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INTERACTIVE CONCEPT MAPS CAN AUGMENT LEARNING WITH VIDEO MEDIA

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Abstract. Information-rich video media such as television science documentaries make significant intellectual demands on viewers. In watching this media, viewers are acquiring new ideas and revising their existing ideas as a kind of informal learning. Concept maps have a demonstrated value for learning in educational settings, suggesting they may also be exploited to good effect in the new technology of companion apps for television programmes - web enabled applications running on tablets and similar devices that provide accompanying synchronized content for television programmes. CompanionMap was created to investigate the potential for using animated, interactive concept maps in television companion apps. It was demonstrated with an astronomy documentary programme and evaluation with viewer participants in a controlled study showed it improved understanding and recall of the programme. The development of the concept map for the app is described with reflection on the issues arising from its use in this setting.

1 Concept maps and information-rich television programmes

As a form of knowledge representation, concept maps can be used for communicating ideas as much as for eliciting and creating ideas. These uses are well established in teaching and learning: students draw concept maps to externalize their understanding of a subject and may be given concept maps to help them understand a subject (Moon et al, 2011). Extensive research over three decades has shown that concept maps benefit learning across a wide variety of settings used in different ways (Kinchin et al, 2000; Nesbit & Adesope, 2006; Novak, 1990). One of those ways is animated concept maps, where a map of a subject extends visually as it is read. The additional of animation to a concept map has been shown to benefit learning in a comparative study with static concept maps (Blankenship & Dansereau, 2000). The possibility of presenting lesson and lecture notes in this form to accompany a teacher is clear; the map is able to provide a persistent, visual textual, representation of material presented primarily orally by the teacher. The value of concept maps used in this way has been demonstrated in a study of learning with spoken recordings where learning was enhanced by a concept map (Adesope & Nesbit, 2013).

A related use for concept maps is as a visualization for television companion apps. These are application programs, typically running on a tablet or other handheld connected device, that provide synchronized accompanying content for television programmes. When created for an information-rich programme such as a science documentary, a companion application can augment viewers' following and understanding the programme. In this setting, concept maps have a similar purpose to their use in classrooms for accompanying a teacher. The potential for representing information-rich television programmes with concept maps is already demonstrated in classrooms where teachers use programmes within their class teaching and ask students to create maps of what they have understood from the programme. Figure 1 shows a map created in a second year high school class by a pupil studying biology whose teacher was showing them an episode of the *Frozen Planet* natural history TV series. Clearly the map lacks some formal features of a concept map but is also clearly more than a simple 'mind map'.

The reasons why an animated concept map companion app might benefit viewing of information-rich television programmes can be anticipated. First, viewers will benefit from a representation of the content they have already viewed. Television is, of course intrinsically transient and viewers' recall of what they have viewed needs to be augmented since science programmes often involve relating together their parts within a linear narrative. Therefore, the concept map can provide a persistent representation of the content already viewed that can be re-consulted. Moreover, the animation of accumulating map content will allow the viewer to easily find their place in the map, to coordinate their reading of the map with their listening of the programme.

Second, viewers are unlikely to benefit from a verbatim transcript and frame-by-frame record of the programme; rather, they need an abstraction of the content that summarises the important ideas and their connections. The process of understanding the programme is fundamentally a construction of this conceptual abstraction over the content. Concept maps provide exactly this synoptic representation

which is also a means of categorizing, indexing and therefore re-finding content already viewed. Interactivity clearly has to be designed carefully as extended interactivity will lead to distraction that will undermine comprehension of the programme.

A third benefit is the personalised viewing that a concept map makes possible because of its mutable and extensible form. Different viewers will have different needs and expectations for how programmes should be augmented. Viewers with a little knowledge would need more explanation to properly understand the programme, while viewers with better knowledge would need more information. Concept maps can be extended and navigated to reveal additional information. By providing choices for viewers in navigating and browsing the map, a concept map is able to provide a pesonalised interaction in a rudimentary sense. If the choices available to the viewer are constrained by their individual profile, or by the trajectory of choices already made through the map, then the map is achieving a more sophisticated degree of adaptivity.

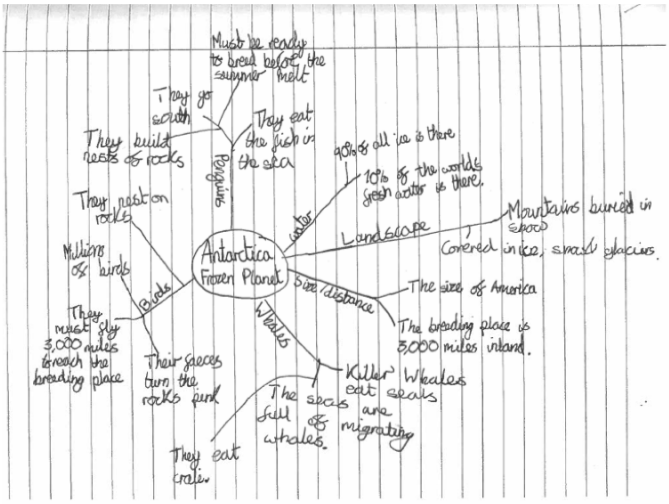

Figure 1. Concept map constructed by a high school student while watching an episode of the *Frozen Planet* natural history programme in a biology class.

Whilst these benefits of concept map based companion apps can be anticipated, there is also clearly a potential for maps to compete with the television programme for visual attention and either be ignored or distract from viewing the television. Unlike the Adesope and Nesbit study where the visual map complemented the auditory speech, television is of course highly visual and so a companion app competes for the viewer's visual attention. To investigate the design possibilities of concept maps as companion apps, and to evaluate their use by television viewers, the CompanionMap app was created as now described.

2 Developing an interactive animated concept map companion for an astronomy documentary

A concept map was created of the conceptual content of an astronomy documentary *The Seven Ages of Starlight* (BBC, 2012). Figure 2 shows a concept map of a 5-minute section of the programme concerning supernovae. The map was created using the CmapTools (Cañas et al., 2004) by a graduate astronomer in consultation with astrophysicists who had advised the makers of the programme. The nodes of the map represent the main ideas explicitly stated in the narration overlaying a set of related video images in this part of the programme. The narration has been parsed and re-expressed into these separate nodes then relationships fixed between them. The figure uses colour coding to differentiate the nodes for each successive minute of the programme. The orange shaded nodes relate to the first minute of the programme.

Development of the concept map involved a number of iterations in which questions emerged about how to translate the programme, how to apply the concept map formulation and how to create an accessible piece of communication. The labelling of the nodes with concept words or with phrases was

only the first issue. The earlier versions of the map used word labels and short phrases (visible for and exists for just one night), the later versions used sentences (The explosion lasts just a few seconds but the remnant will brighten over the course of a night). It also became clear that the map needed to use only a limited set of link types if it was to be easily readable whilst watching the programme. The issue also emerged of whether the map should accurately only represent the concepts presented explicitly in the programme (by speech and visual image) or whether it should also include concepts that were missing the programme or only implied but necessary to be technically correct. The programme's producer had skillfully selected content that would be accessible for a wide audience rather than provide a substantial and complete account of the astrophysics.

A companion app was developed to present the concept map as an animation synchronized with the programme. CompanionMap was developed as a native app for the Apple iPad tablet. The app was able to import the concept map file created by Cmap, parse the file and extract the map content and geometry. The map was then animated by creating draw events for each element in the map and mapping these to time stamp tags added to events in a recording of the programme. The map was now synchronized with the programme, nodes and links appearing appropriately with the content of the programme. Colour was used to indicate the newest node in the map and the colour of the most recent nodes progressively faded, aiding coordinated reading of the map. The speed of delivery of verbal spoken content in the programme was relatively slow and dictated the speed at which new elements appeared in the map. Clearly the speed of growth of the map trades off with the density of nodes and the complexity of their labels, from a user's point of view. There are also many possibilities for the visual transitions in displaying the map. For example, it might be presented as a fixed global view that is progressively filled in with blossoming nodes and arcs. Alternatively, the view might be a roving porthole that skims across the map revealing the network of nodes 'already there'. Both a roving porthole and dynamically appearing nodes could be used. Multiple detailed presentation design decisions arise, for example, the limiting speed of transition of the moving map without disrupting reading.

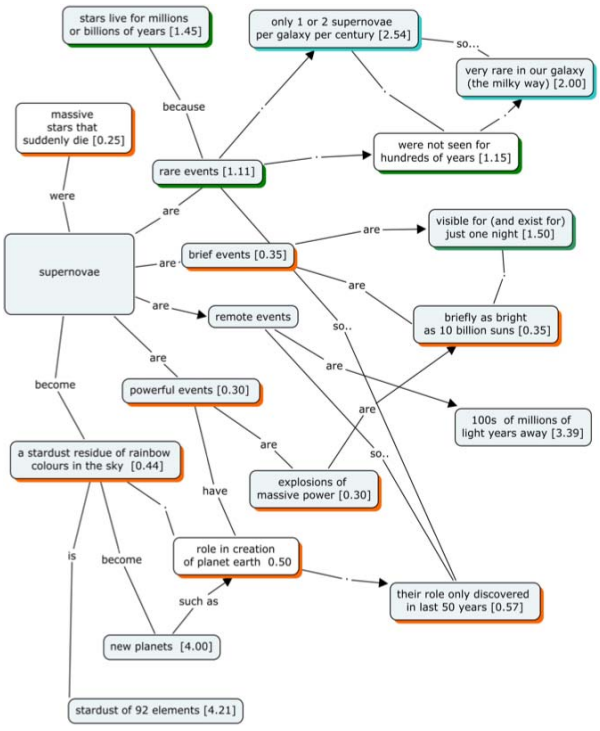

Figure 2. Concept map of the first five minutes of *Supernovae*, episode 5 of *The Seven Ages of Starlight* TV programme.

Additional interactive features were added to the map in the form of extra information cards. Tapping a node would open a card expanding on the concept of that node. The possibility for drilling down further on a node to reveal more detail means that it is able to provide a synopsis of varying abstraction. Additional interactive possibilities for the map would be allowing viewers to pause the dynamic display of the map. The map would then need to catch up with the programme if the programme continues to play, but alternatively the action would be able to pause the play of the

programme if it was a recorded or on-demand session. Beyond this simple touch-and-hold interaction, viewers could navigate the map and expand and mark nodes. A further interactive feature added to CompanionMap was that nodes could be miniaturised to help viewers keep track of which nodes they had read. Interactive concept maps have been previously demonstrated as a knowledge elicitation tool (Kornilakis, Grigoriadou, Papanikolaou, & Gouli, 2004) but the companion app greatly expands the possibilities for interaction.

CompanionMap was evaluated in a controlled study involving 28 participants using the app whilst watching The Seven Ages of Starlight (Dowell et al., 2015). A within subjects design was used with participants watching two parts of the programme and using the app in one of those parts. Participant's recall and understanding of the programme were assessed using probe questions administered immediately after watching the programme. Some probe questions assessed content that was only in the programme, some assessed content that was in both the programme and the companion app. The results showed an improvement in the scores for questions assessing knowledge of content that was both in the companion app and the programme ($T=2.2$, $p=.044$). This result is positive evidence for the benefit of the concept map in aiding recall and understanding of the programme. A questionnaire examined participants' reactions to using the companion app and these were strongly positive, though some noted a difficulty in knowing at which device they should be looking at which point in the programme. A model characterising the cognitive processes involved in the multimodal cross device use of a companion app is described in (Dowell & Kim, 2015) providing an interpretation of some of these observations from the evaluation of CompanionMap.

3 Summary

Concept maps are a promising form of visualization for companion apps that augment viewing of television programmes. They provide a persistent and synoptic visual representation of programme content that may be intellectually challenging for viewers to remember and process. They connect the 'bits together' that are unnaturally separated by the linear narrative of television and similar information-rich video media. When animated they provide an accumulating representation that enables the viewer to coordinate their map reading with the programme viewing. They may interactive, opening extraordinary possibilities for actively following a programme and accessing accompanying content as individuals prefer.

CompanionMap was developed for an astronomy documentary to investigate the design possibilities and evaluate their value to viewers. Evaluation has shown that viewers' recall and understanding of the programme are improved by using the concept map and viewers also liked the experience of using the app. Many open questions remain about the form of concept mapping second screens. If done badly it is entirely possible that a concept mapping second screen would be ignored, or even disrupt viewing of the TV programme. For example, giving viewers suitable opportunities to switch their visual attention from one screen to another will need to be taken into account in the design of the app and probably the programme too. However, the development of CompanionMap and its subsequent evaluation indicate the considerable potential of using concept maps as a visualization to augment information-rich television programmes and video media.

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