STREAM: a Flexible Model for Transforming Higher Science Education into Blended and Online Learning

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Abstract: This paper presents a flexible model, 'STREAM', for transforming higher science education into blended and online learning. The model is inspired by ideas of active and collaborative learning and builds on feedback strategies well-known from Just-in-Time Teaching, Flipped Classroom, and Peer Instruction. The aim of the model is to provide both a concrete and comprehensible design toolkit for adopting and implementing educational technologies in higher science teaching practice and at the same time comply with diverse ambitions. As opposed to the above-mentioned feedback strategies, the STREAM model supports a relatively diverse use of educational technologies and may also be used to transform teaching into completely online learning. So far both teachers and educational developers have positively received the model and the initial design experiences show promise.

The Underlying Incentives and Ambitions of the Model

Traditional higher science teaching is usually composed by different kinds of teaching activities such as lectures, theoretical exercises in terms of assignment work in smaller groups or similar, and lab and/or field work. Generally, the lectures play a significant role as the activity where the curriculum is being taught. Oftentimes these lectures are one-way, non-interactive with a large audience, and various studies show that this way of teaching is ineffective and sometimes even frowned upon (cf. Hill et al., 2003; Kember & Wong, 2000). This overall design of higher science teaching has been used for decades and initiatives have been taken to improve the learning outcomes of, in particular, the lecture activity. Recently, pedagogical initiatives and strategies such as active learning (cf. Bonwell & Eison, 1991), including Flipped Classroom and Peer Instruction (PI) (cf. Mazur & Hilborn, 1997), PeerWise (2013, and cf. Denny et al., 2008a; 2008b), and Just-in-Time Teaching (JiTT) (Novak et al., 1999; Simkins & Maier, 2010), has been successfully adopted in many science teaching practices making good use of educational technologies such as clickers, online quizzes and surveys, simulations, and other kinds of multimedia. Still, these pedagogical initiatives do not fundamentally change the composition of science teaching; the face-to-face lecture still plays an important role and the educational technologies are primarily used for merely enhancing and augmenting the teaching practice.

Nevertheless, educational technology has additional potentials allowing a *transformation* of the traditional composition into completely online learning and/or replacing the traditional lectures and other teaching activities with technology-enhanced alternatives and thus to unlock important affordances of the technology (cf. Price & Kirkwood, 2011). Examples of potentials and educational affordances of the technology are: higher flexibility in time, place, and pace for the students, support for diverse kinds of interaction with peers and feedback, and a high student satisfaction and engagement (ibid.; Conole & Dyke, 2004). In addition, a model for applying educational technology in teaching practice may have institutional capacities seen from educational developers' and management's point of view as well. Aarhus University, as many other universities, has an ambition to continuously develop and enhance its teaching practice by providing up-to-date educational technologies for teaching and learning and pedagogical (and technical) assistance to teachers for rethinking their teaching practice with technology (cf. Aarhus University, 2011). The objective is that 60 % of all teachers should receive an offer for 'rethinking assistance' by February 1st 2015 (ibid.). With the limited resources in mind, it would not be realistic with tailored assistances for each individual. One possible solution is to find or develop a versatile and generic model for enhancing and/or transforming the diverse science subject areas and teaching practices with support for the various individual levels of ambition. The model should not only support the ambitions of the university in terms of good use of up-to-date technologies, the stated percentages, and realize educational affordances; ideally, it should also support a flexible and stepwise, incremental implementation of the technology according to the teachers' personal level of ambition. This way the model can facilitate the teachers' continuous ownership of the teaching practice (cf. Godsk, 2006), and reluctant teachers can start by developing a minor part of their course and expand this later on (cf. Moravec et al., 2010).

Existing Models and Frameworks

A major challenge for educational models is to make sense for various contexts without being too abstract or constraining. Models should be easy-to-use, tested, and - most importantly – practical, as many teachers do not have the skills for making a good use of the technology or access to appropriate training (Conole & Hill, 2005). Popular models and frameworks such as Salmon's Five Stage Model (Salmon, 2003), Novak et al.'s JiTT (1999), and Mazur's PI and Flipped Classroom (Mazur & Hilborn, 1997) each have demonstrated to be of great value in various contexts for rethinking existing teaching practices and/or enhancing learning with technology. However, none of them fully cover our current demands. For instance, Salmon's Five Stage Model would require a rather extensive training of the teachers in order to facilitate the role as 'e-moderator' and developer of 'e-tivities' (Salmon's terms for the online teacher role and online activities, respectively), which would not be realistic. The flipped approach and JiTT would similarly require training of the teachers (Turpen et al., 2010) and does not directly allow for an abrogation of the lectures, which in some cases would be required. Pedagogical frameworks and approaches such as problem-based learning (PBL), experiential learning (Kolb, 1984), situated learning (Brown et al., 1989), and Laurillard's Conversational Framework (Laurillard, 2009) each provide valuable knowledge about learning, but would not be concrete enough to prescribe how the materials should be designed and the actual teaching carried out. Therefore, more concrete models and toolkits like for instance Conole and Fill's learning design toolkit (Conole & Fill, 2005; Conole et al., 2004) and the POL model (Dalsgaard & Godsk, 2007a) may smooth the path for the teachers though some educational support may be needed (cf. Oliver et al., 2002). As there have been good experiences with various forms of active learning at the faculty including an intensive use of clickers in lectures (cf. Vicens & Caspersen, in-press), it seemed natural to build on this pedagogical strategy and expand this with the abilities of JiTT, the characteristics and ambitions of the university and existing educational services, and important affordances of educational technology in general into the STREAM model.

The STREAM model

STREAM is an acronym for 'Science and Technology Rethinking education through Educational IT towards Augmentation and Modification', where 'Science and Technology' refers to the subject area of which the model is aimed and the name of the faculty where it is going to be implemented. The concepts of 'augmentation' and 'modification' are inspired by certain levels of enhancement and transformation with educational technology as described in the SAMR model (Puentedura, 2010), 'rethinking' is the term used in the official policy, and 'educational IT' is the concept for educational technology used at Aarhus University (cf. Aarhus Universitet, 2011). The model outlines how parts of or an entire course can be transformed into blended or online learning. It consists of a major cyclical process ('feedback loop') shifting between out-of-class content and self-study, preparatory activities, and in-class or online activities. As in the feedback loop of JiTT (cf. Novak & Patterson, 2010), the 'out-of-class' activities are used to provide feedback to the teacher or tutors about the students' learning and can be used to adjust and prepare the in-class activities, e.g. on-campus lectures or exercises, or online follow-up. The experiences from the in-class and online activities can be used to adjust the out-of-class content and activities so that it meets the students' needs and the following week's out-of-class content and self-study, preparatory activities. Depending on the schedule of the course, a typical loop could be equivalent to a teaching week and/or a defined topic.

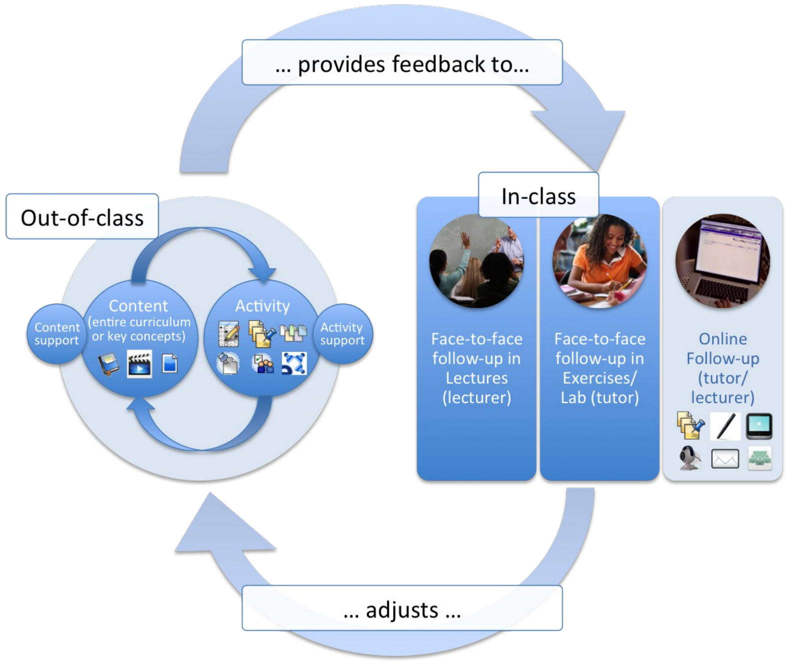

Figure 1: The STREAM model.
The tool icons exemplify which educational technologies and digital media that could support the activity.

Out-of-class Content and Activities

The out-of-class content and activities are similarly structured as a cyclic process shifting between content - e.g. reading a textbook, watching a webcast, or other materials that contains sources for information/curriculum - and activities that activates the content that has just been acquired. If the aim is to completely abrogate the lectures, their entire curriculum should be covered in the content-activity cycle; however, the out-of-class activities may also be used to merely teach key concepts.

Activities can be set up very differently depending on the purpose of the activity, the subject, the students, and the technologies available; however, if a standard learning management system (LMS) is available, tools such as quizzes, surveys, wikis, discussion forums, and weblogs can be useful to allow feedback and support collaborative activities. The teacher can keep track of the students' activity and feedback, and, for instance, use the dialogue in forums, weblog postings, the quiz or survey results to get an idea of the students' level and difficulties with curriculum. Also, a LMS can be useful to construct the out-of-class cycle by combining the content and activities using the build-in learning module tools and provide online forums for support. It is recommended to provide support on both the content (i.e. the curriculum) and the form (i.e. how to participate in the online activities) (Dalsgaard & Godsk, 2007b). The forums can be moderated by the teacher or tutors, or by letting the students give feedback to peers. A basic way of constructing the out-of-class cycle is illustrated in Figure 2, where the topic of 'projection and orthogonality' in a calculus course is transformed into online learning. The out-of-class content and activities are combined in the learning module in a LMS and shifts between dual-stream webcasts where the teacher presents theory and multiple-choice self-assessment quizzes related to the presentation. The quiz results will be available to the teacher for online follow-up and for adjusting the subsequent in-class activities (in this case an optional three hour self-study session on-campus) to meet the students' needs. In general, the out-of-class activities should strive to be thought-provoking with answers that cannot easily be looked up and therefore require the student to explore the content, synthesize, and formulate, tick off, and/or discuss the correct answers (Simkins & Maier, 2010) for actualizing the higher levels on Bloom's taxonomy (cf. Krathwohl, 2002) and for good learning outcomes. Depending on the learning setting and systems available, the teacher may even allow the students to develop and share their own out-of-class quizzes using systems such as PeerWise (cf. Denny et al., 2008b) in order to recap the current topic prior to the in-class exercises or as 'warm-up' for the next out-of-class activities. In order to reveal students' misconceptions in detail for feedback in the follow-up activities, it may also be fruitful to include open questions in the out-of-class cycle about what the students find difficult, confusing, or most interesting (referred to as 'warm-up exercises' in JiTT settings) (Crouch & Mazur, 2001; Marrs & Novak, 2004). Thoughts can be shared in discussion forums, by, for instance, asking the students explicitly about what they think about certain parts of the curriculum and let them comment on postings from peers (cf. Salmon, 2002; and others).

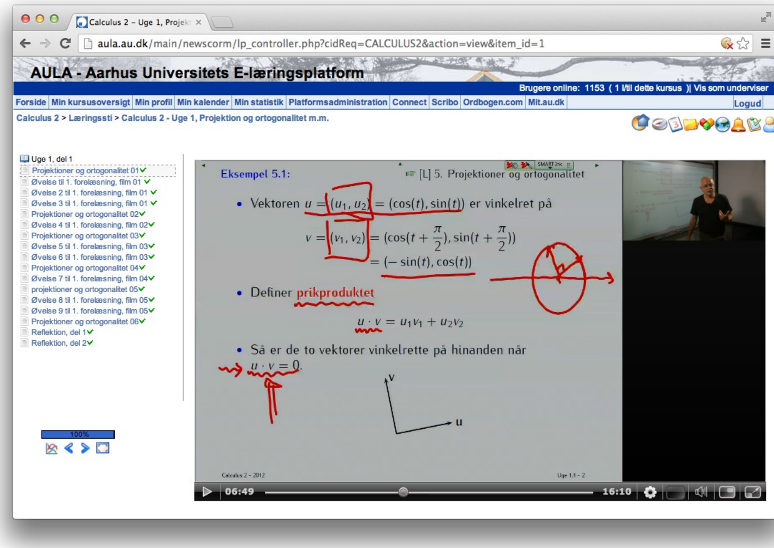

Figure 2: Example of how out-of-class content and activities (in this case webcasts, multiple-choice quizzes, and 'warm-up exercises') are combined in as a sequential learning module in the LMS.

In-class and Online Activities with Follow-up

Carefully designed out-of-class activities and forums provide valuable information to the teacher about the level of the students and, thus, the needs for follow-up. If the teaching is organized with face-to-face lectures and/or exercises, these can be used to follow-up on the out-of-class activities. The follow-up can, for instance, consist of a review or repetition of difficult parts of the curriculum according to the out-of-class quizzes or discussion, a further elaboration or perspectives on the subject, or simply allow time for an open discussion or group work. By following-up on the students' online activities, feedback, and comments, it is possible to actualize student-centered learning, which in JiTT context has demonstrated to enhance the students' motivation and uncover their misconceptions (Simkins & Maier, 2010). As in-class time has been saved due to the transformation of curriculum into out-of-class activities, there is released time to do these follow-up activities in-class. In case of completely online learning, the follow-up can be carried-out as a synchronous activity using a video conferencing tool and/or as an asynchronous activity using tools and technologies such as tablet drawings similar to Khan Academy (2013), tabletcasts (cf. Godsk, in-press), and pencasts for rapid hand drawn explanations where the teacher needs a blackboard-like tool (cf. Murray, 2012). However, in many cases tools such as text forums, emails, and webcam recordings may be sufficient.

Conclusions and Future Work

This paper presents the first outline of the STREAM model and its pedagogical and institutional ambitions and basis. At this point there is only little first-hand experience with using the model in practice; however, the up to now development meetings with teachers and educational developers have shown an appreciation of the model and indicated a good understanding of its pedagogical principles. In general, the referred theories and models related to the STREAM model - and in particular active learning and JiTT - favors the underlying ideas of the model and as such renders its educational potentials probable. Yet, there are inherent challenges with the JiTT related approach in terms of making the students adapt to the new way of studying as well as a number of new challenges associated with the more intensive use of technology.

As the model is work-in-progress future work has to be done with refining and evaluating its design, versatility, and utility for different subject areas and ambitions. Also, the educational affordances of the model, the learning outcomes, and its institutional impact, such as cost-effectiveness and potential for acting as a catalyst for incremental educational development, should be analyzed. Currently, five courses are planned to be either 'augmented' or 'modified' during autumn 2013 and spring 2014 by means of the model, so we expect to have some data about the reception of the model in late 2013 and more solid data about the pedagogical and institutional potentials early 2014.

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