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ON-LINE LAB-EXPERIMENTS, A HELP FOR IPD-PROJECTS?

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ABSTRACT

This paper describes the results of an investigation in the appreciation of on-line lab-experiments and suggestions for the way of use in Integrated Product Development (IPD)-projects. Together with other educational institutes and companies Fontys University of Applied Sciences participated in a number of projects in which distance learning courses were developed. Some courses have been integrated in the regular curriculum. Our study was set up to get insight into the appreciation of students for this way of learning, especially concerning online lab-experiments. By using surveys and interviews after the students accomplished either a regular course or a distance learning course on the same object we tried to get a better understanding of how students used the course and appreciated it. Also we wanted to know whether an online lab-experiment is more or less effective than a regular one and how it can be used in IPD-projects. Preliminary data analyses have shown that the appreciation of an online lab-experiment is dependent on a number of items, like the educational contents of the experiment itself, the way accompanying theory is presented, possibilities of doing the experiment in an alternative way, the organization around the experiment etc. It appears also that students give serious suggestions on developing other online lab-experiments and the way to use it in IPD-projects. This paper describes the web-based experiment "cube measurement", which is carried out using a remotely operated robot and image processing functions. The students' appreciation will be discussed and suggestions will be done on how comparable experiments can contribute to work in an IPD environment.

1 INTRODUCTION

1.1 Projects involved

In 2006 and 2007 Fontys University of Applied Sciences participated in two projects in which distance learning courses were developed. One of the projects was called "Process4MKB" [1]. The general aim of this project was to improve the international competition possibilities of small and medium enterprises (SMEs) in the field of batch process industry. Eight institutes in higher and secondary technical education participated in this project. Together, students and teachers of those institutes gathered knowledge based on the needs of industry and translated this into web-based learning modules. The second project Fontys contributed to was called "Labs-on- Line" [2], a project initiated by the *Digitale Universiteit*, in which a number of Dutch universities co-operate. Participating institutes in this project were the *Universiteit van Amsterdam*, the *Vrije Universiteit*, *Fontys Hogescholen*, the *Hogeschool Utrecht* and the *Haagse Hogeschool/TH Rijswijk*. "Labs-on-Line" continued the development of two earlier projects at Dutch universities; first the project FlexLab [3], in which the *Hogeschool Utrecht* and the *Technische Hogeschool Rijswijk* created a number of remote labs and secondly the project "eXperimenteren+" [4], in which the *Universiteit van Amsterdam*, the *Vrije Universiteit*, the *Universiteit Twente* and *Fontys Hogescholen* have developed similar products. Both projects delivered an operational, prototypical online lab infrastructure. In quite general terms the objectives of "Labs-on-Line" have been the enabling for large groups of students to use remote laboratories flexibly, efficiently and universally. The ambition of the project "Labs-on-Line" was to

create a model for remote experimenting that could grow into an (inter)national standard for online labs, a standard that other projects and initiatives can easily adopt. By now most of the objectives of the project have been realised. The distance learning case that has been derived from this project is the case "Cube measurement" which is carried out by using vision techniques. It will be described in the next paragraph. This case has been used to consider the possibilities of using similar on-line lab facilities in favour of IPD-projects.

1.2 A distance learning case

The web-based exercise "Cube measurement", also called "Vision experiment" has the educational objective to introduce basics of vision technology to students. Specially the influence of illumination and most common image processing functions are dealt with. The experiment is set up in such a way, that a teacher and a can formulate different assignments, depending on the level of the students. The assignment, created for our students is to determine the colours and sizes of a cube with the use of a camera and a computer. In order to make all coloured faces of the cube visible a robot is used to throw the cube several times in a visible field. The student has a reasonable degree of freedom in controlling the corresponding processes. During the execution of the experiment the student is provided with tasks that he or she has to fulfil in order to be able to proceed. The experiment creates an environment in which the assignments can be carried out. There is no evaluation or grading system included but log files are generated with information on the actions that the students have taken. These log files can be used by a teacher to evaluate an assignment. In Figure 1 the experiment set-up is shown.

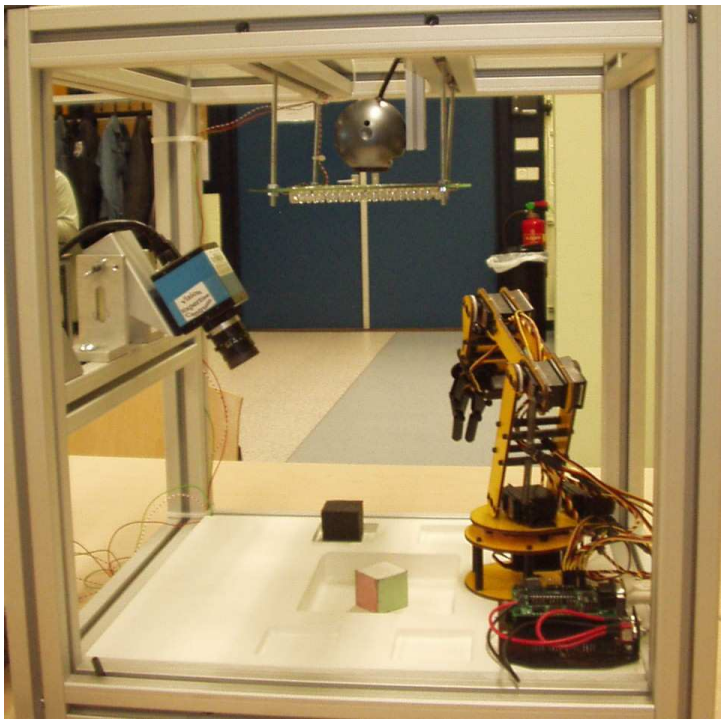

Figure 1: Vision experiment

In the picture the vision camera which is used for image processing is visible in blue. Also a webcam can be seen with which the student can follow the actual movements of the robot and see the position of the cubes. Beneath the webcam LED based illumination is mounted, which can be switched on in segments by the student. The students can get access to the experiment by using a reservation system. The way this reservation system is built is described in [5]. This article also describes the solution found for the problems involved with integrating the two different reservation systems, outcome of the projects "e-Xperimenteren+" and "Labs-on-Line".

1.3 A suitable IPD-project

Of course more IPD-projects might be suitable to use web-based lab-experiments. We decided on one of the projects that is being carried out at Fontys during the current Spring semester. A recent description of Fontys IPD-projects can be found in [6]. The selected project is called *Infoloader*. Our client wanted a system for making information services on trade fairs easier and more convenient. To realise this the idea arose to make all the information services digital instead of the currently used flyers. In this way, trade fair visitors can just store all the information they need on a USB stick which only weighs a couple of grams. By the way, most of the flyers are often thrown away immediately after the show which is not environmental friendly. To realise this idea the student group created a system that is be capable of data transfer on a low level, this means it will be able to transfer data from one carrier (e.g. a USB stick), to another carrier without using the help of a computer. To be able to do this, an embedded system is made that runs on an ARM 9 processor, using embedded Linux. With this system it is made possible to just plug the USB stick into the desired console and the system will do the rest. In addition to supplying the trade fair visitor with the desired information, there will also be a data stream in the opposite direction to give the company the contact information of the visitor. In order to produce this system, several tasks had to be fulfilled. A lot of discussions with the client were needed after which the plans could be produced. EE-students had to design a circuit board, one ICT-student (embedded specialization) developed the software for this board and one ICT-student wrote the software to analyse all the visitor details and put this into a database. During the project two Industrial Design students (from the *Haagse Hogeschool* were added to the project. Their task was to design the housing with the restriction that it looks attractive for fairs, that all electronic equipment will fit inside it and that the memory sticks can easily and safely be plugged in and out. Part of their CAD-model is shown in Figure 2.

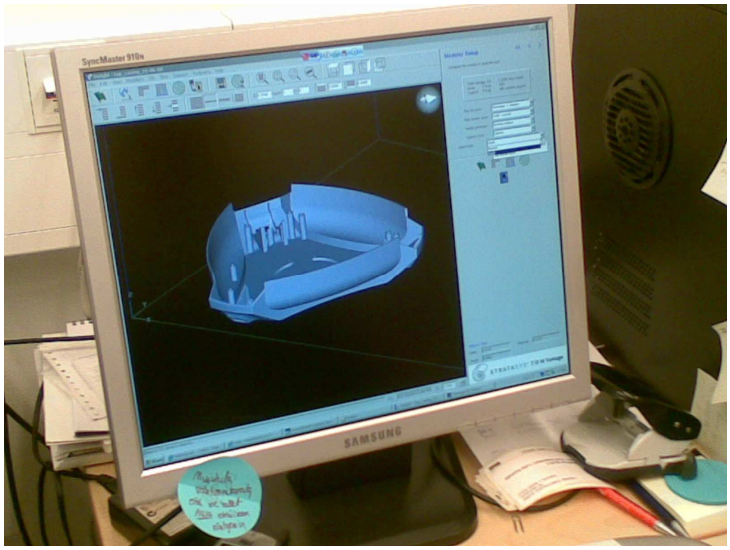

Figure 2 CAD model of Infoloader housing

Finally the idea came to produce a prototype of the housing. Therefore the Oulu University of Applied Sciences in Finland, earlier involved in IPD-projects (e.g. see [7]) has been consulted. They have a lot of rapid prototyping facilities and they were asked to make an RP-model for us. The students had to send special CAD-files to Finland for that purpose. The way of working in this project and the web-based activities are analysed and compared with the lab-experiment.

2 PURPOSE OF THE INVESTIGATION

The purpose of our investigation was to determine the appreciation of students for distance learning, not in general but for a well known case that is used within our own institute; the web-based lab experiment. For this case some comparison could be done, as the lab experiment is also available without using the control through Internet. We wanted to know whether the experiment was as effective as it promised to be and what possible difficulties students could meet when executing it.

Also we wanted to know whether web-based lab experiments could be suitable to use within IPD-projects or what can be learned from those experiments which we can use to improve communication within IPD-projects. Parts of these questions we hope to answer in this paper.

3 APPROACH OF THE INVESTIGATION

In order to find out what the appreciation of students for web-based experimenting is (in this particular case), we have been monitoring students for one year and a half. All students that took part in the course had to fill out a questionnaire. Also online evaluation forms were included in the course but the accompanying questions were more directed to the contents of the courses and filling out these evaluation forms was voluntary. A difficulty was, that only a minor number of students (about fifteen) did the online vision experiment. However also a few students did the vision experiment directly on the system, they can serve as a reference group. These numbers are too low to draw solid conclusions from, but they give an indication for further research. In order to retrieve more information all the students were interviewed. As none of these students participated in IPD-projects we could not ask them for suggestions; this was done in an informal way with the IPD-students. Results will be discussed in the next chapter. The interviews gave us more insight in the students' ideas of pro's and con's of web-based experimenting. In order to have a base for our investigation, we did some desk research in advance. E.g. the effectiveness of e-learning was reported in [8]. Also a search was done to find comparable cases for our online lab experiment. It was interesting to learn, that throughout the world a lot of people is developing this kind of experiments and also make them available to a broad public. E.g. a recent publication [9] describes a real electro-technical experiment conducted in a laboratory, remotely controlled and monitored by web-based tools. Earlier work has been done at the University of Siena (see e.g. [10]), where an automatic control lab [11] has been developed, which can be accessed from everywhere and was even found in a recent curriculum of the Yeditepe University in Turkey [12,13]. Finally an online experiment was found that showed great similarity with ours [14]. It made use of lots of similar components as applied in our case. E.g. LabVIEW was used both to control hardware and a camera as well as to create a web-interface.

4 RESULTS OF THE INVESTIGATION

In the questionnaire students were asked to rate the contents and the concept of this learning module. It was also asked whether they found this concept suitable for this module. Further questions concerned the sufficiency of earlier knowledge and the need for additional explanation. On a scale from 1 to 5 most items were rated around 3.5, both from the students who did the on-line experiment, as from the reference group (the students that performed the lab experiment directly on the system). The only item that differed for those groups was "the suitability of the assignment for this concept". This was rated by the "on-line students" with 3 and by the reference group with 3.5. In the interviews afterwards we tried to find out the reasons for this. Most of the times it was mentioned that the system reacted too slow and sometimes produced errors which could only be solved by a system manager. Also the web-based lab-experiment group was asked to mention advantages and disadvantages. Besides suggestions for improvement of the content and the navigation the most important pro's and con's came up in the interviews. Almost everyone mentioned as biggest advantage the possibility to schedule an experiment whenever they wanted. Also the possibility to do this at home was mentioned. The biggest disadvantage was that there was no direct possibility to put questions when things were not clear; they preferred more direct feedback. Additionally it was mentioned, that it was just an interesting way to perform a lab-experiment, that they became aware of the difficulties of controlling systems through the internet and accompanying communication. The most important disadvantage that was mentioned was failure of the system with the impossibility to resolve this from a distance. Next to slowness also the fact that they could not actually see the robot move was mentioned as a disadvantage. This could not be compensated with the "life" pictures of the webcam, that is integrated in the system. Some students mentioned the fact that they first had to install some software (this was when using their own laptop) before they could start performing the actual assignment. Another outcome of the interviews was that students did serious recommendations for improvements of the assignment and gave suggestions for making more experiments, which are part of their curriculum, available through internet. Additionally we interviewed a number of IPD-students, asking them of what kind of applications they could think for web-based lab experiments in the context of IPD-projects. Most of

the answers pointed in the direction of co-operative (distant) working on design tools. This concerned both mechanical CAD systems and electrical CAD systems as well as CASE systems for the development of software. Often it was mentioned that the students in the IPD-group already made intensive use of e-mail, not only to communicate with each other, but also to exchange CAD files, drawings or software. Only a few students mentioned the possibility to use the computer to produce a product or rather a prototype at a distance or to perform distant measurements on the product. Within the "infoloader project" as mentioned in 1.3 the possibilities of distant working and experimenting were investigated more thoroughly. However the given answers did not differ much from the answers that were received more in general. It is obvious that the members of this group did not forget to mention the rapid prototyping facilities. Besides questioning the members of the project group we observed the way of working and the web-based activities the members developed during this project. Soon after the start they got the idea to create a group mail address, so every member would receive the e-mail which was sent to this address. Also a workspace was opened, where every member could upload his files and some used an additional e-mail notification facility for that. Although recognized as a possible valuable support they did not use the possibility of collaborative working at different sites on CAD-systems or software development. Reason for this was that they were working physically close enough to consult each other when working with this kind of programs. Therefore using programs as I-visit or even msn were not taken into consideration.

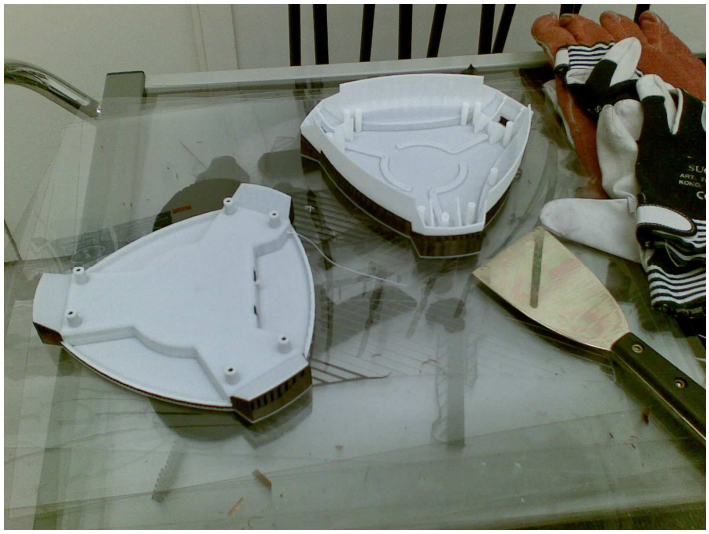

Figure 3 Infoloader housing parts

Finally they would have liked to follow the process of producing the FDM model in ABS on a rapid prototyping machine in Finland with a webcam, but (supposed these facilities were available in Oulu) they were to busy preparing their presentation for the IPD symposium. FDM means Fused Deposition Modeling and is used to turn the computer aided design geometry into solid products. ABS (Acrylonitrile butadiene styrene) is the material used to build the model. The result of the RP-process is shown in Figure 3.

In our opinion a renewed survey for the communication means and other web-based support for IPD-projects as we did in 2000 (see [15]) is needed.

5 CONCLUSIONS

The student ratings for the web-based lab experiment give a positive view. This was supported by the figures from the online inquiry for all experiments available through the reservation system. It gives a base for doing some recommendations to the management about enlarging the availability of web-based experiments. We were strengthened in this opinion by the outcome of interviews in which students gave suggestions for other web-based applications, not only in the form of lab-experiments but also to support distant and collaborative working in IPD-projects. Other conclusions from the

interviews are that the web-based lab experiments become more acceptable when the reliability has improved. This can be achieved by using more robust equipment and better data connections. Also the speed of connection has to be improved as well as the quality and the grade of reality of webcam pictures. All these arguments apply for IPD-projects as well. As most important advantages of distance working the independence of place and time to work or to perform an assignment were identified. One of the questions in an online questionnaire connected to the remote lab-experiment referred to the use of the reservation system; it appeared that 90% of the students were able to make the reservation at the time they wanted to. From the institute's point of view we can add that using web-based versions of lab experiments and learning systems is a perfect solution for the problems that arise when students are ill or handicapped. For institutes with departments that are spread out over a city or a region there is no need to have more than one laboratory at a site and students can work collaboratively without (too much) travelling. The determined disadvantages were most in the field of functionality of the used systems. For the web-based lab-experiment an important issue remains: the impossibility to put questions to a teacher during performing the experiment. Several solutions can be found to anticipate (slightly) this disadvantage. We could think of a lab-assistant with whom students can communicate by the use of a webcam or any e-meeting system. Experiments in this field are described in [16]. The disadvantage is of course that such an assistant is only available during office hours. Other possible solutions are creating a workspace with FAQ's, starting msn-like communication for students to be able to help each other and building in more help suggestions in the system itself.

6 FURTHER RESEARCH

As the investigations were performed with a limited number of students we only have preliminary answers to our research questions. Further research is needed with larger groups of students. With this research more emphasis can be laid on the factors that might influence the appreciation, like educational context, possible earlier experiences with distance learning, background of students and their expectations about their education. Also it is interesting to find out whether improvements on the systems influence the ratings that students give for the different items. In interviews more suggestions can be asked to cope with the problem of the need for instant answers to questions that rise during the execution of the experiment. As mentioned in section 4 a renewed survey for the communication means and other web-based support for IPD-projects is needed in the near future.

In the "Labs-on-Line" project [2], initiated by the *Digitale Universiteit* the ambition was to create a model for remote experimenting that could grow into an (inter)national standard for online labs. The latter might have been "one bridge too far", but a lot of the objectives of the project have been realised by now. However the *Digitale Universiteit* has ceased their existence and we are looking for a platform to continue the community of institutes that use, support and maintain the online lab experiments. When this community grows more experiments on each others' sites can be carried out and more data comes available in order to determine the appreciation of students and to continuously improve the quality of these courses. Performing IPD-projects with partners abroad can be simplified a lot in this way. Interested parties are encouraged to contact us!

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