Learning design for science teacher training and educational development

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This paper presents the impact and perception of two initiatives at the Faculty of Science and Technology, Aarhus University: the teacher training module 'Digital Learning Design' (DiLD) for assistant professors and postdocs, and the STREAM learning design model and toolkit for enhancing and transforming modules. Both DiLD and the STREAM model have proven to be effective and scalable approaches to encourage educators across all career steps to embrace the potentials of educational technology in science higher education. Moreover, the transformed modules have resulted in higher student satisfaction, increased flexibility in time, pace, and place, and in some cases also improved grades, pass rates and/or feedback.

Keywords: learning design, science education, teacher training, educational development

Introduction

Since the early 00s learning design has gained momentum as an approach to educational development in higher education. The learning design approach provides tools and models that can help educators pedagogically inform and share teaching practices and, when used for educational technology, help qualify the transformation of traditional teaching into blended and online learning. In addition, learning design also helps defeating well-known barriers in more conventional ad hoc approaches to educational development such as missing sustainability of initiatives and the missing link between educational research and practice (Conole, 2013; Cross et al., 2008; Godsk, 2015; Koper & Tattersall, 2010; Laurillard, 2012; Nicol & Draper, 2009). Centre for Science Education (CSE), the pedagogical development unit at Faculty of Science and Technology (ST), Aarhus University, has adopted a strategic approach with a focus on (1) development issues that resonate with educators and (2) solutions that are effective, efficient, and supported by solid research (Vicens & Caspersen, 2014). In order to facilitate this approach and optimise its impact and scalability, a framework-based learning design approach has been adopted. With this approach the educators are active developers of their own practice, and potentially producing reusable and sharable materials and practices (Conole, 2013; Cross et al., 2008; Godsk, 2015; Koper & Tattersall, 2010; Laurillard, 2012).

The STREAM model as learning design

Faculty of Science and Technology (ST) is one of the four faculties as Aarhus University and has approx. 7,000 students and 1,650 full time academic staff (full-time equivalent) (Aarhus University, 2015). At CSE the aim for educational development is to provide educators with an open-ended learning design, where essential pedagogy-informed aspects of the learning designs are fixed while other aspects are open for variability. The open-ended learning design approach is carefully developed and conveyed particularly regarding efforts in technology-based educational development. In practice this is actualised by means of a learning design framework designed for this and similar settings: 'the STREAM model' (Godsk, 2013; Figure 1). 'STREAM' is an acronym for 'Science and Technology Rethinking education through Educational IT towards Augmentation and Modification', where the terms 'augmentation' and 'modification' refer to two different levels of blended learning (Godsk, 2014a; Puentedura, 2010). The STREAM model is based on well-tested and acknowledged teaching strategies for science higher education such as *just-in-time teaching* (Novak et al., 1999), *active learning* (Bonwell & Eison, 1991), *flipped classroom*, *peer instruction* (Mazur & Hilborn, 1997), and socio-cultural theories used particularly to inform and qualify the apprenticeship between learners (apprentice) and more experienced peers (co-learners and educators) (Fjuk et al., 2004). The model provides an outline of how a module may be transformed into blended and online learning using feedback loops, online out-of-class activities, in-class and online follow-up, and suggests tools and technologies that support the design.

In addition to the STREAM model, a toolkit is provided for the educators consisting of a webcast recording facility and a media lab providing easy production of the materials needed for the transformation of modules and technical support, respectively.

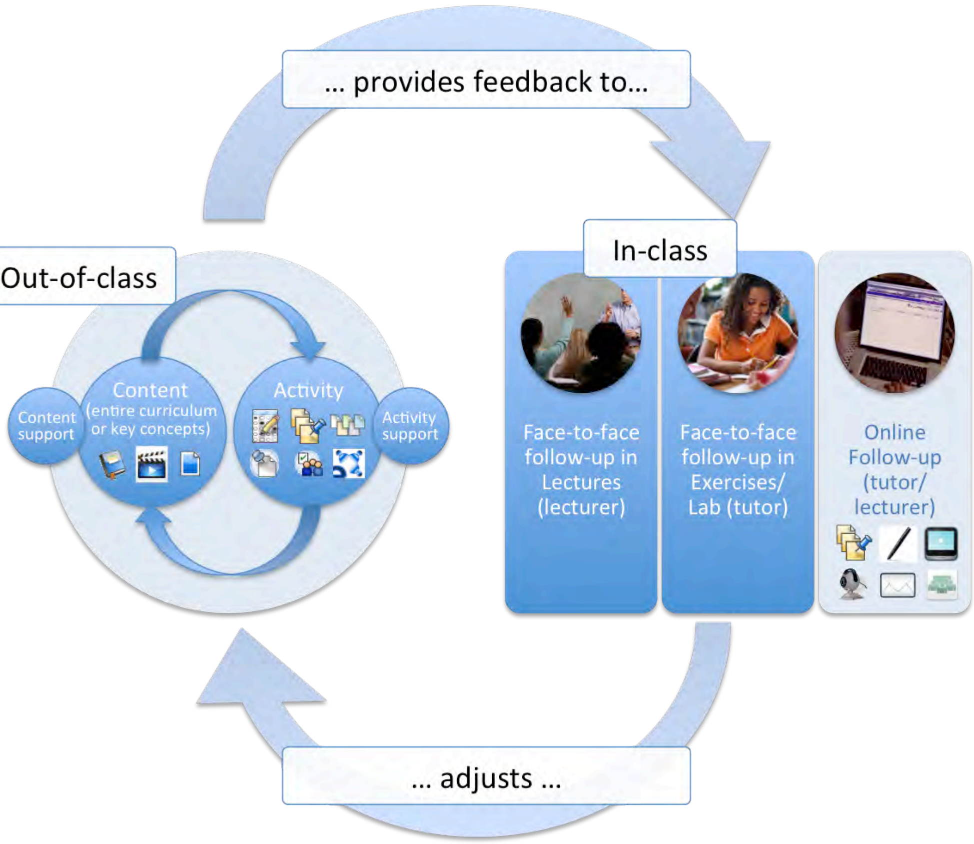

Figure 1: The STREAM model

The STREAM model is currently being used for the transformation of modules, and it is being disseminated through individual meetings with educators, workshops, websites, the teacher training programme, and department meetings. Thus, the STREAM model functions as both a pedagogical framework and an organisational change agent. This is reflected in two major initiatives targeting two different groups of educators:

- The teacher training programme, 'Digital Learning Design', for assistant professors and postdocs. The programme introduces educational technology and learning design including the STREAM model.
- STREAM as a stand-alone learning design model and toolkit for ad hoc assistance to professors and associate professors and their transformation of modules with educational technology.

Learning Design in Teacher Training

Teaching at Aarhus University is predominated by face-to-face activities including lectures, small class teaching, laboratory teaching, etc. However, it is a specific aim in the university policy to rethink existing teaching practice with technology (Aarhus University, 2011). To pursue this aim a module on educational technology was included in the mandatory teacher training programme in 2012. The Teacher Training programme is offered primarily to assistant professors and postdocs and counts for 5 ECTS (European Credit Transfer and Accumulation System, 1 ECTS credit corresponds to 25-30 hours of work) (European Union, 2015). The programme includes four mandatory modules of which three are common to participants throughout the university, while the module on educational technology is organised differently for each individual faculty. At ST this module is DiLD and has a workload of 30 hours (1 ECTS credit equivalent to approximately 1.5 hours of participation per weekday during the module). The objective is outlined in the overall module description:

> The objective of the [DiLD module] is to give an introduction to Educational IT and Educational Technology at Faculty of Science and Technology (ST), Aarhus University. During the module participants will be introduced to the potentials of using different technologies in teaching and it will be demonstrated how technology supported teaching can be designed. The participants will be introduced to the services provided within educational IT at ST and they will develop a digital learning design to be used in their own teaching. (Godsk et al., 2014; p. 1)

The DiLD module is designed according to the STREAM model and implemented in the institutional learning management system (LMS), Blackboard Learn (Figure 2). The module consists of four weeks of flexible, entirely online learning (except for a concluding session) and introduces a range of educational technologies and learning design models. By demonstrating how educational technology has a potential to increase the learner flexibility, the module gives the participants a first-hand experience with online learning and serves as inspiration for the participants' own teaching (Godsk et al., 2013). Each week consists of a learning path of 6-12 steps with 4-6 activities. The activities aim to build upon participants' existing teaching experience and support the development of their own teaching practice and materials in order to make the module directly applicable (Godsk et al., 2013). Though most participants are not currently teaching online modules; both the institutional strategy for technology in education (Aarhus University, 2011) and the fact that educators are including an increasing number of online elements such as video, online discussion forums, and online assignments in their teaching practice highlight the importance of being proactive by also pedagogically informing their future uptake of technology. As such the DiLD module format serves two purposes: to give as much flexibility as possible to the participants and to illustrate the design of an online module.

As prescribed by the STREAM model, DiLD is designed with a continuous interplay between readings, articles, videos, etc. and active learning through participation in moderated discussions and wikis. By mixing *individual* exploration of online materials and *participatory learning*, such as asynchronous discussions and peer-feedback, the module design ensures a balance between *acquisition* of new knowledge, and *collaboration* and *participation* (Brown et al., 1989; Lave & Wenger, 1991; Sfard, 1998). The readings and activities are interlinked with a narrative about the topic of the relevant week to bring the reading and activities into a cohesive whole (Weller, 2002) and at the end of each week the activities and readings are wrapped up by the e-moderators through an e-mail send to the participants via the LMS. The subsequent week is then adjusted according to the needs and interests of the participants. The basic idea is to support *a progressive learner role* where participants progress from being a learner to a designer of digital learning activities through active participation during the module (Lave & Wenger, 2003; Salmon, 2011).

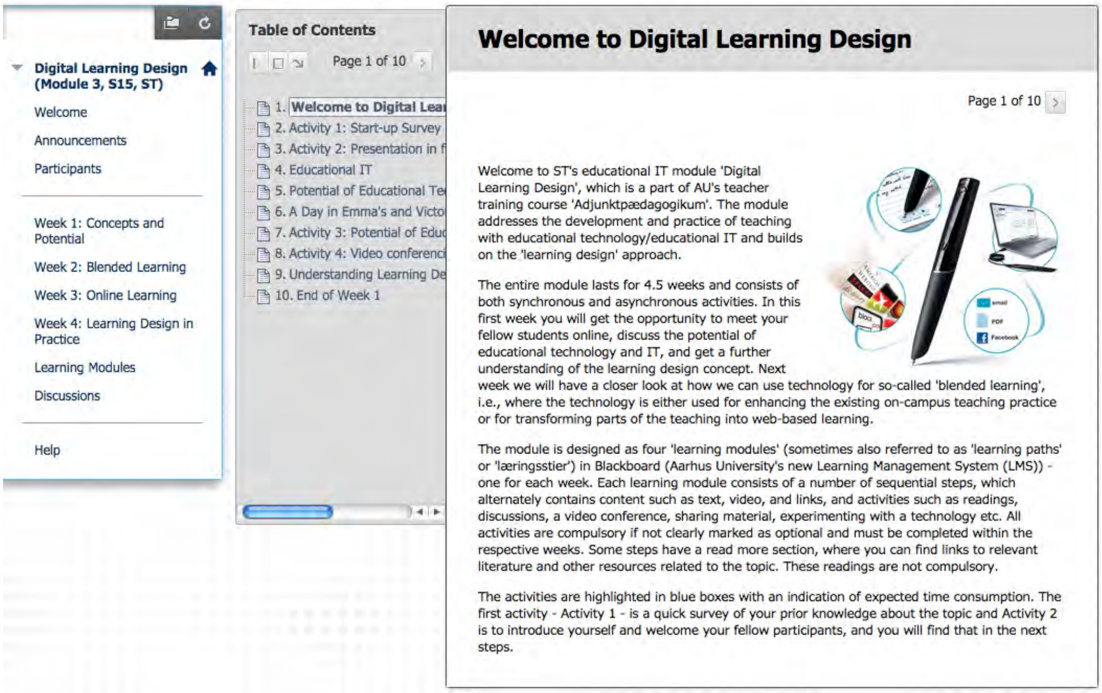

Figure 2: Week 1's learning path of 'Digital Learning Design' as implemented in Blackboard Learn.

The module culminates with each participant developing an individual learning design for their own teaching practice describing both concept and materials. The design is then presented at a concluding poster session where peer-feedback is received. In developing the learning designs, the participants are encouraged to adopt an existing learning design approach, such as the STREAM model, the Five-stage Model (Salmon, 2011), or a model for structured discussions for their own teaching development (Sorensen, 2005), or develop their own according to the presented theory. In the individual learning design, module participants identify components of their current teaching practice that need to be transformed or enhanced with educational technology, a suitable learning design model, and relevant technology such as webcasts, lecture captures, learning paths, online discussions, and online exercises. In addition, the participants set the level of the transformation in terms of the revised SAMR model which operates with four levels of transformation of traditional teaching ranging from 'substitution', where the technology merely substitutes existing teaching practices, to 'augmentation' referring to settings where 'educational technology is used for enhancing activities or transforming components' (Godsk, 2014a; p. 184), 'modification' referring to where the technology is 'used for transforming entire activities' (Godsk, 2014a; p. 184), to 'redefinition' where technology is used to completely transform or reinvent the teaching practice (Godsk, 2014a).

The efforts associated with running the module, consist of on-going update of the content, moderation and summing up of online discussions, communication with the participants, individual supervision and feedback, organising the poster-presentation, and various administrative tasks and evaluation. This workload is shared between a handful of e-moderators and the module chair and estimated to 504 hours annually (two DiLD modules per year). In addition, the media lab assists the facilitation by organising an online workshop in video conferencing and supporting the participants with technical issues. This assistance is estimated to 75 hours annually. The costs for handling the enrolment, providing a LMS, and providing basic IT support are defrayed by the Educational Development Network and the IT department.

The Participants' Perception of Learning Design

The participants were primarily employed as postdocs (40%) or assistant professors (30%) and their teaching experience ranged from experienced lecturers responsible for modules with more than 100 students to postdocs or researchers giving occasional lectures and being involved in project supervision of students. According to a pre-survey carried out in connection with the last two runs of the module, 7% said they had heard, read about or had first-hand experience with learning design, 5% had used educational technology to transform parts of their teaching to online teaching and 0% had used educational technology to teach entire modules online.

At this point it is still not possible to measure the impact of the DiLD module on teaching and learning or the success of using learning design for teacher training. However, indications on how the participants perceived the module is provided by evaluation data collected after the last four repetitions of the module (Autumn 2013, Spring 2014, Autumn 2014, and Spring 2015). The collected data represents 20, 16, 31, and 9 module participants, respectively. In total the data basis is 76 module participants.

The module evaluation addresses the participants' prior experiences with educational technology and learning design, the evaluation of the module, the participants' perceived learning outcomes, their perception of educational technology and learning design, and a survey of their future plans for adoption. When asked about perceived skills acquisition during the module a majority of participants expressed that the module had enabled them to design and develop blended learning (83%) and transform traditional teaching into blended or online teaching (73%). Most participants agreed or strongly agreed that they gained insight into relevant educational technologies and pedagogical methods and theories (80%) and were able to evaluate the potential of using educational technology in their own teaching (88%). 82% agreed or strongly agreed with the statement: 'the content of this module is relevant for my own teaching' and 70% of the participants expressed that their perceived learning outcome during the module was high.

In addition, the intended transformational level according to the revised SAMR model provided an indication of an ambitious use of technology. Scrutinising the individual learning designs revealed that 84% aimed at *augmenting*, 7% *modifying*, 7% *redefining*, and 2% *substituting* their teaching practice with technology. Bearing in mind that Aarhus University is a traditional, campus-based university with an insignificant amount of distance learning, the transformational levels witness a general high level of ambition for educational technology. The individual learning designs also revealed a highly diverse but generally very ambitious and intense use of educational technologies such as videos, discussion forums, learning paths, and peer instruction tools. Various kinds of video formats (30% of individual learning designs) such as webcasts, lecture captures, screencasts, and pencasts, peer instruction tools (15%) such as PeerWise (Denny et al., 2008) and curriculearn (Brodersen, 2014), and the use of learning pathways (14%) were particularly prevailing.

The individual learning designs indicated a pronounced uptake of the presented learning design models and in particular the STREAM model. In practice, this meant that more than 80% adopted the STREAM model for their learning design with the remaining 20% split evenly between a completely new learning design model and other existing learning design models such as the Five-stage Model (Salmon, 2011) or a model for structured discussions (Sorensen, 2005) which they found relevant to their own teaching practice (Figure 3).

Prospectively, 80% of the participants in the last two runs of the module (i.e. Autumn 2014 and Spring 2015) expressed in the evaluation that they had plans to adopt learning design in their teaching practice within the next year or more, and 45% within the next 6 months.

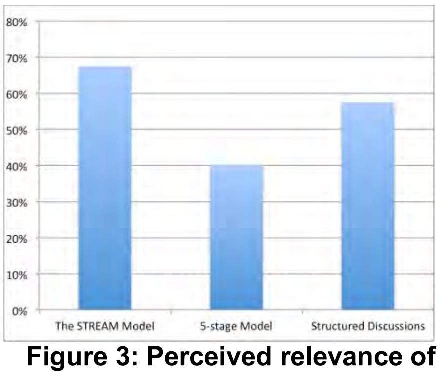

Figure 3: Perceived relevance of the three presented learning design models.

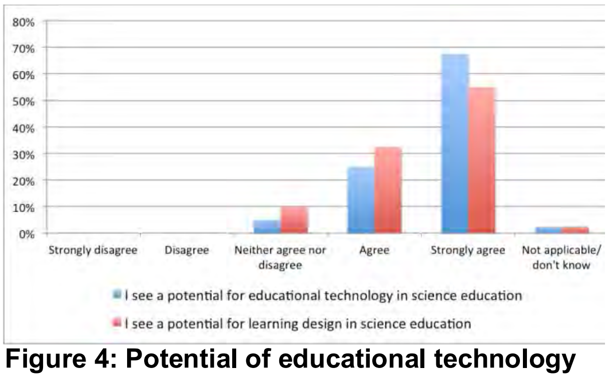

Figure 4: Potential of educational technology and learning design in science education.

In spite of the participants' limited prior experiences with educational technology and learning design, the module led to a highly positive attitude. According to the module evaluations, the participants spent an average of 34 hours on the module (median 35 hours) ranging from 10-87 hours, a bit more than the estimated 30 hours (~1 ECTS) and what was required. Furthermore, most module participants saw a potential for both educational technology (93%) and learning design (88%) in science education (Figure 4).

Transforming Modules with Learning Design

Besides the DiLD module for assistant professors, the STREAM model and its toolkit are used, presented, and referred to through various channels aiming at all educators. It serves as a reference at meetings with educators, the locally held Frontiers in Science Education 2014 conference, invited talks and workshops on educational technology, development meetings with the educational committees at the faculty, freely available online resources on STREAM (e.g. Godsk, 2015b), and published papers on the topic (cf. Godsk, 2013; 2014a). Furthermore, STREAM has also been a prominent part of educational development meetings with all twelve educational committees at ST in the spring of 2015.

Most associate professors and professors are highly self-governed with regards to their teaching practice and uptake of technology and STREAM may be used without CSE's knowledge inspired by a conference, a workshop, the website, etc. Hence, the full extent of the impact of the STREAM model and toolkit is unknown. For transformations where the educator has been in direct dialogue with CSE, however, the impact on teaching and learning has been assessed. An overview of the completed transformations and their institutional impact in ECTS credits and full-time equivalents (FTEs) as well as impact on students' learning is provided in Table 1. Institutional impact is expressed in ECTS credits and calculated as (the number of students) x (the number of ECTS credits associated with the module). One FTE corresponds to 60 ECTS.

Table 1: The STREAM transformations' institutional impact and impact on learning.

Module	Learning Design	Institutional impact	Impact on students' learning
Calculus 2, 2013 (undergraduate, 5 ECTS)	The module was *modified* by replacing all lectures with learning paths containing webcasts, MCQs, reflection exercises, and online follow-up in Dokeos LMS.	Approx. 60% of the 1,184 students followed the transformed module. I.e. approx. 710 students, 3,550 ECTS/59.2 FTEs	The evaluation of the module and examination results showed that the online students obtained significantly better examination results, better pass rates, and were significantly more satisfied with the learning compared to the face-to-face students (cf. Godsk, 2014b).
Astrophysics, 2013 (undergraduate, 5 ECTS)	The module was *augmented* by supplementing lectures with webcasts, learning paths, online activities, and online feedback in Blackboard Learn.	123 students, 615 ECTS/10.3 FTEs	The module evaluation indicated a high satisfaction with the format (70 % of the students responded that they referred the transformed format to traditional lectures) and provided evidence of an increased degree of flexibility in time and place, support for repetition and examination preparation, and more time for discussion during lectures (Godsk, 2014a).
Microbial Physiology and Identification, 2014 (undergraduate, 10 ECTS)	The module was *modified* by replacing all lectures with webcasts structured in learning paths in Dokeos.	25 students, 250 ECTS/4.2 FTEs	The end-of-module evaluation indicated a high student satisfaction (76% preferred the transformed format to traditional lectures) and a higher degree of flexibility in time, place, and pace. 87% most frequently watched the webcasts outside regular teaching hours.
Evolution and Diversity, 2014 (undergraduate, 5 ECTS)	The module was *augmented* by transforming parts of the lectures into webcasts.	123 students, 615 ECTS/10.3 FTEs	N/a.

Calculus 1, 2014 (undergraduate, 5 ECTS)	The module was *modified* by replacing all lectures with learning paths containing webcasts, MCQs, reflection exercises, and online follow-up in Blackboard Learn.	1,048 students, 5,240 ECTS/87.3 FTEs	The end-of-module evaluation indicated a high student satisfaction (51% preferred the transformed format to traditional lectures), a higher degree of flexibility in time, place, and pace, and a wide utility of the learning paths. 81% found that the online activities supported their understanding.
Calculus 2, 2014 (undergraduate, 5 ECTS)	Modified as described for Calculus 2, 2013.	821 students, 4,105 ECTS/68.4 FTEs	The end-of-module evaluation indicated high student satisfaction (50% preferred the transformed format to 31% preferring traditional lectures), a higher degree of flexibility in time, place, and pace, and a wide utility of the learning paths.
Astrophysics, 2014 (undergraduate, 5 ECTS)	The module was *augmented* by replacing lectures and 25% of the final assessment with webcasts, learning paths, assessed online activities, and online feedback in Blackboard Learn.	125 students, 625 ECTS/10.4 FTEs	The examination results and the module evaluation provided evidence of a high student work rate and satisfaction (85% very satisfied or satisfied with learning outcome, 76% preferred the new assessment format), lower fail rates (50% lower than the previous year) and a wide use of the flexibility offered.
Microbial Physiology and Identification, 2015 (undergraduate, 10 ECTS)	The module was *modified* by replacing all lectures with webcasts in Blackboard Learn.	12 students, 120 ECTS/2 FTEs	The end-of-module evaluation indicated high degree of flexibility in time, place, and pace. 50% used the webcasts for assignment work and examination preparation. However, only 25% preferred the transformed format to traditional lectures.
Evolution and Diversity, 2015 (undergraduate, 5 ECTS)	The module was *augmented* by transforming parts of the lectures into webcasts.	117 students, 585 ECTS/9.8 FTEs	N/a.
In total	9 modules were delivered augmented or modified using STREAM.	Approx. 15,705 ECTS (261.75 FTEs) were impacted by learning design.	An overall positive impact on students' learning, including an increased student satisfaction, a higher degree of flexibility in time, place, and pace, and in some cases also improved grades and/or pass rates.

To promote the STREAM model and toolkit and help the educators with the adoption, a number of resources have been developed. This includes a website (Godsk, 2015b) with a short introduction to the model, its potential for improving teaching and learning, its practical benefits, a list of already transformed modules and their incentives, and a 6 minutes long video introducing the model and how it is applied. The website and video were launched 6 January 2014 and until now (25 June 2015), the website has been accessed 659 times and the video played 110 times, which is equivalent to an average of 37 views of the website and 6-7 plays of the video per month. In addition, a short learning path has been developed and provided to the 46 educators signed up to the resource page in the LMS. Finally, the educational results and information about the STREAM model and transformations were disseminated to the 213 subscribers of quarterly newsletters of which approximately 30 were educators at the faculty. A press release was issued on the transformation of Calculus, which resulted in news coverage in two media (Loiborg, 2014; Stiften, 2014) and publication of three academic papers, two conference papers (Godsk, 2013; 2014a) and one journal paper (Godsk, 2014b).

In total, the initiatives have reached a large portion of the educators at ST through one channel or another and the vast majority of all undergraduate students.

Using Learning Design for Educational Development with Technology

Using a framework-based learning design approach, exemplified by the STREAM model and toolkit, has demonstrated a number of advantages:

1. STREAM provides a uniform and common language to articulate educational development in the initial phase of implementation as well as later phases of refinements and exchange of experience;
2. STREAM provides the opportunity to more uniformly facilitate technology-based educational development through standard templates and guidelines;
3. the overall learning design (the fixed/invariant parts) is developed by educational experts who can prioritise, integrate and balance the various aspects in an optimal overall design;
4. the specific learning design (refinement of the variant parts) is left to the educators to accommodate specific needs. These can be subject-specific needs or individual preferences or beliefs (still maintaining a common denominator among the learning designs).

In addition, the STREAM model has at least two build-in potential advantages:

5. STREAM provides a common structure that addresses analytical and management issues (quality assurance, accreditation, etc.);
6. STREAM ensures a common and recognisable overall LMS structure for students while still providing opportunities for detailed variation to accommodate individual needs and preferences.

Some of these advantages are common to many learning design practices in general. This includes the potential to provide a common language for sharing teaching and learning practices, the ability to operationalise the pedagogical knowhow of the educational experts and accommodation of the development of individual learning design according to and by the educators themselves (Agostinho, 2006; Cross & Conole, 2009; Godsk, 2015a; Koper & Tattersall, 2010; Laurillard, 2012; Mor & Winters, 2007).

Though the STREAM model is designed with a specific context in mind, the fact that the model is build on well-tested approaches to educational development and a strong research base within the area of learning design, the experiences and findings should apply in other teaching contexts as well. Hence, the authors strongly recommend a learning design approach to educational development with technology, including the STREAM model as the concrete learning design model.

Conclusions

The educational development effort at Faculty of Science and Technology, Aarhus University, revolves around a learning design approach and in particular the STREAM learning design model. This has proven an effective way of getting educators at the faculty to embrace the potentials of educational efforts, as, for instance, reflected in the fact that 93% of assistant professors and postdocs participating in the Digital Learning Design module see a potential for educational technology in science education, 88% see a potential for learning design, and that 80% expect to adopt learning design within the next year or more. 68% find STREAM relevant to their own teaching practice and the majority feel that the Digital Learning Design module has enabled them to transform, design, and teach with educational technology.

The associate professors and professors are exposed to the topic of educational technology and learning design through a string of activities ranging from small meetings to conferences. The process of sharing practices and ideas, including the STREAM learning design model, through many different initiatives has made it possible to reach a large portion of the educators. Furthermore, the process has resulted in a series of transformations, which, judging from the institutional impact and impact on students' learning, have been highly successful resulting in increased student satisfaction, a higher degree of flexibility in time, place, and pace, and in some cases also improved grades and/or pass rates for a large number of students/FTEs. As an added bonus, the results have led to a persistent inflow of new educators interested in transforming their teaching practice with educational technology and the STREAM model.

At this point, the experiences with learning design in terms of the DiLD module and the STREAM model are positive and suggest that learning design is a suitable, scalable, sustainable, and effective approach to educational development for implementing educational technology in science higher education. The approach has demonstrated its practicality and effectiveness for engaging educators in the transformation of traditional teaching practice into blended and online learning, and that a relatively limited institutional effort has the potential to stimulate a highly positive attitude and high ambitions towards educational technology among science educators.

Now, the mission is to measure the actual uptake of learning design among the assistant professors and ensure the continued inflow of professors interested in transforming their teaching practice with technology.

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