PROJECT HANDOVER IN UNDERGRADUATE PROJECTS - EFFICIENT HANDOVER FOR INCREASED LEARNING OPPORTUNITIES

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ABSTRACT

In this paper, we describe a method we have employed at the University of Bristol to improve the undergraduate project experience. We describe the methodology we employ, which consists of a pre-built environment, close supervision by a senior student, and compiled reference material. We then compare the methodology with its absence using the frequency of undergraduates publishing as our metric. We observe a noticeable increase in the number of undergraduate publications under the new methodology, as well as a number of unexpected benefits for the students.

Index Terms— Education, Undergraduate Project, Electronic Engineering, Hand-Over

1. INTRODUCTION

Most, if not all, universities employ long-term project work as a key aspect of their undergraduate degrees, especially in the Science, Technology Engineering and Mathematics (STEM) degrees. While standalone or disposable projects can and do occur, they are often contrived and over-simplified, lacking the depth required to give a student insight into the real challenges present in their subject area. This leaves the student ill-prepared to succeed in their chosen discipline, failing to meet many important learning criteria that many employers seek from universities. Therefore, a large number of projects are ongoing pieces of work to which a student will contribute a component, thereby satisfying the project criteria. This project, with the added component, is then passed on to an undergraduate the next year for addition of another component.

Previous studies have examined the undergraduate project experience as a standalone piece, such as in [1, 2], where they consider the benefits of project work as opposed to other forms of work and [3, 4], where they consider the experience itself and how it may be integrated into the curriculum. Some have even suggested methods of improving the undergraduate project experience, such as [5] which suggests the inclusion of significant amounts of group work and collaboration even on disparate projects. However, none consider the impact of a project being passed between students year-on-year, and how the methodology behind this transition can harm or assist a student's learning opportunities and outcomes.

In this paper we will describe the methods we have implemented on a selection of students at the University of Bristol in order to make the initial stages of their projects more efficient so that they learn and achieve more in the limited time frame available to them. We will do this by first explaining the extra support we supply to our students, and then using those students as a case study to examine the effects, compared with students from previous years who did not receive this extra support.

In the following section, Section 2, we describe the lead-up to the study and the question we want to answer. This is split into Section 2.1, where we describe the observations made prior to the start of the study, Section 2.2, where we describe the problems we perceived to occur in undergraduate projects, and Section 2.3, where we describe the solution we believe will fix these problems. After that will be the Methodology section, Section 3, where we describe the exact methodology of our experiment, including the test setup in Section 3.1, the prepared materials in Section 3.2, and the work done during the experiment in Section 3.3. Then, we show our results in Section 4, with the baseline results appearing in Section 4.1 and the subsequent results in Section 4.2. Next, we discuss the observed results in Section 5, which is finally followed by the conclusion in Section 6.

2. HYPOTHESIS

2.1. Observations

While supervising projects in the Department of Electrical and Electronic Engineering at the University of Bristol, in particular undergraduate projects that had significant history behind them (i.e: they had been continuing for a long time and a substantial amount of development work had been carried out), some recurring observations have been made.

Students participating in these projects often experienced significant difficulties in operating the hardware they were given. This came in many forms, from difficulties providing supporting hardware such as power supplies and understanding communication protocols, to difficulties learning the development tools and APIs used to operate the hardware. These were recurring issues where the supervisor would already know the solution as previous students had encountered the same problem. However, they still cost significant time as the student would try to solve the problem themselves before asking their supervisor.

Also, students would often experience issues with the distribution and collection of data. For example, for hardware aimed at solving signal processing problems, most students would experience difficulty getting signals in and out of the hardware, all eventually discovering similar, if not identical, solutions to the problem after spending significant time on the issue.

Finally, a large number of students would find themselves struggling to find the correct documentation to answer their questions about aspects of the hardware they had been given. This information would often be spread across multiple documents, require some prior knowledge to understand, and also be hidden behind some inferences. While most students either found the answers or asked their supervisor for help, they all spent significant periods of time on this.

2.2. Perceived Problem

Having observed students spending large periods of time on the same problem year on year, we became aware of this as an inefficiency in the learning process. Many of these problems provide insignificant learning experiences for the student compared to the time invested, and so we came to question whether we could improve the experience by solving these problems preemptively, or at the very least make the answers quicker and easier to find.

For the issues students had with operating the hardware, we questioned whether we could collate the information needed to operate the hardware in such a way that the student would still experience the same learning process, but without investing the same periods of time into the process. In such a case, the student would then have more time to pursue other learning goals and further develop their project.

For the data distribution and collection issues, we questioned whether we could provide pre-built data distribution and collection systems to reduce the time the student spent on this area without significantly affecting the learning process. In such a case, the student would have more time to focus on the core of the project (which may involve the creation of novel algorithms or hardware) and hence improve the learning experience and achievements.

For the documentation issues, we also contemplated collating the documentation and re-writing it in a form more useful to the students, highlighting the points that are most significant, spread across multiple documents or require some form of inference to arrive at. With these materials, we suspect the student would spend less time searching for the correct documentation on a topic, and more time developing the core of their project, once again enhancing the learning experience.

2.3. Suggested Solution

In order to solve the problems highlighted above, we suggest that the following additional resources should be provided to the students. If these resources are provided to the students, then we expect to see a significant increase in performance from the students with access to these resources.

First, we suggest that a pre-built platform be provided to the students. This platform should include all the tools installed with known versions and in tested working order. By providing the pre-built environment in a ready-to-use state, the student will spend less time troubleshooting the tools and more time on the core of the project.

The pre-built platform should also include some ready to use example applications which include data input and output. This will allow the student to quickly start operating the hardware and experimenting with various components to examine the system's response to changes. The increased pace of this experimentation stage should allow the student to more quickly move on to the development stage of their project, thereby increasing the student's performance.

There should also be some compiled information on key aspects of the platform provided to the student. The key requirements behind these should be that they have answers to the common issues experienced with the hardware, as well as references that can effectively guide the student to the correct pieces of original documentation for specific, unique issues they may encounter.

Finally, there should be close supervision by a person who knows the hardware well and has been in contact with previous students and seen the issues and solutions previous students have met and developed. The presence of this supervisor will allow the student to pass mundane issues quickly and hence quickly encounter the aspects of the project that involve beneficial learning experiences. For this purpose, we suggest the use of a PhD student in the same area, as they are generally less busy and more numerous than the main supervisor of the project, and so can more closely follow the student.

3. METHODOLOGY

3.1. Test Setup

For the testing of our ideas, we selected to use a baseline measurement of projects we have supervised prior to implementing our solutions. These projects are all of those that we have supervised that ended more than two years prior to this paper (ended on or before the summer of 2015). During the year leading up to the summer of 2015, we prepared the materials required to collect our subsequent measurements. The following two years, leading up to the summer of 2017, are the years from which we collected our subsequent measurements.

As our dependent variable, we selected the rate at which the students published papers. If a student is able to publish a paper at the end of their project, this implies that they have made a significant development in the field and hence the learning experience has been significant for them. If we observe a large increase in publication rates, this suggests that more students are getting enough out of the project to publish, and hence the average value of the project has increased.

3.2. Preparation

The materials prepared for the experiment were as such: First, we trained a student on the platform that we would be using for the experiment, the Texas Instruments Keystone II processor, contained within the 66AK2H12 Evaluation Module. This platform exhibits all the necessary traits to be able to benefit from the aforementioned improvements: the platform is complex enough that the initial setup is not trivial, the data input and output requires some detailed knowledge of one or more of the interfaces available on the system, and the documentation is split across multiple documents, sometimes requiring cross-referencing and inference to obtain the answer to a problem. This student then assumed the role of the close supervisor with knowledge of the hardware.

Next, we compiled information on the key aspects of the platform, including the initial setup, available APIs and interfaces, data import and export, peripherals and development tools. This information took the form of a book, "Multicore DSP: From Algorithms to Real-time Implementation on the TMS320C66x SoC" [6], authored by Dr. Dahnoun. This book contains details of two digital signal processors, the 66AK2Hxx, and the closely related TMS320C66xx, from which the book derives its title. Sections of this book were given to the students to assist them during their projects, so they had reference material that focused on the key points of the system, as well as showing them where to look for more detailed information on a topic.

Then, we generated a pre-built environment in which the students could perform their development. As it was the most reliable and efficient method of generating identical environments for many students, we decided to make use of Virtual Machines (VMs) for this purpose. A VM consists of the definition of some virtual hardware, along with the contents of one or more virtual disks. On these virtual disks, we installed a known version of all the tools the students would need, alongside working examples which sent data to the platform, performed some processing on the data and returned the processed data to the source, the VM. The examples we provided implemented, amoung others, an FIR filter and an FFT, as these are common algorithms to be performed on signals and the FIR is the core of most other signal processing algorithms.

Figure 1 shows the software and hardware setup, with the student only changing the dataset and application sections for their project. The boilerplate sections are pieces of code that the student does not need to change and is there purely for the purpose of managing the hardware and transferring the digital signal in and out.

As the virtual disks and virtual hardware definitions were the same for all students, we could be sure that all students were given the same starting point. Also, as we knew the exact tool versions, not only could we easily duplicate results ourselves, but we could also advise the students on the operation of the tools without concern for the exact setup of the student's computer. Finally, the working examples served as starting points into which the students could insert their code which was the core of their projects.

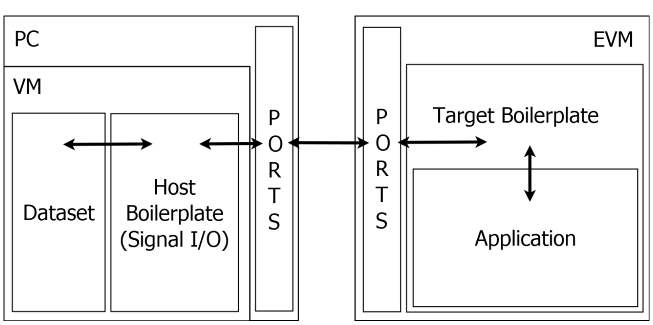

Fig. 1. The hardware and software setup provided to the students.

3.3. Implementation

Once the undergraduate projects that would undergo this altered methodology started, we closely monitored the progress of students who had been given the pre-built environment and extended documentation. The close supervisor spent their time working in the same lab as the undergraduate student and regularly interacted with this student, asking the student about their progress, current issues and future plans.

Where appropriate, the supervising student provided suggestions to solve issues from their own knowledge of the platform, including issues that they or other students had experienced while operating the platform. Where appropriate, the supervising student also guided the project student to the correct documentation so that the project student could quickly find the correct answer to their issue without being told the answer immediately (thereby maintaining the experience of problem solving that is an important component of these projects).

As the students neared the end of the project, if they had developed their ideas to the point where they had something publishable, they were encouraged to do so. This was decided on the same standard as before the implementation of the new methodology, so that any increase in paper publications could be attributed to an increase in the quality of the projects.

4. RESULTS

4.1. Baseline Readings

Prior to the implementation of the new methodology, paper publications were rare. As was already explained in Section 2.1, the students spent a large portion of the project time solving mundane issues with the hardware, resulting in significantly less time spent on the core of the project and hence fewer projects worthy of publication. For example, for projects beginning in the fall of 2012 and ending in the spring of 2013, there were only two publications [7, 8] from 4 students. For the years from the fall of 2012 to the summer of 2015, the percentage of project students publishing papers were 50%, 0% and 0% from 4, 4 and 5 students respectively.

4.2. Subsequent Readings

We have collected data from two years' worth of project students, from the fall of 2015 to the summer of 2017. In these two years, the paper publishing rates have been 75% and 63% respectively. For the year of 2015 to 2016, the papers published were [9, 10, 11], with 3 out of 4 students publishing. For the year of 2016 to 2017, the papers published were [12, 13, 14] with 5 out of 8 students publishing. Of particular interest were [12, 13, 14], where the students were using a different platform from the one for which we had developed a pre-built environment, and so only benefited from the access to a knowledgeable close supervisor and collated information (due to the supervisor's experience with the platform on which they were working).

In addition to the primary method of measuring results that we had selected, we also noticed some other beneficial effects. For the year of 2015 to 2016, the three students who underwent the altered methodology and published papers were all accepted for Masters' degrees at Cambridge, something that had rarely occurred in previous years. Further to this, one of the students was given funding to continue on to a PhD at Cambridge, while another was accepted for a PhD at Cambridge under their own funding. This decision was influenced by the publishing of a paper and the increased student excellence from participation in the test.

Furthermore, students who underwent this methodology have experienced increased opportunities outside the university. One student who had access to the close supervisor was requested for consultation work with a company involved in high performance communications, while another student was selected to work in various projects on next-generation personal-area network technologies.

5. DISCUSSION

As can be seen from the results presented in the previous section, there was a significant increase in the number of published papers under the new methodology. This occurred despite no significant changes in Departmental policy that could have affected this result. Not only this, but we have also observed other benefits during the course of the experiment which further suggest that the students are benefiting from the altered methodology.

Unfortunately, due to the long time an undergraduate project takes as well as their infrequency, we do not have as much data as we would like. When we include the number of students in the 2016-2017 year that did not use the platform and instead only made use of the close supervisor, we still have very few students on which to base our conclusions. While the differences in that small number of students are significant enough that we can reasonably conclude that it is not due to random variation in our sample set, we would like to have more students with which to verify our results, particularly in regards to quantifying the benefits of the various aspects of the methodology. Our results so far are mainly qualitative in that there is a clear improvement from the data, but we cannot be sure how much of an improvement occurs.

6. CONCLUSION

In conclusion, we noticed some issues with the undergraduate project experience, and have implemented a new methodology to help undergraduate students past the time-consuming parts of their projects so that they might spend more time on the core of their project and achieve better learning outcomes. We achieved this by building an environment in which the students could quickly get started using virtual machines and example applications containing fundamental signal processing algorithms, providing close supervision by a senior student, and compiling reference material for the student that highlighted key points about the platform and pointed to the correct documentation for specific details.

We evaluated our methodology by first taking baseline readings from students which did not have this methodology applied to them. Then, we applied the methodology to two years' worth of project students and observed noticeable increases in the number of publications from the students, which indicates that the methodology is indeed benefiting the students. Also, we observed other benefits for the students that experienced the methodology which were initially unexpected. We concluded that we have obtained promising results that indicate our methods benefit the students.

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