Creativity and Technology – Interdisciplinary Course on Computer-generated Visualization

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1 Introduction

Necessary changes in the curriculum of computer science are reflected in the way we teach computer graphics and computer-generated visualization. Due to societal and economical changes we need to adjust contents and structures of our lectures. Such adjustments are e.g. the desire to accommodate students from areas other than computer science (e.g. media studies) or the desire to attract more women into our courses. In our paper we describe the use of an educational tool (SIMBA) based on multimedia components that supports a modular construction to create courses to teach aspects of computer graphics and visualization. The content of each module can be motivated by applications rather than technology and can be taught and learned in its full breadth or depth, depending on background and aspired aim of the teaching and learning party.

The course "Creativity and Technology" was held at the University of Paderborn, Department of Computer Science. The students were either in the Master Program of the Computer Science Department (further referred to as "CS students") or studying towards a Master in Media Studies (further referred to as "Media students"). The goal was to have students of different disciplines work on the same project. In order to be able to communicate with each other, though coming from a different knowledge background, the students needed a common "language". This was accomplished by using the same multimedia tool (SIMBA) to teach both kinds of students, but teaching them at different levels of depth.

1.1 The University

The University of Paderborn [www.uni-paderborn.de] in Germany hosts 14,000 students in five different Faculties. The Department of Computer Science is part of the Faculty of Electrical Engineering, Computer Science and Mathematics and grants degrees of Bachelor, Master and PhD of Science in Computer Science. The department of Media Studies is part of the Faculty of Cultural Studies. The Media Studies curriculum leads to a Master of Science in Media Studies.

1.2 The authors

Gitta Domik is professor of computer science and specializes in computer graphics, visualization and image processing. She is also a member of the ACM Siggraph Education Committee. In the '90s she organized the development of the Visualization Curriculum, of which many aspects found their way into the SIMBA tool, which was used for teaching the interdisciplinary courses. She was the responsible lecturer for courses described in this paper.

Frank Goetz is research assistant working towards his PhD in Computer Science. His research interests are in computer graphics, specifically in 3D web technologies, shader technologies, augmented reality and collaborative visualization. He lectures upper level CS student in seminars and project groups as in the case of the seminar and project group for Creativity and Technology. He also advised the interdisciplinary project of the project group.

Monika Schroeder was project leader of the interactive educational tool SIMBA at the University of Paderborn. She is now a teacher at a vocational school.

1.3 Previous projects

This is not our first course for students outside our faculty. An earlier example of such a course is described on the course website wwwcs.upb.de/cs/ag-domik/bildverarbeitung/bic-vl-ws0001/index.htm, where Media students participated in a course called "The Digital Image". The emphasis there was on teaching methods of manipulating digital images rather than on the current technology. The underlying idea was that fast changing technology must be grasped by its meaning not by its use of short-lived software systems. In the project part of this course (click on "Project" on course Web Site) the Media students developed an augmented reality system with the help of two upper level computer science students on the basis of the ARToolkit [Billinghurst and Kato 1999]. The results were very encouraging and the plan was born to further the connection of CS and Media students.

In a sabbatical during 2001, Gitta Domik had the chance to observe interdisciplinary courses at the University of Colorado at Boulder, specifically the course "Technology for the Community" by Professor Elizabeth Jessup and other courses of the Technology, Arts and Media (TAM) program. These and other highly successful Boulder projects strongly influenced the ideas of the here described work.

2 Changes in teaching CS courses

Due to societal, economic and technological changes we need to adjust contents and structures of university curricula. Changes in teaching computer science can best be observed by the IEEE and ACM curriculum guidelines. The latest guidelines, the 2001 Computing Curricula (www.computer.org/education/cc2001), reflects changes and challenges that were foremost in the authors' minds when teaching the Creativity and Technology courses.

Changes e.g. occur because of

- advances in technology (e.g. the rapid growth of networking) and in pedagogy (e.g. the use of new technology in the class room),
- increase of computing in every day life, or
- growing economic influence of computing technology.

All this and more has led to changes in **what** we teach (e.g. networking technologies, the Word Wide Web and its applications, graphics and multimedia, sophisticated application programming interfaces), **how** we teach (e.g. internet courses or distant courses, or interactively in the class room), and **who** we teach. So, **who** do we teach? Not only CS students will work with computers in their future jobs. Other students want a share in this fast growing economy and demand a deeper knowledge of computing issues, not being satisfied with just learning how to click buttons. The "breadth-first approach"[1] suggested by CC2001 allows the simultaneous teaching of interdisciplinary students combining several advantages:

- CS students get a holistic view of a topic before they learn about more complicated details
- CS students can then move on to any depth-level
- students of other disciplines learn of the importance of a topic through the goal of the application
- students of different backgrounds can be taught together at the breadth-level
- all students are being taught the same "language" to describe a topic

Computer-generated visualization and other issues of computer graphics are being taught in our breadth-first approach described here. The courses, their tools, results and evaluations are being described below.

3 The tool

SIMBA is an educational tool based on multimedia concepts to teach and learn key concepts of Computer Science. Its goal, and at the same time its difference to other similar tools, is that it is broken down into key concepts (inside modules) rather than into lecture size. Lecturers making use of SIMBA can make use of texts, presentation slides and interactive applets and exercises, within their own time restrictions and contents. SIMBA was developed within a time frame of three years by several German universities sponsored by the German government. Consequently most of its content is in German.

Figure 1: wwwcs.upb.de/cs/ag-domik/SIMBA enters SIMBA. Click e.g. on "Computer-generierte Visualisierung" and enter "simba" as username and "computerbilder" as password.

[1] Start with a holistic view of the topic to teach (breadth), undermine it with an application; then use depth to the level the students are ready for.

Some of the key concepts developed into modules were: computer architecture, algorithms, didactics of computer science, computer generated color, and computer generated visualization. It is the latter two that were developed by our group and used in the lectures for "Creativity and Technology" (see [wwwcs.upb.de/cs/ag-domik/SIMBA] and Figure 1). Only computer generated visualization has a translation of its presentation slides into the English language. Unfortunately the many interactive applets of computer generated color can therefore only be used by German speaking students and lecturers.

Each of the modules is presented to the student in two dimensions: in breadth and depth. Breadth means that all methods and techniques that are necessary to present the concept are explained in a horizontal menu. Depth means that for each method or technique, while being explained, there are more difficult levels revealed in a vertical menu. An example for computer-generated visualization is depicted in Figure 2.

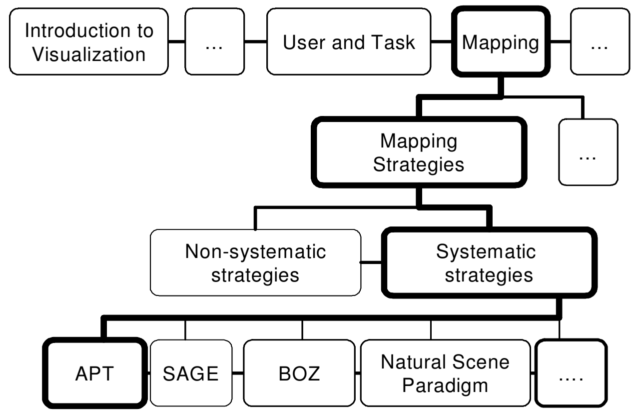

Figure 2: SIMBA shows topics of breadth (here the example of computer-generated visualization) in its horizontal axis and depth (for example on APT, a systematic mapping strategy developed by [Mackinlay 1986]) in its vertical axis.

The breadth of the topic is represented by the different themes fully describing computer-generated visualization and runs from left to right. By clicking on any one of the themes, e.g. "mapping", this subtopic is explained and additionally a deeper level of information becomes visible, in this case "mapping strategies", "problems in the mapping process" and "visual context". Selecting "mapping strategies" reveals information on "systematic strategies" and "non-systematic strategies". Again, while informing on systematic strategies, another level of depth is opened to the user and e.g. information on APT (A Presentation Tool, [Mackinlay 1986]) can be studied. Each click reveals information that can be understood without going into more depth, though a full and deep understanding of the key concept can only be evolved by going through all levels in breadth and depth. In our case, Media students would be led through all breadth topics but only CS students would be led through all breadth and depth topics.

It is interesting to note here, that it is very hard to divide a key concept into independent breadth levels, without increasing depth when going from left to right. In the case of computer-generated visualization much effort of a subcommittee of the SIGGRAPH Education Committee has gone into developing independent themes and the results were quite satisfying. In the case of computer-generated color the success of the authors was not as good and for insiders of computer-generated color it is easy to note a slight increase of depth in the breadth dimension on that module.

Each module has a motivational application to explain the value of this concept to the "real world". E.g. visualization is motivated by the environmental issue if and where to build high-risers in a valley. This question is to be decided by using visual representations of the terrain and environmental parameters such as wind speed, direction and humidity (see Figure 3).

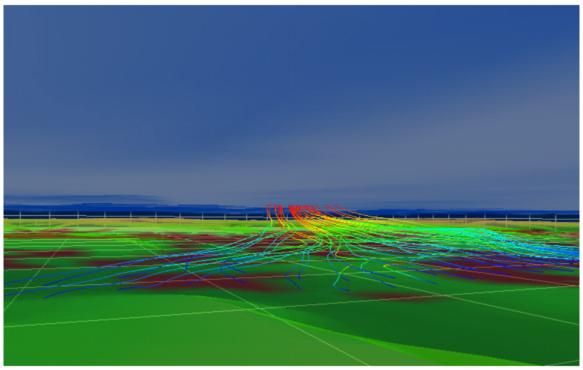

Figure 3: Visualization of a valley and some of its environmental parameters.

With this application it is easy to explain and understand that visualization goal, mapping strategy selected, or individual abilities and goals of the viewer influence the effectiveness of a picture. The students are being motivated to learn more about these themes in order to generate interpretable images.

Computer-generated color is motivated by some of the wide spread user interfaces for color selection that are often not clear to interpret (e.g. what does a hue of "21" mean in the MS Word color editor?). By asking more detailed questions about this much used editor we have found that the curiosity to know more about how to create colors is being peaked independently of the study field and independently of gender.

SIMBA needs to be further developed to be fully translated to English and to finish the third module "Digital Image Processing".

4 CS Side of teaching/learning

Participating CS students signed up for the two semester project group "Creativity and Technology" that met for six hours every week during semesters. This included lectures (on computer-generated visualization using the SIMBA tool, on creativity and computing and on other topics), a seminar (on 3D Web Technology) and project work. The prerequisites to take part in the project group were two courses in computer graphics. Therefore students had a solid grasp of the rendering process, raytracing, radiosity, and volume rendering, and some understanding of texturing and animation.

The project that evolved over the two semesters was a client-server based tool for remote visualization based solely on open source technology [Goetz and Domik 2003]. In order to challenge the display on the remote clients, the visualization process was intended for large, complex data. A suitable data set that modeled the area of a 10 km x 10 km terrain, including simulated data of wind direction, pressure, humidity, and temperature for each defined volume position in space over the terrain and over time was used as a test set (Figure 4).

Nine CS students participated in the project group.

5 Media Sciences side of teaching/learning

Media students had no prerequisites to fulfill. Fourty students participated in the course that was also called "Creativity and Technology". The main content of the lectures was "computer-generated visualization" following the SIMBA tool, but not to the depth of CS students. Computer-generated color was also taught from the SIMBA tool, again in full breadth but limited depth. The lecture on "Creativity and Computing" was held in the same form as for CS students, following scientific articles in [CACM 2002] to better understand how creativity can be supported by a computer system.

Media students also learned to use Maya (by Alias), Flash and Shockwave (both by Macromedia) in the lab. Using this software (or any other software they were knowledgeable of) students were trained to develop expressive and effective visual representations for complex data sets keeping in mind specific visualization goals.

"Creativity and Technology" for Media students ran for one semester, parallel to the second semester of the CS project group named identically.

Mid term of the Media science course was marked by a written exam for Media students to make sure terminology and practical experience with computer-generated visualization was well understood.

6 Working together

The lecture for Media students after their mid-term exam was filled by a presentation of the CS students to show their visualizations of the complex, environmental data set. Also, CS students specified some specific visualization goals for this data set: e.g. a town council using this data set to decide

- where to place a high-riser,
- or where to place a dump site

Together they discussed which visualization elements should be developed over the remainder of the course. CS students and Media students had the advantage of speaking the "same language" when speaking of the system to be developed: "expressive and effective" had the meaning defined by Mackinlay (1986); the influence of viewer abilities or the influence of the visualization goal was well understood on both sides. From here on CS students and Media students would meet and work together over new visualizations. Examples of joint developments are shown below. Figure 5 shows a glyph for multivariate data on wind parameters designed by Media students, and Figure 6 shows the terrain with these new elements in the openVisaar Tool.

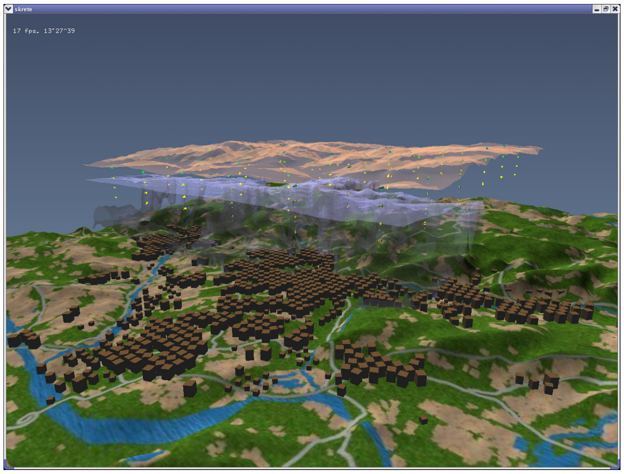

Figure 4: The openVisaar System (developed by CS students) depicting the same terrain as in Figure 3.

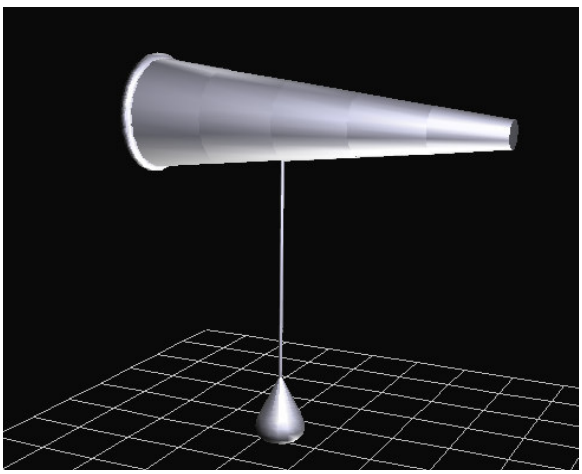

Figure 5: Glyph for multivariate data on wind parameters designed by Media students: colors and size of wind tube and drop are parameter driven.

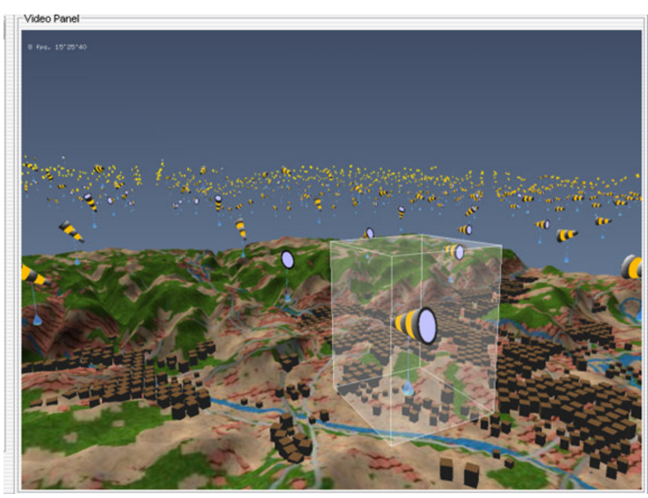

Figure 6: openVisaar with glyphs designed by Media students.

7 Performed Evaluations

We did not evaluate the quality or value of the courses “Creativity and Technology”. However, we did evaluate some of the decisions we made for SIMBA, which we used in teaching these courses. This section is a summary of some of these evaluations.

One study was conducted to find out what kind of applications would motivate CS students to learn more about “computer-generated color”. A questionnaire was handed out to 80 CS students (62 male, 18 female) to indicate or rate their preferences for suggested applications (e.g. the history of color; color editors; designing web pages; technical aspects of color; generation of visualizations). The application mostly named was “generation of visualization” (37.6 % of male students, 29.4 % of female students). An interesting result was that motivation by “technical aspects of color” was named by 11.1 % of male students but not by a single female student! We understood this result as a message to introduce key aspects of computer graphics (or in general of Computer Science) through SIMBA in a non-technical, but rather human oriented approach in order to address men as well as women. Without further formal tests we were quite confident that this approach would also motivate non-engineering students.

One year later, as SIMBA was mostly finished, another study [Tigges 2004] was conducted with 84 CS students (70 male, 12 female; 2 unknown). More than 90% of students found, after using the tool, that specifically the interactive elements were helpful to enhance their understanding. 70% found the modules motivational. Also 70% improved strongly of the breadth and depth order in the menus. The same amount of students (70%) declared that it became clear to them by the application why the topic is relevant to their studies. Technical problems using SIMBA were named by 73% of women and 25% of men. Among these problems were incompatibilities of SIMBA with Linux or a slow Internet access from home.

8 Conclusions/Follow-up

The course(s) “Creativity and Technology” joined CS and Media students in developing elements for openVisaar. The joint work was ended successfully, because of many commonalities between the students:

- a common “language” between different disciplines
- a common motivation between different disciplines
- a gender independent motivation.

References

[CACM 2002] Creativity and Interface, a series of papers in the *Communications of the ACM,* Vol 45, No. 10, 88-126.

[Mackinlay 1986] Mackinlay, J. 1986. Automating the Design of Graphical Presentations of Relational Information*, ACM Trans. on Graphics,* Vol. 5, No. 2, April 1986, pp 110-141.

[Goetz and Domik, 2003] Goetz, F. and Domik, G. 2003. Remote and Collaborative Visualization with openVisaar, *Proc. of The 3rd IASTED International Conference on Visualization, Imaging, and Image Processing,* Benalmádena, Spain, pp. 902-907.

[Tigges 2004] Tigges, A. 2004. Evaluation des Lernmoduls “Compute-rgenerierte Farbe” des SIMBA-Teilprojektes “Computerbilder”, Universität Dortmund, Lehrstuhl Hochschuldidaktik.

Billinghurst, M. and H. Kato. 1999. “Collaborative Mixed Reality”, *Proc. International Symposium on Mixed Reality. Mixed Reality--Merging Real and Virtual Worlds*, Yokohama, Japan, pp. 261-284.