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An instructional design model for screencasting: Engaging students in self-regulated learning

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Students entering first year university mathematics courses in Australia often show gaps in their mathematical understanding and may not have the cognitive and metacognitive skills to cope with abstract thinking. Screencasts produced as learning support for these students have definite benefits as learners have flexibility in accessing the resources at their convenience, and they can watch step by step model explanations of concepts and operations. Nevertheless, the instructional format of most mathematical screencasts focuses on expert performance of, and commentary on a particular skill, and often neglects to consider the active engagement and participation of the learner.

This article provides an overview of instructional design approaches to screencasts, and of self-regulated learning models. It then introduces a preliminary instructional design model building on self-regulated learning theory for the creation of screencasts, in order to foster and enhance students' cognitive and metacognitive skills in understanding complex mathematical concepts.

Keywords: screencast, self-regulated learning, engagement, mathematics support

Introduction

Interest has grown in recent years in what is sometimes referred to as the learner experience. It situates learners at the centre of the experience, and empowers and motivates them to assume responsibility for their own learning. It benefits from teaching and learning strategies designed to encourage students to see themselves as active thinkers and problem-solvers (Creanor, 2008). Learner-centred education may be facilitated by technology, for example through the provision of online learning material, self-access resources and peer support, mediated through online discussion and sharing of ideas. When learning complex and abstract concepts and problem solving, learner support is often crucial, as it is in the case of mathematical concepts and logical reasoning. Most Australian universities offer mathematics support to their students in the form of face to face help from a tutor, during certain hours. There are access limitations if many students are seeking the tutor's help at the same time, for example before assignment deadlines or for exam preparation.

To provide 24 hour support to students, tutors at the Mathematics and Statistics Help (MASH) Centre at Swinburne University of Technology produce screencasts for students to access through the Centre's website. What commenced as a small project to support students from one university, has now become a collaborative research project involving The University of Limerick (Ireland) and Loughborough University (UK), and will lead to a large number of screencasts available to students (MathsCasts, 2011).

By accessing video based instruction that combines multiple media formats, it is expected that positive learning outcomes will be achieved. Nevertheless, the instructional format of most screencasts has relied upon a didactic model of pedagogy, and often does not include scaffolds to ensure the active engagement and participation of the learner. To address this issue, we consider an instructional design model based on self-regulated learning theory in order to foster and enhance students' cognitive and metacognitive skills in understanding complex mathematical concepts.

Instructional design approaches

A screencast is a video recording of movement on a computer screen, together with audio narration. In mathematics learning, screencasts have been used to capture the handwritten step by step solution of a mathematical problem. With such recordings, students are guided by an expert as they would in face to face explanation, but there is an added benefit of flexibility of access and use of these explanations. Students can watch a screencast anywhere anytime, online or alternatively download and play back offline or from a mobile device, pause it to make an attempt at a solution themselves and replay as often as required.

Most literature on the effectiveness of screencasting in higher education focuses on student learning and use of the recordings, but not on student engagement and best practice of instructional design. Sugar, Brown and Luterbach (2010) describe the "anatomy of a screencast", following analysis of screencasts on how to undertake certain tasks on the computer. The authors found common structural elements and instructional strategies. However, these relate to a computing context, and may be different for mathematical problem solving screencasts. Heilesen (2010) provides an overview of the literature relating to podcasting and points out that the positive outcomes from the use of screencasts may be caused by the use of the technology, rather than by the technology itself. He argues that techniques shown to improve academic performance such as active learning and revision may be supported by the technology. Screencasts may be designed to allow students to personalise their learning, highlight important information and listen at their own pace (Sutton-Brady, Scott, Taylor, Carabetta and Clark, 2009). Sutton-Brady et al. also emphasise the need to focus on pedagogical design when producing short screencasts targeting individual topics to distinguish them from a repeat of lecture content. Heilesen (2010) recognises the opportunities available through this technology, as screencasting "has opened up for new ways of integrating classroom teaching and net-based learning on the basis of pedagogical concerns rather than mere administrative convenience".

McCombs & Liu (2007) suggest to record complimentary information rather than replicate existing information, and to add extra visual information to explain the content and to trigger "new focus and attention". Particularly in mathematics education, this visual information needs to be captured when explaining a solution step by step. In the mathematical context, Mullamphy, Higgins, Belward and Ward (2009) point out that "this presentation format [screencasts] is considerably more engaging for students than the use of chalk, PowerPoint or audio-only podcasts."

While there are strong arguments for the provision of screencasts for mathematical support, there is no guarantee that students will either access these or learn from them. It cannot be assumed that all students would have the skills to self-regulate their learning when presented with complex mathematical concepts. In this paper, we argue that screencasts of explanations of mathematical problem solving, where emphasis is on a clear explanation of the problem solution, may not in fact be as engaging as they could be if instructional design also focused on student engagement. To address this problem, self-regulated learning theory is considered in relation to the design of screencasts and we suggest a model to enhance engagement of students with screencasts.

Self-regulated learning

While screencasting provides a form of content and academic scaffolding, our concern is to ensure that students independently develop the skills to self-regulate their own performance and become aware of the gaps in their understanding of complex conceptual tasks. Effective learning is only guaranteed if learners are actively engaged in processing learning resources. Therefore the most essential instructional design approach for effective screencasting is to ensure that the pedagogical approach encourages and promotes self-directed learning or self-regulated learning (SRL). Models of SRL share certain assumptions about learning and metacognition, though they may differ on mechanisms to foster SRL processes (Corno, 1989; Pintrich and de Groot, 1990; Goldman, 2003).

There are five assumptions shared by all SRL models. Self-regulated learners are expected to:

- be active in all aspects of the learning process, i.e. in creating goals, inferring meaning and applying strategies;
- be capable of monitoring, controlling and regulating aspects of their own cognition;
- be able to set goals for learning and self-monitor their own progress;
- they may be limited by individual or contextual constraints or distractions; and
- are influenced by the characteristics of the learning task and environment. It is the learner’s own self-regulation of motivation, cognition and behaviour that mediates the impact of these external factors.

More important for the design of instruction however, are the three stages of self-regulation, which may occur linearly or recursively during a learning episode:

1. planning and goal setting;
2. monitoring processes and metacognitive control, whereby the learner tries to regulate aspects of the tasks, self and context; and
3. reflection on self-knowledge and task achievement.

SRL was selected as a guiding theoretical framework for the design of screencasts as it is based on assumptions about the learning process that are constructivist and regard effective learners as those who are capable of setting goals for their learning. They plan, monitor and regulate their own cognition, behaviour and motivation (Zimmerman, 2001). While some learners are able to apply general cognitive strategies to well-structured as well as to ill-structured domains, most students need some practice to apply their general cognitive strategies to new domains. Students who have not yet learned to regulate their learning in relation to a domain need external regulation and scaffolding to process and integrate new information.

Both cognitive and metacognitive strategies are central to knowledge construction activities. Coping with new and abstract concepts requires learners to possess specific strategies related to understanding content, but also to have a repertoire of metacognitive processes so that they are able to monitor and regulate their attention and motivation when complex concepts have to be learnt. In general, research has shown that students who lack self-regulatory and metacognitive skills learn very little from didactic, teacher centred approaches, and that some form of scaffolding is needed when they encounter challenging tasks.

There is little research on the specific area of how students learn from screencasting, but there are parallel studies with web-based multimedia formats indicating that successful learning is an interplay between system features (i.e. the screencast), learner characteristics and cognitive processes (Azavedo, 2005). In short, students can learn successfully when they are motivationally, behaviourally and cognitively active, able to set goals, plan their own learning pathway and monitor their understanding. This can only happen if the learning environment or learning episode invokes SRL, and when cognitive and metacognitive processes are scaffolded.

SRL theory to inform the design of mathematical screencasts

By applying SRL theory to the design of screencasts, certain pedagogical features need to be considered and scaffolding built into the design. We propose the following preliminary model based on the three stages of self-regulation, for the design of mathematical screencasts:

Table 1: An instructional design model for the development of screencasts, built on SLR theory

Stage of self-regulation	**Scaffolding**
1. planning and goal setting	• Provide an overview of the concept being presented • Activate prior knowledge
2. monitoring processes and metacognitive control	• Ask students to set a goal for the session • Present questions and tasks to check for understanding, and to get students to actively engage in the problem solving process
3. reflection on self-knowledge and task achievement	• Encourage students to reflect on the learning process and on their understanding of the concept • Ask students to document areas of uncertainty and to prepare questions for their lecturer or tutor

This model is a preliminary model as we have not yet applied it to an actual screencast and evaluated its effect on student engagement. We suggest how it could be applied to a screencast in the next section.

The model applied to a screencast

A typical mathematical screencast is this example on how to identify the equation of a circle (The Equation of a Circle, 2011). This screencast captures the tutor's explanation of how to rearrange an equation in such a way that the centre and radius of the circle can be found, thus showing that the equation indeed represents a circle. The screencast proceeds as follows:

- Equation and the task are given.
- Statement of what general form to look for, and how to find centre and radius once the form is found.
- Step by step explanation resulting in the general form, statement of centre and radius.

This screencast was recorded for first year Engineering Mathematics students and focuses on the mathematical explanation, without explicitly attempting to engage the learner in active problem solving. In that sense it is a typical mathematical screencast. An instructional design approach taking into account SLR and following the above model may also include the following:

- At the start, the problem is placed in context, to motivate why it may be beneficial to know if an equation represents a circle.
- Prerequisites are listed, and guidance is given on how to acquire these, e.g. if a learner does not remember how to complete the square, they are guided to the appropriate screencast.
- The learner is asked to note which areas covered in the screencast (or not covered) they have problems with, and follow up on these with the tutor or by watching relevant screencasts.
- The learner is also asked to set learning goals, e.g. "I will be able to identify the equation of a circle by rearranging the equation after working through these screencasts".
- The narrator pauses regularly, suggesting to the learner to pause the recording and try for themselves first before watching the explanation. The narrator also asks the question "what would the next step be", and gives the learner time to think.
- The learner is asked to self-assess their performance, e.g. after watching they are asked to attempt the same problem themselves, and to try other problems.

Conclusion and future work

The paper has provided a brief overview of self-regulated learning models, and applied SRL as a guiding theoretical framework for the instructional design of mathematical screencasts. SRL is a good choice because it allows us to directly theorize how learner characteristics, cognitive processes, and system structure interact during the cyclical and iterative phases of planning, monitoring, control, and reflection while learning - features that are typically ignored in the design of screencasts. Our primary goal has been to explain the dynamics of students' activity as they seek to understand abstract concepts. To achieve optimum learning learners need to be self motivated, mostly self-guided, and to be supported in learning situations where they are expected to learn abstract concepts individually, mediated by technology. Our research indicates that by including scaffolds to foster cognitive and metacognitive strategies, students will be better able to comprehend complex concepts and evaluate their own performance to direct their efforts. Our future research will seek to embed these scaffolds into screencasts and to evaluate their effectiveness in engaging learners.

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