Use interactive multimedia to improve your programming course

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Abstract: This paper reports first year students' experiences with multimedia-based learning for programming and its influence on students obtained from two case studies at Napier and Brunel universities. Engineering students at the universities have taken programming courses from their first year and many have showed difficulties in their learning. The main reason is that it is a very abstract domain, which means that both lecturers and students can have difficulties in explaining and understanding abstract concepts verbally. Considering the strengths of Interactive Multimedia(IMM), i.e. interactivity and visualisation, we decided to use it to improve students' learning.

An empirical study was planned and IMM materials were designed for this. A trial and two case studies were carried out from December 2000 to June 2001. The designed materials were integrated into the curriculum as a teaching aid and self-guided learning materials. The data gathered from the case studies indicated that many students felt the multimedia-based learning helped their understanding of the programming concepts, and some became very motivated in programming. Also, using the interactive multimedia materials for both teaching and learning enhanced students' learning experience. At last, we found educating both lecturers and students on what is multimedia-based learning prior to a course can increase its effectiveness.

1. INTRODUCTION

This story goes back to early 90'. The first time a student encountered programming was she started Eng Computer Science course at a university. She had neither prior experience with programming nor experience with a computer. The course was chosen with the belief that she would enjoy studying the leading technology and it would ultimately lead her to a bright and promising future. Well, what was waiting for her broke all of her illusions. One major problem she faced was that she simply could not understand programming. It seemed to her that the abstract concepts of programming were conceptualised easily by some students when others including her had much struggle to understand them.

Another problem she got was that she could get little help from her tutor to solve the problem. Still now she remembers the puzzled look of a young lecturer who did not understand why some students had difficulties with understanding the programming concepts. At that time she thought, 'Ok, you think programming is a piece of cake. But it doesn't mean it is to everybody. What I need right now is not a brainy lecturer who knows how to programme but one who understands my problem and can help me grasp these concepts.' At the end of the semester she found herself still struggling with programming. She decided to spend the whole

summer vacation on studying programming and to change my course if she could not improve her understanding.

Many students may think this story depicts their problems as many students face same or similar problems with programming. Because of its abstract concepts, programming is not an easy subject to learn. 1st year students, particularly with low self-esteem or low motivation to learn, could be easily discouraged to learn this subject, which seems occurring at many universities in UK.

Brunel and Napier universities, which are ex-polytechnics, also have encountered similar problems with 1st year students with programming modules. As a solution, we decided to use IMM to support both teaching and learning the subject.

The remaining paper will describe the brief background literature taken - learning and IMM, brief description of the empirical study with the design features used and contextual learning environment. Finally, students' experience with IMM, which are factors affecting their learning with IMM, their responses to the IMM materials used and multimedia-based learning, and lessons we learnt will be discussed.

2. LEARNING AND MULTIMEDIA

"Without love there is no learning". This comment made by David Mitchell at ALT-C 2001 conference had me pause and think about learning. You may have an experience being around a child asking many *why* questions because the child wants to learn things. According to Mitchell, we cannot really teach things to children unless they want to learn – meaning not only acquiring facts but also understanding the meaning. And many children stop asking *why* when a teacher starts to teach them.

It seems as if the learning and teaching process that the current educational system supports does not always facilitate learning effectively. Probably, to solve this problem we should think teaching in terms of supporting learning and choose teaching techniques accordingly. What is learning and how could we support it?

Learning
Learning concerns *thinking* - reasoning and reflection(1). Students should use reasoning such as deduction and induction, and reflection to construct their knowledge relating to their existing one. Learning should be meaningful more than memorising or reproducing knowledge presented by a teacher (2,3).

Entwistle et al. define this as 'deep learning', which means that in order to transfer outside information into internal knowledge, students must understand the information presented(2). They should conceptualise the information, make connections with already existing knowledge and have *deep understanding* of it. Mayes' learning framework(3), which is following, illustrates the internal process effectively.

Mayes' learning framework
This framework illustrates the cognitive learning process with three learning stages(figure 1). The first stage is *conceptualisation*, which refers to the student's initial contact with a

learning material. The second stage is *construction* requiring students build on the concepts learnt in the conceptualisation stage and refine their understanding by working on tests and examples. The third stage is dialogue, which requires for students to refine their understanding through dialogue and discussion.

Fowler and Mayes (4) have later modified the learning framework, shown in figure 2, by extending the notion of dialogue into the three stages. This includes dialogues or learning conversations for clarification and confirmation at the conceptualisation stage, and dialogue for co-operation and collaboration at the construction stage. They also replaced the dialogue stage with the stage of 'identification' in which students reached a sufficient level of understanding to be able to relate to other conceptualisations and thus begin the process again. Fowler and Mayes(5) emphasise dialogue as the vehicle for conceptual movement.
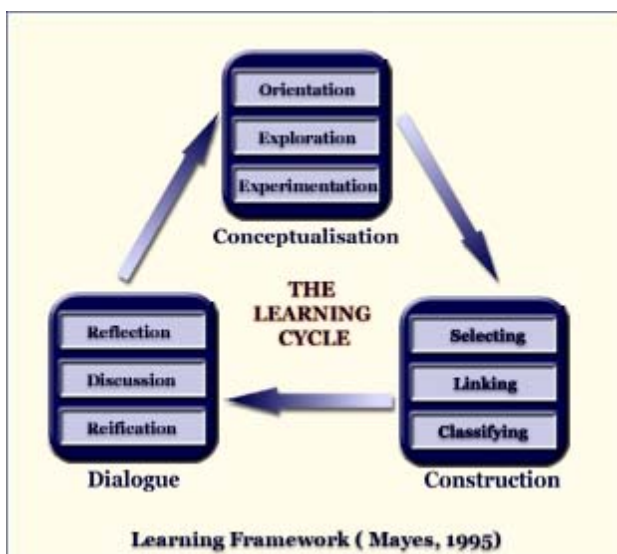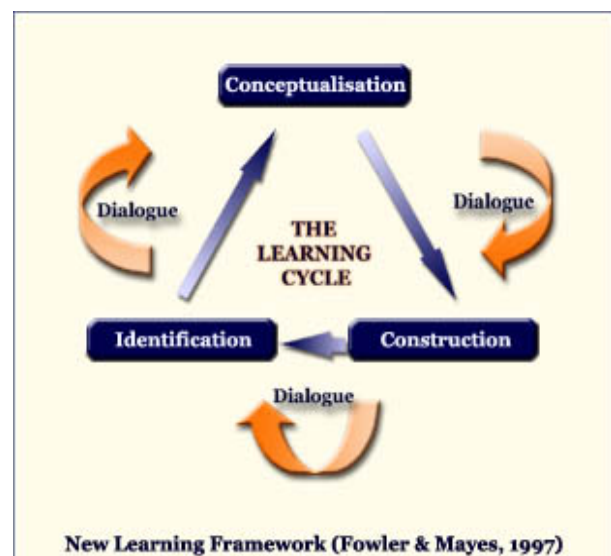
Figure 1 Learning framework(Mayes,1995)   **Figure 2 New learning framework(1997)**

Interactive Multimedia (IMM)

Many students have shown difficulties regarding their learning with abstract domains, and one of them is programming. It is difficult to grasp abstract concepts as research shows that 65% is perceived visually(6). Like an old Chinese proverb "Seeing is believing.", visualising the abstract concepts can help students understand them. IMM has strengths for visualisation and furthermore, interactivity.

Multimedia with its combination of graphics, video, sound, animation and text has a number of potentially powerful characteristics which can be used to improve the learning process. First of all, by definition, it implies the use of combined media in presenting information which can be more effective than any single medium(7). The most appropriate medium for the required message can be selected, e.g. text for thoughts, graphics for spatial relations and animation for dynamic information. It also reinforces and supplements information through multiple representations.

Secondly, multimedia allows simulation and visualisation which are particularly useful in areas that require understanding of complex, abstract, dynamic and microscopic processes(8). Moreover, multimedia allows users to take their own path through the material, and to build up their own knowledge. Enriched context with static and dynamic media enhances learning

with the above strengths; however, the essence of multimedia is interactivity (9). Effective interactivity enhances the interplay between internal and external cognitive processes (10). In order for multimedia to have a genuine pedagogical value, we should provide appropriate activities and design effective interactivity to support conceptual learning. Also, along with a sound design of IMM learning materials, they should be delivered in a way students can learn best.

3. STUDY : LEARNING AND TEACHING WITH INTERACTIVE MULTIMEDIA

IMM materials were designed to teach and learn two programming modules at Brunel and Napier universities. As they were aimed to be used as the main courseware for the modules, the content was designed together with the module lecturers.

Overview of the case studies
The IMM materials at Brunel university were used by 160 1st year undergraduate students for EE1036S Software Development module in the second semester of 2000/2001. The students had taken a basic programming course with C++ in the first semester, so the IMM materials were designed to teach and learn pointers, variables, structures and etc. The module was delivered by two lecturers, and the IMM materials were introduced by the second lecturer in week 4 and used till the end of the semester.

The IMM materials at Napier university were designed for CO12002 Software Development module and used by about 150 1st year students. The aim was to teach and learn software design with object-oriented approach using Java. They were used for the first 7 consecutive lectures and tutorials during the first 4 weeks.

Design Context
The following two things are required to facilitate learning with IMM successfully. First is designing an effective material which supports the learning process, and next is using it appropriately. We suggest that promoting cognitive interactivity within the material and supporting dialogue with it are the key issues for designing and using an IMM learning material effectively.

In order to achieve this, we designed two types of IMM materials, which are a resource-based material and a task-based one. The first aims to provide information as the main courseware and to be used in lectures. The latter is to provide tasks which enable students to apply the concepts they learnt in tutorials. One expected result of the environment in which the materials are used, is dialogue and collaborative work are supported and encouraged.

To promote internal interactivity, hyperlinks and animation are used - animation for visualising the abstract concepts in the resource-based material and hyperlinks supporting cognitive interactivity, cognitive dialogue and reflection, in the task-based one. Figure 3 shows how the proposed structure of design and the contextual learning environment supports the modified Fowler and Mayes' learning framework(4)
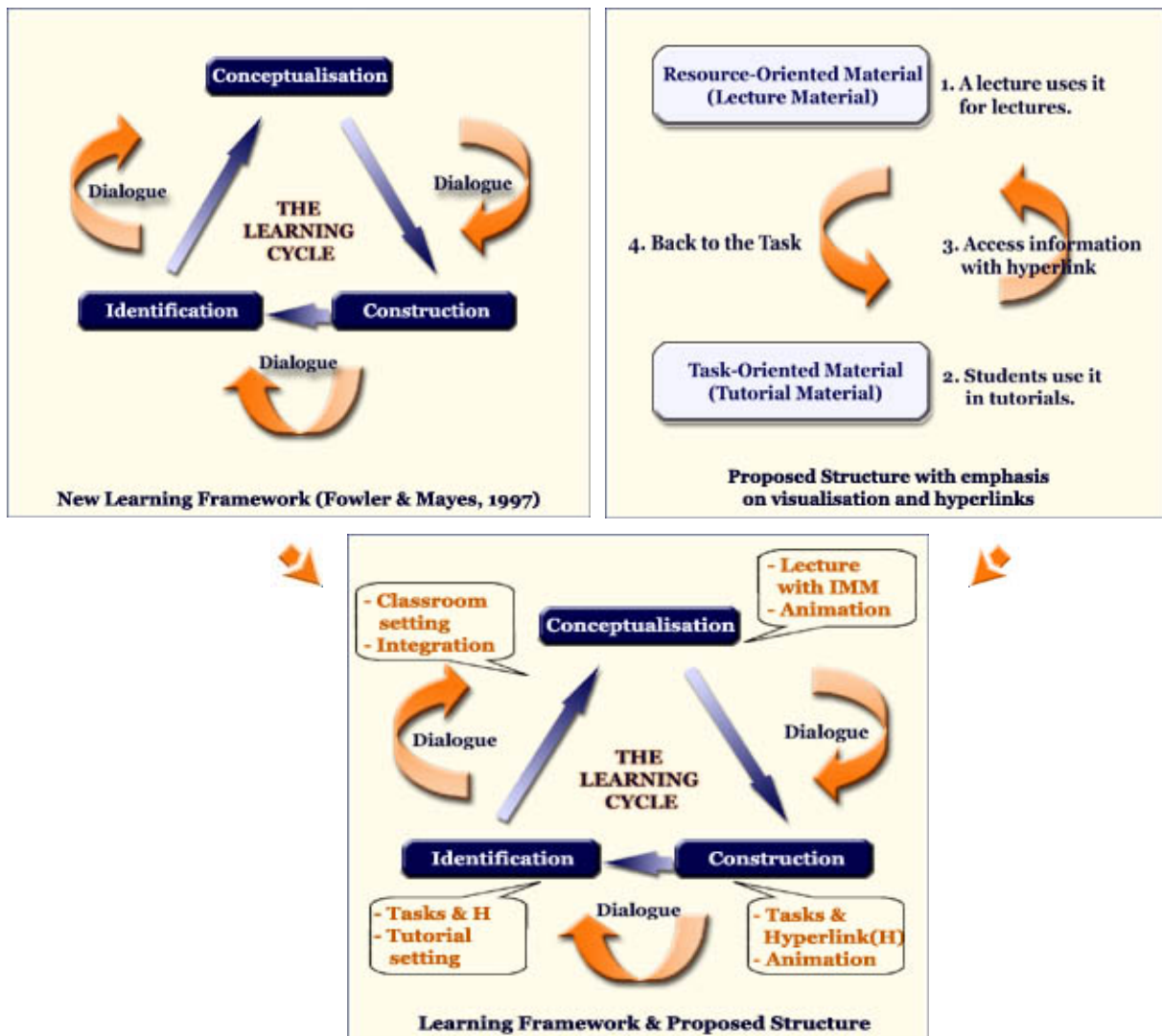
Figure 3 Learning framework and proposed design

Students' experiences with IMM

What do you think the female student decided to do at the end of the summer– stay on or change her course? The answer is that she has an Eng degree in computer science. That summer she went through many programmes in order to understand how they worked. While going through each programme, she found drawing the flow of the programme a great help.

Similarly, using IMM helped students at Brunel and Napier to learn programming. This section will describe students' experiences with IMM in three areas – factors affecting their learning, their perception on the IMM materials used and their responses toward multimedia-based learning.

Factors affecting students' learning

Like Prosser and Trigwell(11) suggest, students' prior experience, perception on learning influenced their learning. Furthermore, their learning was affected by their perceptions on multimedia-based learning and attitudes toward a new experience which is one strong barrier identified in this empirical study.

a. **Prior experience**: Students' prior experience with learning and experience with IMM influenced them to perceive the multimedia-based learning differently. Students with prior experience of using IMM responded more positively to using IMM and considered it very beneficial for their learning. On the other hand, students whose idea of learning was to be paper-based one got the least benefit as they simply dismissed the materials.
b. **Perception on multimedia-based learning**: There is a notion that IMM can provide the control of learning to students. We found that many students and even some teaching staff interpreted this as students should learn on their own with IMM.
c. **Attitudes to a new experience**: Along with students' perception on learning, we found students' negative attitudes to a new experience problematic. Interviews with students revealed that some students were afraid of trying something new. Also, instead of perceiving that the IMM materials were provided to aid their learning, some felt that more workload was put into their direction.

A student's comment about his experience with the IMM materials well summarises the factors mentioned the above.

"….. In the beginning, I hated to use the multimedia materials. Before taking this module, my only learning experience with paper. Without trying, I complaint to my friends outside the uni. And they said, "Try. If you don't like it, then delete it." So, I try it. I do not want to say it, but I liked it. I really liked it. At home I went over the materials from the beginning to the end several times. It really helped me…..After that, whenever my classmates complaint about the material, then I simply told them, "Try. If you don't like it, delete it….."

Students' experiences on using the IMM materials
Students' attitudes to IMM became more positive as many realised the benefits it offered. There were few questions regarding how to use the materials, and students felt easy to use them after trying a couple of times.

Most students considered visualisation helpful to conceptualise the abstract concepts and hyperlink beneficial to correct their misconception. Many comments similar to the ones below about animation and hyperlinks were made by students.

"…One thing is the animation…because the animation makes it very simple to understand things … like …mmm… it makes you see what's really going on in the computer. And that makes it very useful, I think for me….".

"…Yes. They was useful. Hyperlinks helped me correct my misconceptions……"

Students' responses toward multimedia-based learning
Most students preferred to use IMM for both teaching and learning. Only some students wanted to use them for independent learning or teaching only. 71% of students at Brunel and 93% at Napier considered using IMM useful for their learning. The different percentages can be explained that the lecturer, who had prior experience of teaching with IMM at Napier, provided the content more suitable for IMM use and delivered the material more effectively.

The following comment and conversation reveal how students perceived their learning with IMM for programming.

"…The multimedia material helped me understand the concepts a lot. But I don't know the basic concepts of C++ programming covered in the first semester. Multimedia should have been used from the first semester…."

Lecturer : "…This flowchart is not right. You should do…. But you seem to know pointers and structures and have applied them in your programming…."
Student : "…Yes. Pointers and structures are easy concepts to understand. Isn't it right? But flowchart is very difficult to learn……" There could be many who do not share this student' opinion. This may indicate that students got more benefits than they realised.

4. DISCUSSION AND CONCLUSION

The data gathered from the case studies indicate that using IMM to teach and learn programming can bring benefits. It helped students conceptualise and apply the abstract concepts of programming in a problem-solving context. It also supported a lecturer, with a visual aid, to teach the abstract concepts which were difficult to explain verbally.

However, some obstacles were found with the multimedia-based learning. One is some students' disinclination to learning the subject caused by their perceiving that they had more work to do with IMM than the paper-based learning and by their no attempt to use IMM for their learning. Our ultimate goal of bringing IMM into the curriculum was to help students who had difficulties with learning programming. Observation, survey and interview showed that some students, who needed help most, were the ones who declined to use the materials.

How could we solve this problem? Many mentioned that when they used IMM first time, they did not like it for their learning, but they began to realise the benefits once they started using it. Perceptual change toward IMM is required for these students to get the expected benefits from using IMM. When their mind is against it, they cannot realise the true value of it.

Another problem identified was that using IMM required certain equipments, i.e., a computer and CD-ROM driver or Internet connection. The materials were distributed via the university Intranet and Internet(only at Brunel university). Not all of the students had a computer at home although most had and the materials were always available at the universities. At Brunel some students felt frustrated as the IMM materials were the main courseware and there were not many additional materials which they could use at home without a computer.

In addition, teaching staff's inappropriate supports of the IMM materials were found as a problem. As caused by the misinterpretation about IMM offering one's control of their learning, some tutors considered that using the IMM materials replaced their teaching. It was not the intention of ours and we expected using IMM in tutorials to allow a tutor to pay more attention to the students who needed personal help.

To rid of those obstacles, we emphasise that both students and tutors to be educated on how they could make most use of IMM in the beginning of a semester. It can help a tutor to better support students' learning with programming. It can also help students realise the value of using IMM and as a result lead to their perceptual change toward multimedia-based learning. We should be aware that IMM is not the answer for learning and teaching but a means which

has the potential to improve learning and teaching with programming. Therefore, we should use IMM to meet the needs of our students.

5. NEXT STEP

Having modified materials with the findings from the case studies, a new case study is designed and will be carried out to support students' learning with object-oriented software design at Brunel from October 2001. In this case study, IMM materials will be used for the whole semester for learning and teaching, and in the beginning a special session will be given to introduce IMM to the teaching staff and students. The materials will be distributed via Intranet, Internet, and CD-ROM, and additional paper-based materials and guidance for IMM will be provided if required.

ACKNOWLEDGEMENTS

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