

## Animated visual models to enhance student understanding of complex processes

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### Background

This report concerns use by a tutor of computer simulations<sup>1</sup> to provide animated demonstrations of complex concepts and processes during lectures. These simulations are intended to allow students to see the operation of the systems and algorithms being described as clearly as possible and thus enhance the students' motivation and their understanding of the topic. This evaluation covers the use of the simulations for a second year module on communications theory which is taken by students studying for a variety of electronics engineering degrees. The simulations are also used in several other more advanced courses. The simulations are used in lectures and practical lab classes and are available for students to use after lectures in their own time. In lectures, the tutor first introduces the system to be investigated (for example a queuing system or a baseband modulation scheme) and then shows how it works using the simulation projected on to a large screen this includes demonstrating the system's limitations. Once the students have seen the problems, the hope is that they will be more interested in the mathematical techniques required to characterise the system's limitations and the approaches available to enhance its performance. Each approach is explained theoretically and demonstrated using the simulation. Some of the simulations are complex, capable of running with many optional parameters or displays, and of showing many different aspects of the system they illustrate. An important feature of the simulations and how they are used in lectures is that students are introduced to this complexity gradually options or aspects which have not yet been covered are invisible in the demonstrations.

The simulations are available from the tutor's university website for students to download and use in their own time after lectures, giving the students the opportunity to review what they have seen in lectures, to explore the systems further and experiment with "whatif" scenarios and to run simulations when solving problems and when revising for exams. The simulations are also available during lab sessions in which the students have to do practical work related to the systems described in lectures. For example, there is a practical session on signal filtering and a simulation of the same which has been written to have exactly the options required to mimic the hardware used in the lab. The students can use the simulation during the lab session and compare the results of the hardware with that of the simulation and with simulations of other more complex setups used in industry.

### Reasons

The tutor's reasons for wanting to provide visual demonstrations based on computer simulations hinged on two factors. Firstly the recognition that many engineers are visual learners, and even for those who aren't, visualising a complex system will help them understand it. The simulations were written to allow students to see the operation of the system as clearly as possible so that the lectures engage both visual and verbal parts of the brain to increase learning effectiveness. The second factor was that engineering students tend to be more motivated by practical

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<sup>1</sup> The simulations can be viewed at <http://wwwusers.york.ac.uk/~dajp1/Demos>.

problems than abstract theoretical descriptions and the use of the simulations is an attempt to show how the mathematical theory is used in solving practical problems. The hope is that, having seen the real performance of the system, the students would be much more interested in the answers to the maths.

Animated visualisations generated by a simulation were chosen over static pictures or movies because the processes being illustrated are dynamic and dependent on a range of parameters. The use of computer simulations over real hardware demonstrations has many advantages in terms of flexibility, equipment requirements and setup time.

### **Lecturer's perspective**

The lecturer believes that the approach is working, that student understanding and motivation is improved. While it is difficult to quantify this in terms of exam results, during lab sessions, for example, when there is an opportunity to talk with students about the systems being studied, the depth of understanding demonstrated is higher than he would otherwise expect. There is also evidence of success in terms of students' engagement with the material which is obvious from attendance at, and attention during, lectures and from student feedback.

The positive response from the students is also motivating for the lecturer and improves his job satisfaction and self esteem, knowing from student feedback that his efforts in teaching what could be a somewhat dry subject are appreciated. The simulations are all selfauthored by the tutor in VisualBasic. His level of skill with this authoring language and the nature of the language itself are such that he finds the creation of the simulations relatively straightforward, and indeed enjoys the programming, using it as a break from less interesting tasks such as marking. It is a source of satisfaction to him that the simulations are used in teaching in several other institutions around the world, mostly by exstudents or former colleagues who have learned about them through seeing them used.

### **Students' perspective**

The students' response to the use of the animated demonstrations was ascertained by a questionnaire filled out by all students who attended one particular lecture and an interview with a group of eight students. This response was overwhelmingly positive, enthusiastic and supportive of the tutor's rationale and belief that he is succeeding in his aims. Of 31 students who returned questionnaires, 25 strongly agreed and five agreed with the statement that "having seen an animation helped me follow the content of a lecture"; 26 strongly agreed and five agreed with the statement that "the animations help me visualise the processes in a communication system" and 24 strongly agreed and seven agreed that "being able to visualise the processes in a communication system helps me understand it." All students returning questionnaires agreed (17 strongly) that "the computer animated demonstrations helped increase my depth of understanding"; 16 students agreed and ten strongly agreed that with a statement that the use of the computer demonstrations in lectures helped them with problem solving. The students strongly disagreed with statements characterising the use of simulations as "boring" and "unnecessary."

In the group interview and in comments on the questionnaire the animated demonstrations were described as "brilliant", "really helpful" and as complementing the lectures and handouts, with the notes giving the "perfect reference" and the demos providing the explanation; "the lectures themselves are more like a discussion, a chat, they're not fixed in stone", with the tutor "not talking at us, just showing us how it all works. That makes it interesting." The three areas that students repeatedly identified where the simulations help were aiding visualisation, enhancing understanding and motivation. For example, in the interview they described the approach as "interactive" and able to illustrate transitions literally "at the click of a button" rather than the tutor

having to "draw another ten waveforms on the board" which would be "direly boring." Comments made via the questionnaire described the demos as encouraging "attention and mind focus during lectures" and making it "easier to concentrate." The students in the interview commented that attendance at these lectures was significantly higher than attendance at lectures for other courses. Perhaps surprisingly, given that it was entirely optional, most students do seem to have accessed the simulations out of lectures, and those who commented valued the opportunity to use the simulations to help with problem solving and revision.

### Issues

The only issues raised by the students were acknowledged by them as being minor or irrelevant to the context in which the simulations were used. These were that the appearance of the simulations "could look nicer" and that the simulations were difficult to understand without seeing them in the lecture first. The tutor raised the issue of the programming language being somewhat dated, which may cause problems in the future.

### Benefits

It seems clear that the students find that these simulations help them visualise the processes and systems they are studying and that this ability to visualise what is going on helps them understand the system, increasing their enjoyment of the course and their motivation. The students and the tutor believe that this increases their depth of understanding and problem solving ability.

### Reflections

The alignment between the tutor's rationale and aims and the students' perception of the benefits offered by these demonstrations illustrates a well planned and executed use of computers to enhance a course in a way that exploits the strengths of the medium targeted at a point of educational need. The only change to their use that was suggested by students was that many commented that they wished a similar approach were taken on more courses.

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