Educational animation: Who should call the shots?

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Despite the increasing popularity of animation for explaining dynamic subject matter, research shows it is not uniformly beneficial for learning. User control has been suggested as a way to enhance learning by ameliorating negative effects of animation. However, giving learners the responsibility for controlling how an animation presents its information does not always produce the anticipated benefits. It appears that the associated interrogation tasks can over-tax learners' internal processing resources so that extraction of relevant information is prejudiced. More prescriptive animation presentation regimes may be superior to free user control, particularly for learners who are novices in the depicted domain.

Keywords: animation, user control, learning, interrogation strategies, complex content

Introduction

Current information and communications technology greatly facilitates the authoring, display and distribution of dynamic graphics. As a result, electronic learning environments that include animations amongst their educational resources increasingly feature in university teaching. The technological sophistication of animations used in these resources has progressed considerably in recent years to the point where interactive animations are becoming commonplace (Bétrancourt, 2005). One of the most widespread forms of interactivity now being provided with educational animations is user control. The provision of user control has expanded with the advent of display software such as Apple Quicktime and Windows Media Player whose video-like controls allow learners to manipulate an animation's overall playing regime. However, more advanced forms of user control tailored to the specific requirements of particular learning experiences are also possible by using dedicated animation software such as Flash.

Whose technology… whose control?

As is often the case with educational technology, the adoption of user control appears to be driven more by technical feasibility than by well-formed ideas or research-based insights about its possible consequences for learning. The relatively unquestioning uptake of user control suggests its proponents have a gut-feeling that there must be an intrinsic educational benefit involved. Leaving aside affective issues such as the positive effects that user control may have on learner feelings of self-efficacy, convincing arguments can be made for the provision of user control in terms of perceptual and cognitive advantages that could result for learners. The nature of these potential advantages can be understood by comparing the perceptual and cognitive demands of traditional system-controlled animations (as presented by film or television) with today's user controllable computer-based animations. Traditionally, the playing regime of animations presented via these media was essentially fixed because of fundamental technical limitations of the display system. There was effectively no possibility for individual viewers to alter the course of an animation's presentation to suit their own requirements. While such system-controlled animations have proven highly successful when the goal is entertainment, research suggests that success is by no means guaranteed when they are used for educational purposes (Tversky, Morrison, & Bétrancourt, 2002). When learning is the goal, the characteristics of the target audience are fore-grounded and the opportunity to modulate presentation of animated information to suit these characteristics becomes a central design issue

If to-be-learned subject matter is presented by a system-controlled animation, the fixed playing regime can result in mismatches between the way dynamic information is presented and the learner's capacity to process that information effectively. This type of mismatch is probably clearest in cases where the animation's content is relatively complex and is presented too quickly for the learner to process all relevant aspects of the displayed information in the time available. The fundamental difficulty here is that animation is a transitory way of representing information. Animations create their dynamic effect by the

rapid sequential display of a series of frames depicting varying information. In order to sustain the illusion of continuous change, each frame of information must be displayed for no longer than a fraction of a second. With system-controlled animation, the sequence of frames is typically presented once only, from beginning to end, and at a constant pre-determined speed. However, this regime makes no allowance for the fact that the demands of extracting and interpreting the presented information vary throughout the course of an animation according to factors that include the information's density, novelty, and degree of interrelation. At particular points in the animation, the conjunction of such factors may raise the demands to a level that is beyond the capacities of the learner's limited perceptual and cognitive processing resources. Unless the values of presentation parameters are modified to reflect these changing demands on the learner, it is likely that *overwhelming* (Lowe, 2005) will result because processing capacity is exceeded. As a result, learning will be compromised. In the next section, we consider the consequences of providing user control in order to address the problem of lack of flexibility in an animation's playing regime.

Who's *not* learning from user control?

User control appears to offer an elegant solution to this problem by allowing individual learners to personalize the playing regime through manipulation of aspects such as the speed, direction, continuity, and frequency of presentation. The assumption here is that learners will be able to make the animation more tractable by matching its presentational characteristics to their own processing capacities. Indeed, when the type of subject matter involved is relatively familiar and straightforward, user control over the presentation of dynamic visual instruction can be highly beneficial to learners (Schwan & Riempp, 2004). However, benefits are far less likely when learners who are novices in the depicted domain are faced with animations that present complex subject matter (Lowe, 2004b). Under these circumstances, the mere *provision* of user control does not necessarily result in its effective use. Although learners who are domain novices certainly take advantage of the user control provided to make the animation more tractable, they are likely to do this in a way that prejudices effective exploration of the available information.

Research indicates two potential sources of problems domain novices can have in learning from animation that incorporates a high level of user control. First, the delegation of control over an animation's presentation regime to learners imposes an additional task on them that eats into their limited perceptual and cognitive processing resources. Ideally, as much as possible of a learner's processing capacity should be devoted to activities centrally concerned with building a proper understanding of the subject matter. However, demands from the peripheral activities of using the control facility and interrogating the animation in an attempt to extract the required information are inconsistent with this ideal (Bouchiex, in press). Second, the results of learners' interrogation of a user-controllable animation are likely to be relatively poor due to inappropriate targeting of information and sub-optimal exploration strategies. Each of these potential problems will now be discussed in turn.

Knowing where to look and when to look

When learners lack background knowledge about the domain from which the depicted subject matter is derived, they tend to target information that is superficially conspicuous, irrespective of its underlying importance (Lowe, 1999, 2004a). This can result in two related effects that have serious negative consequences for learning: (i) the neglect of aspects that are highly relevant to the learning task but have low perceptual salience relative to the rest of the display, and (ii) inappropriate allocation of attention to more perceptually salient aspects that are in fact of low thematic relevance. Put more starkly, worthwhile information is passed over in preference to information that is worthless, or possibly dangerous. While such problems also occur with static graphics due to misleading visual cues about relative importance, they appear to be considerably more severe with animations because *dynamic contrasts* (Lowe, 2005) within these displays can be so compelling with regard to perception. The immediate effect of learners following misleading perceptual cues as a consequence of being given user control over an animation is that they can fail to look in the right place at the right time. Their misplaced and mistimed interrogation efforts mean that key information necessary for a proper and coherent understanding of the presented subject matter is simply not encountered. Further, some of the perceptually conspicuous but thematically irrelevant information they do manage to extract can actually prejudice development of the required understandings (Lowe, in press).

This type of failure in learners' free interrogation of user controllable animations suggests that they may need some form of guidance in how to explore such presentations more effectively. Lowe and Schnotz (2006) investigated the effectiveness of accompanying narrations as a way of providing support for more strategic interrogation of complex animations that depict unfamiliar content. Comparison of interrogation data and eye tracking results revealed that while there was some tendency for general exploration behaviour via the user control facility to be directed towards more task-relevant temporal segments of the animation, learners varied considerably in the effectiveness of their physical search strategies. In addition, there was evidence that unless these strategies were both comprehensive and closely coupled with appropriate visual search behaviour, perceptually subtle information of high relevance to the learning task was likely to be missed. In essence, these findings suggest that even with a high level of guidance, learners may employ user control in a relatively ineffective manner when the animation depicts demanding subject matter. Considering that most current implementations of user control within educational resources do not even attempt to support more productive learner interrogation of animation, the findings raise important questions for those who design and develop such materials. A central question is whether or not user control should be provided for animations at all, and if so, how it could be made more effective.

User control – out of control

A possible but currently unfashionable alternative to the provision of user control would be to provide learners with animations that completely pre-determine how the presented subject matter is encountered. The rationale for this suggestion is that novices tend to be singularly ill-equipped for the rigours of interrogating complex, unfamiliar dynamic information presentations. Instead of leaving learners to struggle with the demands of trying to locate, extract, and interrelate task-relevant information, it may be better to use a more prescriptive approach that does away with these demands. This would require a far more analytical approach to the design of educational animations than is currently the case. At present, the 'end' of the main design and development phase is generally signalled by the production of a completed animation portraying the chosen dynamic content essentially as requested by the subject matter expert. However, in the alternative approach being suggested here, this would be perhaps just the first stage of a far more comprehensive process. Once this initial version had been generated, the instructional design work could start in earnest. It would begin with a systematic identification and clarification of the various information processing demands that the animation as it stands may pose for the target learners. This analysis would constitute the basis for design decisions about how the initial version should be modified in order to make task-relevant information more accessible to the learner. For example, it could be decided to present some key aspects of the dynamic content repeatedly and separately rather than simply showing them once in context. Further, if any of these key aspects possessed a hierarchical dynamic structure, perhaps the repeated presentations could be made at different speeds to reveal the various events and sub-events from which this structure was composed.

The tailored approach being canvassed here would undoubtedly be more time-consuming and costly than present approaches, partly due to the background work that needs to be done in order to make informed decisions about design of the presentation regime. Perhaps the message here is that we need fewer animations but ones that are more effective in supporting quality learning. This would involve a re-allocation of resources rather than an increase. A possible impediment to the suggested approach is that our knowledge about how learners process animated information under different conditions is still in its infancy. The author is currently carrying out investigations with animations of systems having a high degree of dynamic complexity in which tightly structured presentation regimes are provided for learners. These regimes involve separate and specific targeting of different levels of dynamic information within the animation. The approach is to use different combinations of fast and slow playing speeds during a series of repeated passes through the animation. Preliminary indications are that the different regimes lead to learners extracting distinct sets of information from the animation (c.f. Fischer, Lowe, & Schwan, 2006).

More controlling user control

Rather than completely abandoning user control, a middle road could be to take an approach that provides the learner with a measure of freedom in exploring the displayed information but does so within a fixed overarching presentation structure. This clearly cannot be provided by the very generalised approach to user control of essentially dropping an animation into the type of existing control shell that is provided by

Quicktime or Media Player. However, software such as Flash that is specifically designed for authoring interactive animations could be used to generate presentations which give more emphasis to high relevance aspects of the dynamic information than to those that are less crucial to the learning task. A key consideration in shaping an effective animation exploration environment for learners would be how high relevance information was emphasised and low relevance information suppressed. The dynamic character of animated presentations provides many opportunities for such shaping that are not available with static depictions. This constitutes a most productive area for both research and development.

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