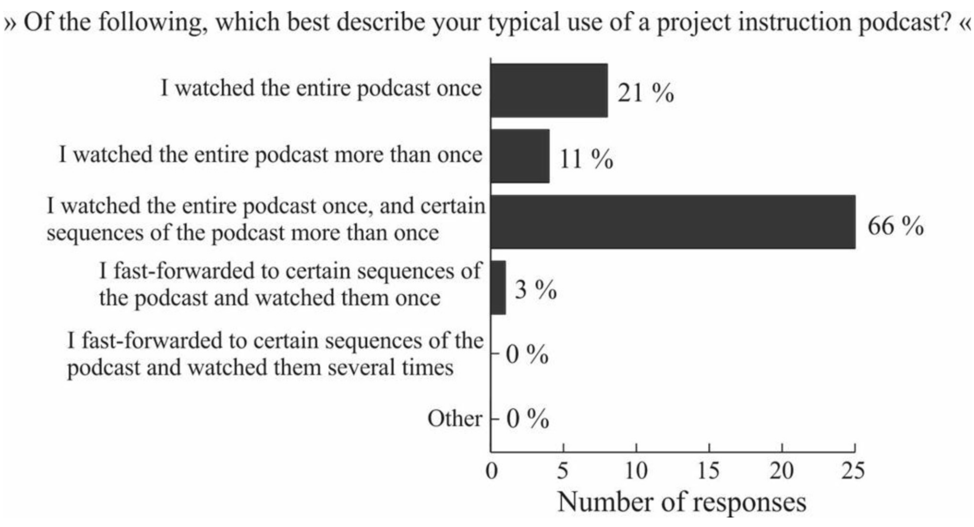

Fig. 3. Were the podcasts watched more than once?

where the teacher left the lecturer role for the facilitator role, interacting directly with students in small groups and experienced increased and qualitatively enhanced student engagement.

Similarly, students reported high degrees of active support from their teacher.
The survey reveals that the podcasts did indeed support student learning in different ways (see Fig. 4). This is concluded under the assumption that the respondents ticked only the personally most salient options, not necessarily maintaining the opposite view for the options not ticked.

Other options were mentioned by five students, one of whom denied any learning support: "It didn't support my learning at all". The other specify further, such as rehearsing for exams:

> We have had no exam yet. I guess it'll help a lot though; wish I had some ready-made in mp3 format for 'break time'' while preparing.

Or just to insist on how podcasts supported their conceptual understanding:

> I could follow through the entire lecture! What I mean is if I get disturbed I could rewind and listen again.

> They helped me better understand the lecture material as I could watch it again and again.

> I got a better understanding in general of the FEM method and its use.

When asked to comment on the disadvantages of running the course with podcasts instead of live lectures, 13 respondents commented that they missed the immediate interaction with the lecturer, i.e. the possibility to ask spontaneous questions. A few respondents also gave comments along the lines of "The demand is high on the technical/IT skills of the lecturer for the podcasts to be useful" and "the slides need to be well-composed". These comments are probably based on the varying quality of teaching material that the students have experienced in their former studies. When asked about comments on possible improvements the highest number of similar comments state that they have no ideas for improvements. Others comment on minor technical aspects, such as uploading the podcasts to iTunes or the possibility for online question sessions. One student remarks that he/she would rather go back to traditional lectures. Another student notes that the podcasts ought to be included in all courses, but that courses in general should not depend solely on podcast lectures. Finally, one student suggests an online questions and answers database with the possibility of getting answers to individual questions as well as getting inspired form questions raised by other group/ members.

The focus group (FG) interviews reveal aspects pertaining to learning strategies in relation to courses versus project work, where the latter receives by far the most priority from students being perceived as demanding higher order procedural skills and conceptual complexity; problem based project work is therefore regarded as the main source of learning at this university. The remaining 50% of the curriculum is covered by course teaching, which elicits rather superficial learning in relation to classes, followed by precipitated learning for exams involving either intense rehearsal of exercise solving methods for written exams, or exposure to subject specific discourse (reading loud, learning by heart) for the oral exams. Pedagogically integrated podcasts appear to alter student learning as they seem to facilitate cognitive processes especially in relation to compact and abstract type of courses: "It is all very clearly expounded, and I get much more out of it: when you are in a normal lecture, your brain may just skip out now and then, and then it's all lost" (FG1).

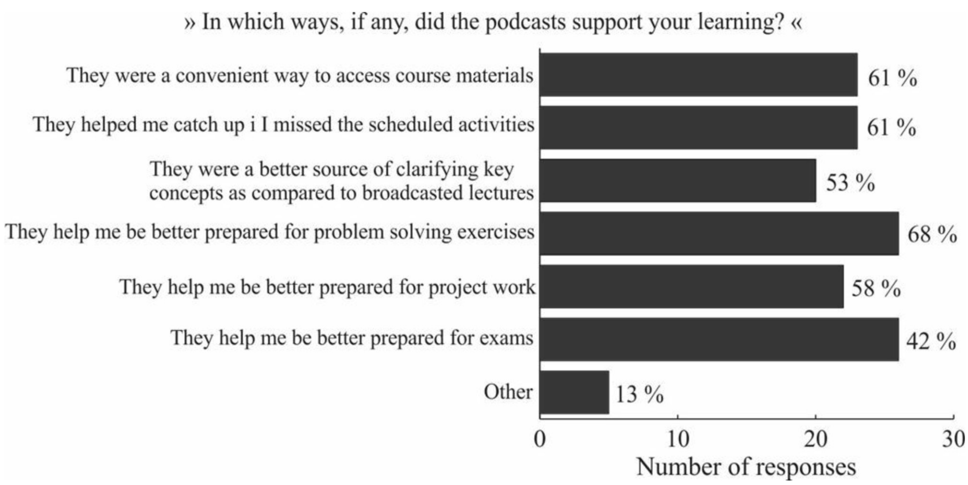

Fig. 4. Perceived learning support. Note that each respondent could tick more than one answer.

It also makes it possible for students to engage in deeper procedural processing of the content, i.e. by re-allocating the time spent on lecture into "more time for doing the exercises, which is the thing that actually matters" (FG2). At the same it imposes a change in the study habits regarding preparation as the students have to visit the content and procedural presentations before class, lest they will miss teacher assistance altogether: "I had to change my study habits: I needed to go through the podcasts before class, but then it perfectly suited my preferences, at home, in my cosy environment" (FG1).

What seems most valuable to students is meanwhile the possibility of rewinding if they miss something: "[w]ith podcasts you can always go back if you miss something (. . .) it is very crucial that I can stop if I am tired or lose concentration because it's often one long logical chain of mental processing, and if you skip for a brief moment, you lose the entire chain. Podcasts help to bridge the gaps in processing information into knowledge" (FG2).

Regarding the interaction during class, this also changes locus. Although some students remark that the absence of lectures deprives students of the possibility of interaction and also for the dynamism of the live experience, including body language and the immediacy of the physical presence, most students maintain that podcasts have a higher explanatory value in that podcast mediation involves compensatory ways to enhance communication:

> . . . as compared for instance to videotaped lectures, podcasts are better for this very reason, that the explanations are more efficient because there is less body language so you have to store the information more precisely. In a lecture he may use body language, but it gets far more effective when it is stored into the verbal, pictorial and structured information in podcasts. The quality of podcasts is much higher than videotaped lectures because the teacher knows that this has to be made accessible also without him being present (FG4).

As per the opportunity to ask questions 'live', the groups agree that "we don't normally ask questions in plenum, but in the study group, preferably after having talked it over in the group. It's a way to optimize lectures and supervision time, not waste time on asking unnecessary questions that can be answered by the group, or that are only relevant to one person" (FG3). The reason for this, students say, relates to the ways that they are acculturated to the study milieu, some students attribute it to the first year of study where lectures are given in very large, multidisciplinary classes: "It's the culture, the lecturing culture at the university: you don't ask, you don't answer. This is not a classroom, this is the biggest difference between school and university: you just come and attend to a lecture and try to get as much as possible out of that, then you go home and struggle with the problem yourself" (FG3).

The opportunity of increased direct interaction with the teacher in small groups is welcomed by students, especially as questions first seem to arise when they get to work with problems in groups: "the questions only arise as we attempt to solve problems. It's difficult to foresee what you need to clarify, and therefore better to get clarifications in the extended practical session, so there is time to find a way to help you" (FG3). The groups agree unanimously on the efficacy of the podcast in teaching, suggesting additional adjacent digital applications such as RSS feeds and the possibility to upload questions and answers that can be shared group wise on a common platform for "not only getting answered the questions in our group, but also questions that we would not have thought of and yet convey important knowledge" (FG4). Meanwhile, students express a certain concern at the prospect of more and more podcast integrated courses as it may imply the need for radical change in study habits. It might "force us to use more and more of our private time and so we can't also attend lectures" (FG2).

5. Pedagogical alignment—threshold concept identification

The intended learning outcome [5] of the finite element method course is that students should be able to program their own 2D finite element code using simple elements, both triangular and quadrilateral. Special focus is on deriving, calculating and programming the stiffness matrices for the different elements. Furthermore a lecture is focused on modeling considerations, stress visualization, stress singularities, etc. Identification of the threshold concepts is vital for focusing the lectures and the exercises on key issues. The threshold concepts identified by the lecturer on the basis of previous experiences in assisting student learning in this course are as follows.

5.1 Assumed displacement fields

A mechanical problem can be solved by basing the solution method on an assumed displacement field using the element shape functions. In earlier engineering studies (and in high school physics) solutions to physical problems are found by setting up some (differential) equations and solving them exactly. Examples are the beam differential equation and the Euler column. On the other hand, by basing the solution on assumed displacement fields within the elements, the solution is not exact. However, the precision, i.e. quality, of the solution can (and should) be validated via a convergence analysis. These concepts force the students to enter a new level of understanding in solving mechanical problems, which is essential, since most of the problems in this field cannot be solved exactly. The students that pass this threshold realize that the linear finite element method is quite simple for both 1d, 2d and 3d, and even for different problem types (structural, heat conduction).

5.2 The logics of basic MatLab programming

Prior to the course, the students know little about the MatLab programming language and computer programming in general. When the students pass the threshold of programming logics, e.g. the concepts of "if-conditions", loops, and program building blocks (called functions in MatLab), paired with understanding the syntax of manipulating vectors and matrices, many of the course exercises become fairly basic for the students. Moreover the students that have passed the programming logics threshold are often much better at breaking complex engineering calculations down to the basic numerical parts, which can be solved using basic programming.

5.3 Numerical integration and its implementation

For isoparametric elements, an analytical solution of the stiffness matrix integral, $\mathbf{k} = \int_A \mathbf{B}^T\mathbf{DB}\ t\,dA$, is not possible, so numerical integration is applied, via the Gauss quadrature, where the above integral is replaced with a sum. This is initially a difficult concept for the students to grasp; they are usually very puzzled by the notion of Gauss points and weights. This is especially true when it comes to the method's implementation. Several of the course exercises focus on programming a MatLab function that calculates the stiffness matrix for isoparametric finite elements. These assignments force the students to attempt to understand the workings of Gauss integration, and the fact that a sum sign, $k = \sum_{\text{Gausspoints}} \cdots$, translates into a loop in the program code. This is very puzzling to most students, at first. Students that pass this threshold find this very simple. When helping the students with exercises in small groups it is easy to tell when students pass this threshold. For these students, the solutions to the exercises are found in a fraction of the time compared with the students that struggle with the concept.

Traditionally, the above mentioned threshold concepts are not dealt with directly in a course, except for the first one, to some extent. Rather, they are seen as secondary aspects of the finite element subject. Nevertheless, the learning outcome is that students are able to independently develop finite element codes, rather than using commercially available software, hence the need to attend to the above mentioned threshold concepts is vital for the students. Using podcasts rather than plain lectures presents several advantages in helping students grasp the new concepts:

- The possibility to hear the lecture explanations repeatedly in combination with slides displaying well-prepared figures in an attempt to illustrate the concepts visually, e.g. shape functions. This helps students pass the thresholds, especially No. 1
- The second and third concepts need hands-on experience for reaching and passing the threshold, which is the reason for the problem solving exercises. A great advantage of the video lectures is that they free up time for the lecturer. Time that can be spent in aiding the students' understanding of the exercises.
- Students choose the time and place to watch the lecture content. This means that they can do it at home in quiet surroundings, sitting in an armchair. Or they can watch the lectures in the group room with their fellow students, having the opportunity to discuss the content.

6. Discussion

Our discussion revolves around the students' perceived benefits of course podcasts that point mainly to the advantage of flexible, unrestricted access to digitally stored content, as well as to the extended interaction with the lecturer, as the whole class time was replaced with teacher/ expert assisted work in small groups. Concerning the first perceived benefit, student testimonies unanimously agree that podcasts support learning. It is the unrestricted and flexible access to course content in the form of high-precision, audio-visually enhanced content supplemented by worked examples that students found enhanced their cognitive processing and problem solving skills. Regarding threshold concepts, students agree that digital representation allows for on demand, recursive use to conceptual explanations, which supports the processing of the very concepts that are troublesome for students, yet are necessary to open up the required disciplinary knowledge. Once integrated, they tend to change student identities as they shift towards increased familiarity with the discipline and its problems.

The second perceived benefit pertains to the pedagogical alignment underlying the use of technology to support the learning objectives. In this case, the course is directly linked to the major problem based project unit of the semester that aims at functional knowledge; therefore, the underlying pedagogy should elicit problem solving competencies at various degrees of complexity. The sustained pedagogic intention of stressing the problem solving aspects of the course has been found to advance student learning from a focus on fixed disciplinary content and habitual examples towards higher procedural and conceptual knowledge forms. This is manifested in the particular interactional pedagogic design, where the teacher acts as an expert consultant continually available for dialogue and clarifications helping students sustain their efforts. Considering the TPCK-model for aligning the pedagogical approach with course aims, in our case, performative knowledge, i.e. students should be able to program independently in MatLab and use this skill in a wider problem solving approach that may even appear counter-intuitive (cf. §5), the teaching approach should promote learning by doing. In this case, it was observed that the teacher encouraged a trial-and-error approach, where mistakes were seen as a source of troubleshooting and thus learning. It was observed how the teacher consistently avoided giving final answers, but showed a preference for asking facilitative questions, encouraging the dialogue in the group. Finally, he refrained from pushing the students through, but had them rather extend their search in the liminal zones, to experience by themselves the range of options to the problem. The use of podcasts supported this approach as it served as a recourse for the students to revisit when stuck, which helped them sustain their efforts.

The idea of learning through solving problems seems crucial for developing deep learning involving a focus on practice and various process competencies, i.e. meaning negotiations, team collaboration, communication, etc. Problem Based Learning (PBL) marks an innovative turn in this respect as it mobilizes higher order thinking and inquiry-based processes based on student autonomy in setting up and pursuing learning goals that are mobilized through dialogic group processes. Knowledge evolves organically, based on individual contributions and group negotiations as per the perceived contextual requirements, revolving around liquid conceptions of learning where students navigate a variety of learning environments and competing perspectives on knowledge to be adapted to changing demands [15]. One of the ways of implementing PBL is the problem and project based learning in use at our university, also known as the PBL–Aalborg model, which exhorts deep and personal learning through team collaboration and complex project based work processes in the specific context of a problem driven project identified by the students [16]. Courses serve to prepare students for PBL and the various project scenarios that will further expand the scope of learning as students become active inquirers and learn to treat knowledge in flexible ways. However, students need to reach a certain level of mastery in order to mobilize the necessary drive and confidence to navigate new knowledge landscapes,so that they can withstand the conditions of liminality connected to PBL, i.e. the ambiguity related to further threshold transition [6].

Digitally available instructions seem to act as holding points for students, providing them with a sense of relative security in the uncertainty of learning new concepts and applying theory into practice. Our findings based on students' perceptions of the ways in which podcasts seem to support their learning efforts posit that what helps is not the podcasts as such, but rather the integrated use of podcasts in a reviewed instructional design. Here, the teaching intention meets the learning needs of the students, i.e. for easy access to content knowledge in ways that free off cognitive capacity to focus on higher cognitive skills such as procedural knowledge and problem solving. Thus, an emerging digitally integrated learning design for engineering courses might take into account the option of involving technology for storing solid content and standard demonstration to serve a resource for active learning that promote students' involvement with problem-oriented, applied aspects of knowledge. Likewise, our findings emphasize the need for a qualitatively enhanced student–teacher interaction, i.e. where the teacher assists students in active learning and problem solving, re-centering teaching on the functional aspects of knowledge. Minor alterations in teaching design through the integration of digital content tools to store declarative knowledge, such as podcasts, can enhance student learning and leverage the value of student–teacher interaction that will focus on more in-depth treatment of critical aspects and on higher level development of engineering competencies, such as application, analysis and critical problem solving.

7. Conclusion

The present study juxtaposes a traditional large-lecture course to an interactive pedagogic design that relies on the active use of podcasts to mediate declarative and basic procedural understanding, and discusses this in relation to active learning and problem orientation in engineering classes. The goal of this study has been to learn from students about the pros and cons of integrating podcasts in course teaching, and use this as an input to the academic discussion on the potential of digital technology in similar engineering courses that aim towards functional knowledge. This is a modest, low scale study, meant to serve as an inspiration for teaching academics who wish to explore the educational potential of this technology in order to leverage the learning outcome of their courses. The results indicate major perceived advantages in the particular use of podcasts from a student learning perspective in terms of unrestricted, flexible access to digitally mediated content and procedural knowledge, enhanced by increased and qualitatively superior teacher–student interaction in small learning groups. Here, the activities were problem-centered, which was perceived as a meaningful way to integrate new knowledge. Students stressed the importance of certain criteria to be met for podcasts to qualify as receptive viewing with an educational aim, e.g. pedagogical-presentational proficiency as well as technical quality. However, they also warn against extended and indiscriminate use of technology, as it may inflict major changes in study habits, which would require careful considerations.

Our conclusion is that it is not the technology as such that enhances the quality of learning, but rather the underlying pedagogic approach that makes it possible for the teacher to elude the traditional lecturer role and partake more of the facilitation and expert guidance roles. The content knowledge and simple procedural mediation are successfully overtaken by podcasts, where both receptive viewing and the worked example formats are valued by the students for the advantage of being used on demand, and as such supporting of self-directed learning. However, in order to extend beyond reproductive learning, they have to be part of an engaging pedagogic design, involving an enhanced teacher–student contact and an extended active learning environment. Informal access to expert facilitation in small work groups can provide the support necessary to help navigate the troublesome realms of disciplinary advancement and avert future challenges.

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Dorina Gnaur holds a Ph.D. in Social Sciences and has, since 2011, been affiliated as an Assistant Professor at the Department of Learning and Philosophy at Aalborg University, Denmark. Her current research and development activities concern learning in higher education including competence development of university staff. For one and a half year, she was affiliated to the Department of Civil Engineering at Aalborg University, with the purpose of conducting research and development specifically within engineering education in order to identify effective learning methods and learning environments, as well as pedagogic innovation areas within the given context. The present article is one of several studies in the course of being reported in international journals.

Johan Clausen is associate professor at the Department of Civil Engineering at Aalborg University, Denmark, with which he has been affiliated since his M.Sc. degree in 2003. His research area is numerical calculations within the civil and structural engineering in general, in particular for geotechnical materials. He is lecturing and supervising students on all levels, from the first year to the final master degree projects and supervision of Ph.D. students. He is the technical coordinator of three semesters in the bachelor/master study programs in civil and structural engineering, and was elected "teacher of the year" by the students in said programs in 2010.