Unlock the rigidity and design for flexibility

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Abstract: This paper reports findings from a project implementing the VL (virtual labs) site featuring flash-based animations developed at Stanford University. The main conclusion in this paper stresses the need to design for flexibility and adaptability of interactive media to better suit the specific situation teachers encounter in their everyday work, in order to allow them to build their own audiovisual presentation kits based on various available resources. Ambitious but rigid visualization products might otherwise end up not being used at all.

Key words: user centric design, education technologies, visualization, biology education

1. Educational challenges and goals

The use of interactive media in the K-12 classroom has been shown to engage students, increase performance, and help educators convey difficult concepts (Hall, et al., 1997; Mayer, 1989). In science curricula, interactive media can transform classroom instruction, making dynamic processes come alive and interactive, while illustrating the connections between different disciplines (Jewitt, 2008). The creation of interactive media for science education has been prolific, however, the adoption of this media has been limited and disorganized (Cuban, 2001; Bayne, 2008; Rieber, 1990). Scientific testing of the use of interactive media has shown that it is not the media alone that contributes to positive results. Surrounding structures, such as curriculum, pedagogy and assessment models, have considerable impact on students' overall results (Roschelle, et al., 2000).

The goal of this project was to consolidate all interactive science media produced to date from VL (virtual labs) and WGLN (Wallenberg global learning network—http://www.wgln.com) projects onto a single teacher resource website. The work included adapting the content for K-12 students, disseminating knowledge about accessible technology to teachers via workshops and on site training, designing implementation strategies and best practice for the use of such technologies together with teachers and the development of the 4 case studies. In this paper, the authors report findings from the case studies, and discuss possible impacts the results might have on the further development of visualization products for educational purposes.

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2. Implementation model

Four teachers from different schools were chosen to participate in the implementation phase of the VL project. Each teacher was asked to choose a suitable application from the VL site and to reflect on how it could be used in any relation to their present course curriculum. It was up to the teachers to use the VL material to the extent that they found appropriate. Two Swedish teachers visited Stanford University for a week during summer in order to discuss and suggest changes together with the VL team. The way to use the VL material in the classroom was left for the teachers to decide.

The 2 Swedish teachers visiting Stanford worked intensively to transform the chosen VL application to better suit their needs in relation to their pedagogic model course content. They believed that parts of the applications were too advanced for their students. After the visit, the 2 teachers and the Stanford development team collaborated via e-mail in order to adapt, correct and improve the chosen applications. The teachers provided remarks and suggestions. They also made critical comments considering some mistakes in the applications. All changes and adaptations were carried out from the Stanford side and a special site for the Göteborg project was created.

3. Design of the study

The implementation model was based on a process model including close collaboration with the teachers. Their input in the process was considered to be a key for understanding how teachers would benefit from using VL applications and for future revision of the site. Thus, pre-meetings as well as post-meetings after the implementation were held with the teachers, where suggestions for possible teaching scenarios were discussed. The authors wanted to get the view of the end users, in this case, the teachers, but the authors were also interested to grasp the students' points of view. Accordingly, focus group discussions were conducted with students after the implementation. The rationale for putting a lot of focus on teachers within the project was the authors' belief that no implementation will ever be realized if teachers are not engaged (Pintot & Millet, 1999). The chosen teachers were engaged and enthusiastic persons teaching biology and natural science. They were all willing to try out some of the VL applications in their own classrooms. Since the authors also were interested to find out how surrounding factors might impact on the implementation of VL applications, the 4 schools and teachers participating in the study varied in relation to both available technology and previous use of technology in the teaching situation, as well as general level of IT (information technology) knowledge and knowledge in natural sciences among students.

The teachers represented 4 high schools in the Gothenburg region:

(1) Komvux Ale, a school where adults can complement previous studies or get gymnasium grades that they for some reasons did not achieve in high school. According to the teacher, the school is struggling with low resources in general including technological resources;

(2) Hulebäcksgymnasiet, a school with high reputation and high-achieving students. The school is well equipped with technological resources;

(3) Lindälvsgymnasiet, similar to Hulebäcksgymnasiet, a school with high reputation and high-achieving students combined with excellent technological resources;

(4) Angeredsgymnasiet, a school situated in suburban Gothenburg, regarded as a low-status school with low-achieving students, particularly in natural science. The school has limited technological resources.

In order to capture the complexity of the situation, gaining a deeper understanding of the various issues, this

project used method triangulation in qualitative research (Silverman, 2005). A combination of methods was used for data collection: group discussions with teachers, individual interviews with teachers, classroom observations and focus group interviews with students. Interviews were recorded and transcribed for later analysis. Classroom observations were transcribed and classified. Teachers were also asked to reflect upon their own thoughts and attitudes, while working with anything related to the VL project. Such situations could be, for example, when going through available applications at the VL website, when reflecting upon how the material might be used in their own curriculum and pedagogic activities and giving response and feedback from colleagues or superiors or experiences from the use of new techniques in the classroom in general. The authors' intention was to "get under their skin" to get an understanding of how the teachers experienced possibilities and constraints in relation to the use of VL applications in teaching situations. The close interaction between teachers and researchers was the philosophy behind the VL project. Teachers later reported that the group meetings between the researchers and teachers were important in having them feel involved in the project.

The authors present in Figure 1 the model they used implementing the VL application. In each phase of the study, the authors evaluated what teachers experienced, whished and suggested.

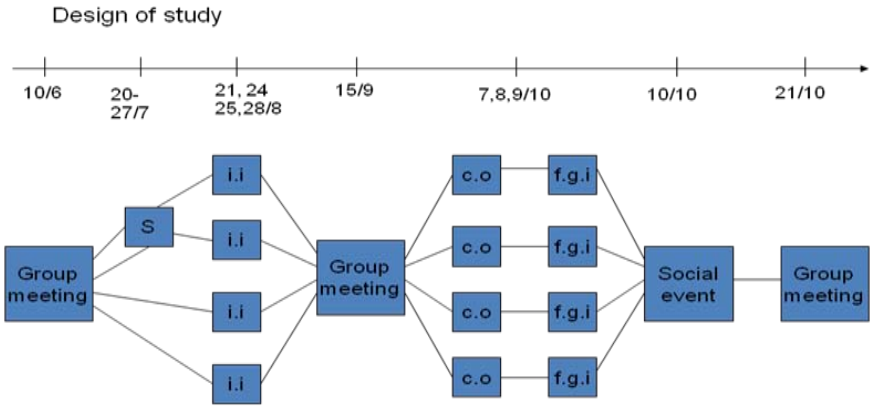

Figure 1 Design of study

Note: Groupmeeting: teachers and researchers meet; S: two teachers visit Stanford;
i.i: individual interview with teacher; c.o: classroom observation; f.g.i: focusgroup interview with students

4. Actual use of VL application in classrooms

As mentioned previously, there was no obligation for involved teachers to use any material from the VL web-site. Consequently, the authors did not know whether any teacher would actually use anything from the available content. During the authors' classroom observations, it became evident that the variations in the individual school's resources, such as available technology, previous experience of technology in the teaching situation and general level of subject matter knowledge among students, would impact on the teachers' way of using the VL applications in the classroom. Thus, the 4 teachers differed greatly in relation to how they implemented and made use of the VL site in their teaching. The authors can, based on their own classroom observations and on focus group discussions with the students, categorize the teachers in relation to how they used the VL application in the classroom the day of the authors' observations: (1) high integration; (2) short side presentation; (3) multiple screens presentation; and (4) not using VL at all.

4.1 High integration

In Komvux Ale, the teacher is an experienced user of IT technology in the teaching situation. The students are highly motivated even though many of them previously have failed in school. The typical student is an adult catching up the gymnasium exam. The school setting is flexible and students have various possibilities to follow courses either at a distance or in traditional campus/classroom settings. The students are used to having access to part of the course material online on the school's own web portal, where course material is presented. The teacher, being the only teacher at the school teaching biology, has no network for collaboration within the school. The teacher was interweaving the VL application throughout the lesson, actively using the VL site and drawing on the whiteboard. Since the VL images were projected on the whiteboard (see Figure 2), it was possible to write personal comments straight on the screen, and also to draw handwritten images at the side. The teacher was using active body language and later also hands-on lab activities for the students. During hands-on activities, the teacher verbally related back to the VL animations and images presented previously. In the following focus group interview with students, they all appreciated the use of the VL material in the teaching situation and expressed that animations were good and helped them understand difficult concepts. They appreciated the variation of methods used in the classroom. They also liked the order of sequences the material was presented in. As an example, the teacher first gave a lecture and then let the students conduct experiments in relation to the previous presentation (see Figure 3). This teacher expressed high satisfaction with the VL application saying,

> I believe that this year, my students test performance improved in relation to their ability to present more detailed answers of how the heart is structured and its functions. This was a positive surprise for me.

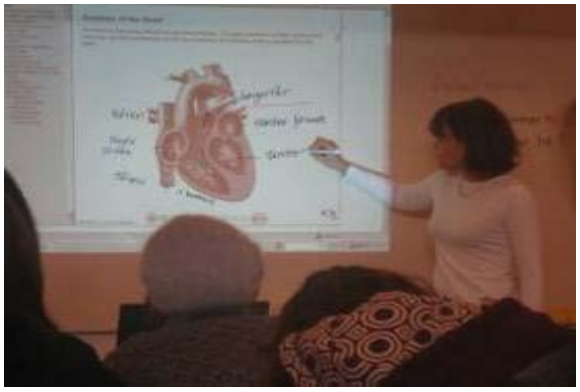

Figure 2 Using the whiteboard to project the VL image makes it possible to white "on the picture"

Figure 3 Picture taken during a heart dissection, one of the practical parts of the curriculum

4.2 Short side presentation

The teacher in Hulebäcksgymnasiet is a very experienced user of IT in the teaching situation and has developed his own teaching material. The students are considered as high-achieving and are highly motivated in both biology and natural sciences. Teachers in this school are mainly working individually. The teacher had a previously developed PowerPoint presentation that was presented for the students. The lecture was given mainly with this material. At one point during the lesson, the teacher projected an animation from the VL site on a screen parallel with the PowerPoint presentation screen (see Figure 4). This animation was approximately 2 minutes long. In the following focus group interview with students, they declared that they liked this style of teaching and in particular they liked the teacher's body language presenting "physical animations" with his own body. They believed that digital animations might be a good supplement, but they might also distract from paying attention to

the teacher (see Figure 5). The teacher had gotten increasingly skeptical to use virtual representations of lab exercises during the VL project,

> Well, I think it's useless to use these as lab exercises. I don't believe in virtual labs any longer. Why not? Because a lab is very much a question of touching things you know, the feeling, smell, being there, be able to do mistakes and all this.

In spite of this sceptical attitude, he also saw some benefit of using VL applications,

> I think you could use it to show things in a lecture and then let the students work with it at home in order to repeat and learn. They can repeat as many times they wish.

Figure 4 The use of 2 projection screen simultaneously to show a PowerPoint presentation and the VL animation at the same time

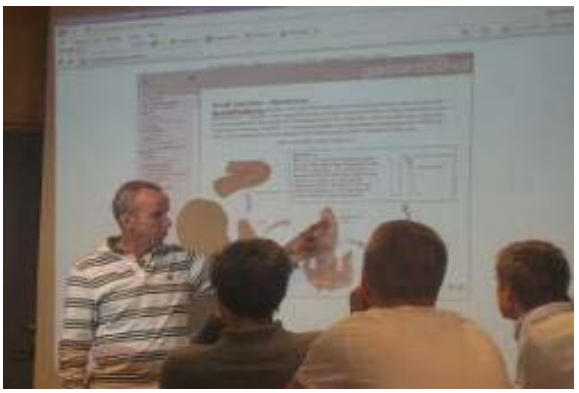

Figure 5 Helping the students focus on the important parts of the animation

4.3 Multiple screen presentation

The teacher in Lindälvsgymnasiet is very experienced in using IT in teaching situations. The students at this school are considered to be high achievers with high motivation. The school is well equipped with IT at all levels, as computers, wireless network connections and projectors in many of the classrooms. The teachers in this school work in teams and plan the courses and the teaching together. She presented her lessons as usual making the students look at various screens during the lesson and moving their chairs around to get a better view of each screen (see Figures 6 and 7). Her students like her way of teaching but think the technology equipment should be improved since some laptops do not work and projectors occasionally go down during lessons.

Figure 6 Many projector screens are in use simultaneously in the classroom

Figure 7 Presenting images on one of the screens

Students commented on the video shown, "I liked seeing the movie in real life. You get a better look at it. But you don't really learn from it". They said they learn from lectures and that videos are useful for seeing "what

something looks like" but not "how it works". Their suggestion was that videos should be played last after the topic has already been presented. They described the VL animations as "better than gestures", and "simpler to see what's going on, where in the video it's all goo".

4.4 Not using VL at all

The teacher was, according to herself, inexperienced in using IT in the teaching situation. The school is poorly equipped with computers (see Figures 8 and 9). The students are usually not allowed to work on their own in the computer room. The teacher is part of a teaching team, as the entire school is working with a fully developed model of problem-based learning. Each team of teachers plan together what to do in their classes and courses. Students in this school are considered to be low-achieving and have poor motivation for biology and natural sciences. Many of the students are studying art, thus natural science is a compulsory subject that is not very popular. However, students clearly like their teacher and the teacher successfully involves them in the subject by putting a lot of effort in getting them engaged. In the focus group discussion, the students had a lot to say about the use of images and animations. They discussed the notion of being misled by images as well as being too entertained by animations. They feared that with entertaining animations, learning might become less important than the entertainment.

Figure 8 No computers in the classroom

Figure 9 OH-projector to show visualizations

5. Conclusion

The VL project's most important finding is related to the issue of providing flexibility for teachers. This concern became evident during the second meeting with teachers when they had all been able to work within the VL site. It was evident that teachers did not like the fact that, images and animations within the site could not be cut out and pasted into a personal PowerPoint presentation. Also, VL applications that teachers would like to use in their own course curriculums were fixed in already preset format and content, whereas teachers needed flexible and adaptable material to suit their own individual needs when developing their lectures. Another problem was that the text-based explanations connected to images and animations were all in English and could not be translated. For the Swedish teachers, this was a huge drawback. Even if Swedish gymnasium students generally are good at English, a foreign language undoubtedly raises an extra barrier when it comes to learning new biology terms and concepts. The teachers also believed that the download time for images and animations was far too long and they feared that students would lose their patience if having to wait several seconds for each animation to download and start playing.

Apparently, what the authors observed during the VL project is a contradiction between a "traditional" view on knowledge creation and knowledge transmission and what teachers are actually asking for in their everyday practice. Whereas the producer traditionally is producing a fixed product, that the teacher traditionally is supposed to utilize in its preset format, many teachers are now asking for material that they are able to modify and adopt to their own pedagogic model and course curriculum. The teacher wants to be in command, being able to build their own lessons based on various available resources. This change of roles very closely mimics a general development in digital media, where there is a move from big professional media producers and passive consumers, to blurring boundaries between producer and consumer (Denegri, 2003). The authors are actually seeing a rapid development in the use of web sites, such as Wikipedia and Youtube also in educational settings, and this is just the tip of the iceberg in this development (UNESCO, 2008).

When creating content for teaching, media producers need to take this into account. The authors believe that moving away from a traditional producer/consumer perspective is necessary. What the modern user/teacher/ consumer/producer needs is the building blocks, the bits and pieces for building their own products. Most teachers can not produce imagery on their own, but they have the need and willingness to select, adapt structure images from a proverbial smorgasbord of content. As noted before, any website or other tool offering these bits-and-pieces must be user-friendly. If ready-made material, like many of the VL website products, will be used by teachers, it is important to restructure the material, so that it enables users to use it in their own way. It should, for instance, be possible to cut out pictures and insert text in relation to individual courses and groups of different students. The VL website material was created by using Flash, which seems to be as a production tool too rigid for this purpose. Future designs should use programs that create flexible applications to allow end users to adapt the sequence of images as well as animations in relation to their own situation.

The authors also believe that the VL animations need to take into account the range of possible levels of complexity, which a representation, an illustration, can have. As Bayne (2008) put it, "Image is never neutral or 'innocent', but rather works to enable particular ways of seeing and occlude others, situating and constituting subjects in specific ways". Rose (2001) also stressed that visual images do not just emanate meaning in some kind of vacuum, despite claims to the contrary. Meaning is made with them, from them, against them, by particular people in particular places. Their audiences are fundamental to their effects.

As mentioned previously, representations in a classroom situation can range from hand gestures to digital animations or computer games. Primarily, the VL animations fall somewhere in between, in a narrow range of short, not very interactive animations. As the authors try to illustrate in the diagram (see Figure 10), each of the 4 teachers had their own individual response curve to different levels of technical and pictorial complexity. Some teachers prefer simple representations, others dream of something very complex. The same goes for students. The crucial question is of course how well each illustration achieves the target of teaching. From the viewpoint of efficiency, simple representation with high achievement is to prefer. At the same time, sometimes a high level of complexity could promise an even higher level of target achievement. There is no answer to where the line between simplicity and complexity an illustration should be. It is dependent on each case. But the authors do believe that it is important for producers of learning material to be aware of the whole range of possibilities. Sometimes, hand gestures may be better and extensive images or animations are not needed. Sometimes, huge resources had better be channeled into advanced game like simulations. Or sometimes, "best practice" is found in the combinations of different ways of presenting the course content as one student pointed out:

Ale 20081007 (student): I liked the combination of the presented material such as mixing handwritten images on the whiteboard with animations and having lab exercises as well.

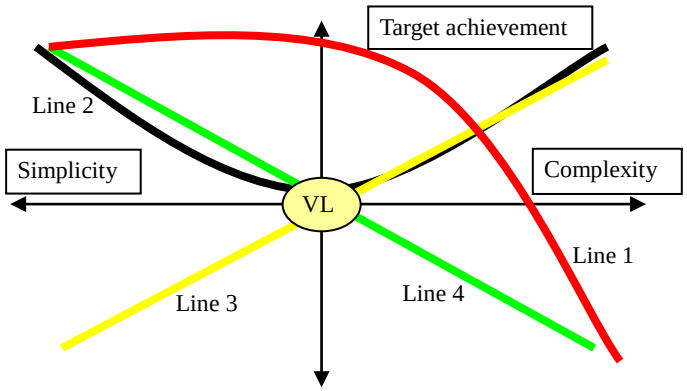

Figure 10 Conceptual model finding the right level of complexity in representations for target achievement

Komvux Ale is indicated in the model above as line number 1. Simple hand gestures was used by the teacher and appreciated by the students. The VL animations were also appreciated by both students and the teacher. However, based on the low technical resources at the school, complex visualization products become useless, since they will be impossible to demonstrate and therefore target achievement goes down the higher complexity the digital visualization product becomes.

Hulebäcksgymnasiet is indicated as line number 2. In this case, the teacher used simple hand gestures to illustrate issues during the class in combination of his own visual representations. In this highly technical equipped school, there are extensive possibilities to use complex visualization tools, something that students also talked about as interesting possibilities. However, these students also raised critical comments, thinking that visual illustrations might sometimes be misleading. The teacher disliked the VL applications and was reluctant to use them in his teaching practice. Therefore, simple illustrations as well as highly complex ones are seen as leading to high target achievements, whereas the VL illustrations are associated to mediocre target achievement.

Lindälvsgymnasiet is indicated as line number 3 in the model in Figure 10. The teacher at this school clearly preferred visual illustrations, and the higher the complexity, the better. Therefore, target achievement with the teaching is seen as increasing as a function of increased complexity in the visual product.

Angeredsgymnasiet is indicated as line number 4 in the model in Figure 10. In that case, target achievement decreases when complexity rise, since technical equipment is very scarce in the school.

It is concluded that the most important is to design for flexibility and adaptability when developing visualization products for educational purposes. Such products should allow end users to adapt the product to their individual preferences and circumstances, which is something that designers mostly are unaware of. Of course, there are restricted possibilities to produce such flexible applications. However, locking the order of sequences in a given application should be avoided in future development of visual tools for educational purposes, since this study shows that when such ambitious visualization products meet learning situations, they tend to become useless for teachers. Rigid applications will be rejected in favor of resources that are more adaptable, and thus suitable for the individual learning situation individual teachers encounter in their everyday work.

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