

Impact of an e-learning Platform on CSE Lectures

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ABSTRACT

This article presents a comprehensive summary and recommendations towards the use of IREEL, an e-learning platform designed for network studies in CSE courses, based on our hands-on experience in a large hybrid undergraduate/postgraduate course at the UNSW. We found that the tool was well received by the students for understanding key concepts, especially when compared to legacy tools used in labs. Furthermore we show that our tool was able to handle a very large number of experiments in a relatively short amount of time.

Categories and Subject Descriptors

K.3.2 [Computers and Education]: Computer and Information Science Education

General Terms

Experimentation, Performance

Keywords

CSE lecture, e-learning, Networking

1. INTRODUCTION

During the last decade, general knowledge of networking and internetworking in particular has become a basic component of the many engineering courses, ranging from pure CS courses to aeronautical engineering through electrical engineering. In this context, when teaching introductory or advanced networking subjects, lecturers face the difficulty of illustrating both the concepts and technologies, and assessing students from various backgrounds. This illustration phase is usually implemented in the form of laboratory classes, where students use a variety of software tools to experiment on various networking scenarios and observe the protocols studied in the lectures in action. While different solutions may be used for different course levels, it is desirable that

such tools allow the experimentations of both basic and advanced networking scenarios. This would offer a degree of consistency and ease the learning curve across a 3–4 year engineering degree. Similarly, the tools used in the assessment phase need to allow the fair evaluation of students in the presented key concepts. For example, the classical client server based programming assignment from most introductory network courses [10] might not be suitable for students with limited programming skills (*e.g.* some undergraduate engineering programs do not have compulsory programming courses).

In order to address student diversity, lecturers have often developed tools and labs based on research tools. Among these tools, two kinds of approaches may be identified; simulation-based such as ns-3 or OPNET [1, 5] and real measurement-based in closed lab settings such as tcpdump or wire-shark [4]. The first offers a large panel of experiments but suffers from the models on which the studied protocols are based. The latter method allows students to get a more realistic experience but the associated labs are difficult to maintain and cannot be repeated once the lab is finished. Lately, a third option has been made available through the development of large-scale testbeds and in particular with PlanetLab [2]. Nevertheless, this kind of approach does not offer a general enough abstraction to be used by students with little knowledge in programming as demonstrated by the implementation in Plush [6] and Seattle testbed [3].

In [7] and its second version in [8], we have proposed a novel approach for teaching networking in undergraduate and postgraduate courses called IREEL¹. This solution originally provided an e-learning platform where students followed labs' description that recalls the lecture and then had to configure experiments to answer related questions. The originality of IREEL consists in offering the ability to run real experiments whilst conserving an easy to use interface. While the two versions of IREEL provide the same basic functionality to the student, the second version [8] offers more flexibility to the instructor. Indeed, we have integrated a state of the art testbed control and management framework called OMF [12] and its companion measurement library OML [13].

During the second semester of 2010, we used IREEL for an hybrid undergraduate/postgraduate introductory course on networking at the University of New South Wales, Australia. In this course, the IREEL platform has been used during two labs whilst the remainder of the lab set used the

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¹The current platform is available on <http://ireel.npc.nitca.com.au/>

Wireshark packet analyser. At the end of the course the students were asked to give an evaluation of both the UI and the teaching capabilities of the tool. The analysis of the students' use of this tool shows that it was able to reach a very high robustness. Furthermore, the evaluation forms showed that the tool was very well rated in terms of overall understanding of lectures key concepts and when compared to the Wireshark labs.

The remainder of this paper is organised as follows. Section 2 presents the methodology used in our study and in particular the details about the students and the course material. Section 3 gives comprehensive statistical analysis of the potential benefit of IREEL as seen by the students and also provides an overview of qualitative measurements of the e-learning platform. In Section 4, we discuss the implications of these results in terms of usability of the platform in an introductory course to networking and as a stand alone tool. Finally, Section 5 concludes this paper and presents some potential future works.

2. METHOD

We used the IREEL platform in a hybrid postgraduate/undergraduate course offered by the School of Computer Science and Engineering at the University of NSW, Sydney during the second semester of 2010. This course, entitled "COMP 3331/9331, Computer Networks and Applications", provides an in-depth overview of computer networks and the Internet. This is a core course for the Software Engineering and Computer Engineering Undergraduate programs and also for the Networking major under the Master of IT postgraduate program.

However, students from various Engineering programs including Computer Science, Bioinformatics, Electrical and Telecommunications Engineering, Mechanical Engineering and Information Technology also enrol in this course. This course has an assessable lab component which makes up approximately 10% of the total course mark. The labs were designed such that students could get a hands-on understanding of the various protocols discussed during the lectures. There were a total of seven lab exercises of which five labs used the Wireshark sniffer [4] to observe pre-recorded packet traces. The remaining 2 lab exercises used the IREEL platform [8]. The aim of the first IREEL lab was to illustrate the behaviour and the evolution of the HTTP protocol. The second lab focused on explaining the basics of reliable data transfer over the network. At the end of the semester, after the conclusion of all lab exercises, students were asked to fill in a written questionnaire to provide feedback on the UI and effectiveness of IREEL as a learning tool.

2.1 Participants

A total of 103 undergraduate and 59 postgraduate students were enrolled in COMP 3331/9331 during semester 2, 2010. Out of these students, a total of 63 students consisting of 41 undergraduates and 18 postgraduates completed the evaluation questionnaire. The students in the sample ranged from 19 to 30 years of age of whom 7 were female and 52 male.

The students were divided into 10 lab classes each containing approximately 16 students. Students worked on the labs in pairs. Each lab class lasted for 2 hours. Six labs took place on Tuesday in 2 hour slots from 12pm–8pm. Two parallel labs were held from 12pm–2pm and 2pm–4pm. Four

labs were held on Wednesday with two sessions in parallel running from 12pm–2pm and 2pm–4pm. The answers to the lab questions were only due in the following week. Thus students could run experiments outside lab hours via the IREEL web interface, which was always accessible.

During IREEL labs, students were teamed in pairs to address questions based on both theoretical background and live experiments. After receiving their marks on the two IREEL labs, the students answered the evaluation forms during a non-compulsory lab session.

2.2 Materials

2.2.1 IREEL Labs Description

The lecture was following a top-down approach [10] and therefore we decided to use our platform to illustrate two fundamental concepts from the lectures; the evolution of HTTP, referred to in the following of the document as the first lab, and the illustration of Reliable Data Transfer, referred to as the second lab in the remainder of this article.

During the first lab, students, after a reminder of the lecture, were asked to analyse the difference in the performance of the two versions of HTTP (1.0 and 1.1). The experiments consisted of downloading several HTML pages with a varying number of embedded objects using the two versions of HTTP and comparing the total end-to-end delay. Overall, in this lab, students had to configure and analyse the results of 13 experiments.

In the second lab, students analysed the performance of different reliable data transfer; Stop and Wait, Go-back-N and Selective Repeat. In this lab, the students were able to analyse the effect of the retransmission time-out based on the end-to-end delay and the effect of the packet loss rate in the transmission of a stream of packets. During this lab, students had to configure more than 30 experiments. However, due to the randomness of the packet loss rate the number of experiments was expected to be greater.

2.2.2 Student Feedback Forms

After the two IREEL labs, students gave us feedback on the newly introduced tool. This feedback consisted of 11 questions rated using a likert-type scale [11] divided in two categories, "UI appreciation" and "learning capability and its comparison with other tool"².

In the first category, the students rated IREEL in terms of user interface, description of labs and questions and general navigation through the website.

In the second category, the students rated IREEL as an e-learning tool, in particular, for concept understanding, related lecture understanding, and whether it was an effective self-learning tool. Students were also asked to compare it to other labs in which they had used Wireshark [4].

3. RESULTS

In this section, we first present the quantitative analysis of the use of IREEL during the two aforementioned labs. Then we present the statistical analysis of the feedback forms.

3.1 Quantitative Factors

During the month IREEL was used, more than seven thousand experiments were configured.

²This form is accessible on <http://guillaume.jourjon.name/ireel.pdf>

If we compare this number with the average number of experiments run on the actual Orbit-lab testbed, we have, during a single month, run more experiments than what is usually conducted using OMF in the Orbit-lab in an entire year. This large number demonstrate the scalability of the platform.

Table 1 presents the experiment success rate summary, where an experiment is considered successful if the student received all the associated results.

Table 1: Quantitative data

	Total Experiment	Success Rate
1 st lab	1,959	100.0%
2 nd lab	5,434	97.9%
Total	7,393	98.4%

The previous table shows that the robustness of the platform is very high despite some error in the second lab. Furthermore we can verify that the students ran more than twice the number of experiments for the 2nd lab as compared to the first. As discussed earlier, the higher ratio is because of the requisite number of experiments to be done to answer all the questions. It is indeed higher than expected because of the reconfiguration of the failed experiments and the fact that some experiments were configured several times in order to obtain the correct packet loss rate.

Table 2 presents the average number of experiments done by each group of student as well as the standard deviation.

Table 2: Number of experiments

	Average	Standard Deviation
1 st lab	20.97	5.30
2 nd lab	60.14	14.84

As expected the number of experiments in the second lab was higher than for the first one. Overall, the average number of experiments for both was higher than the required number. This is explained by two factors; the failed experiment as shown in the previous Table and the fact that even if students were paired, we did not put any restriction on whether one or both students could configure experiments.

3.2 Qualitative Factors

In this section, we provide results from students' feedback rating. These results have been reformatted to be centred on 0 with a scale going from -2 to 2 with 2 being in favour of IREEL and -2 against it.

Figure 1 presents the first, second and third quartile of the eleven normalised likert-type scales [11]. On these normalised scales positive values are in favour of IREEL. For example, if the value is 11 in the case of *norm_spe_concept_vs* it means that the student rated IREEL as a better tool to understand specific concept compared to Wireshark [4].

Overall, the appreciation of IREEL is positive except for the self-learning components. In particular, the user interface components, with the exception of the overall interface, have a median value of 1 and three have a first quartile of 0.

Concerning the e-learning perception, students considered IREEL as an efficient e-learning tool by itself and compared

to Wireshark for teaching general and specific concept but did not find it as good a self-learning tool. This result is surprising especially as Wireshark is only accessible in labs whereas IREEL is available from anywhere, allowing students to go further and configure a larger range of experiments.

3.2.1 User Interface Factor

In Table 3, we present the mean values and the standard deviations of the user interface factors.

Table 3: UI appreciation

	Average	Std Dev
Result Analysis	.60	.834
Experiment Configuration	.27	1.066
Lab Description	.79	.919
Question Description	.75	.861
General UI	.02	1.198

Overall, IREEL received mainly positive UI appreciations. Nevertheless, students gave lower ratings to the general interface than to the other components.

3.2.2 Learning Perception

In Table 4, we present mean values and the standard deviations of the learning capability of IREEL.

Table 4: UI appreciation

	Average	Std Dev
General Concept	.41	1.186
Specific Concept	.60	1.238
Self Learning Tool	-.17	1.498
General Concept vs Wireshark	.41	1.433
Specific Concept vs Wireshark	.54	1.216
Self Learning Tool vs Wireshark	-.10	1.316

This table shows that, with the exception of its self-learning capacities, IREEL has been perceived as an effective tool to promote the student understanding of the general and specific concepts presented previously in lectures. In addition, this table shows that the students agreed less in their perception of the knowledge transmission faculty of IREEL than they did about IREEL's UI impression as confirmed by the larger values of the standard deviation.

3.2.3 Impact of the UI on the learning perception

In Table 5, we present the different correlations between the students' UI perception and their e-learning experience.

These results show a significant correlation between the general UI perception and the three comparisons to the Wireshark's labs and the self learning tool perception. Table 5 also shows that there is significant correlation between the lab description and the understanding of general and specific concepts when compared to the Wireshark's lab. On the contrary, no significant correlation was found between the perception of both experiment configuration and result analysis when compared to the e-learning perception.

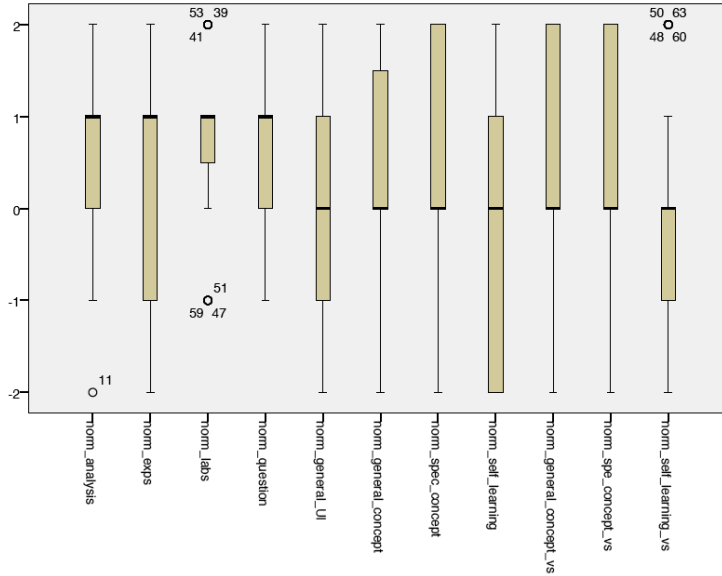


Figure 1: Overall quartiles of the different likert scales from the evaluation forms

Table 5: Correlation of Learning perception vs UI appreciation. (** Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed)).

		Analysis	Experiment	Lab Description	Question Description	General UI
General Concept	Pearson Correlation	.103	.102	.257*	.136	.188
	Sig. (2-tailed)	.422	.427	.042	.288	.140
Specific Concept	Pearson Correlation	.032	-.003	.310*	.252*	.243
	Sig. (2-tailed)	.800	.981	.014	.046	.054
Self Learning Tool	Pearson Correlation	.060	.202	.208	.253*	.361**
	Sig. (2-tailed)	.641	.113	.102	.046	.004
General Concept vs Wireshark	Pearson Correlation	.004	.063	.360**	.348**	.353**
	Sig. (2-tailed)	.973	.623	.004	.005	.005
Specific Concept vs Wireshark	Pearson Correlation	.199	.185	.419**	.272*	.371**
	Sig. (2-tailed)	.118	.148	.001	.031	.003
Self Learning Tool vs Wireshark	Pearson Correlation	.200	.295*	.250*	.220	.420**
	Sig. (2-tailed)	.116	.019	.048	.083	.001

4. DISCUSSION

4.1 On the quantitative metrics

The quantitative metrics, as shown in Section 3.1, indicate the robustness of the platform. Nevertheless, the few failed experiments may have contributed to some of the lower ratings in the evaluation. These weaknesses have been identified in the new version of IREEL and addressed accordingly. They were mainly due to a stack overflow error in the measurement server. This error only appeared in the second lab, as the results in the first lab consisted as a separated file and therefore the measurement server was not in use.

This error in the measurement server has been magnified due to the concentration of the labs. Indeed, as explained in Section 2.2, the ten labs being concentrated in the time span of two afternoons and the experiments not being pre-recorded, students in late afternoon labs suffered some delays when retrieving their experiment results.

These delays did not occur in the first lab mainly for two reasons. The first reason being the lower number of experiments required for the first lab (as shown in Table 2). The second and main reason is the natural learning curve of the students exposed to a new tool. Indeed, we found that when students were using IREEL for the first time, they spent a substantial amount of time reading through the entire description of the lab exercise before starting the experiments. During their first experiments, students waited to get results prior to configuring new ones. Therefore the experiment queue was rarely over ten experiments (*i.e.* about three minutes). During the second lab, students did not take the same approach and very quickly started configuring experiments after only briefly glancing through the lab description. Therefore, when the next lab started, the platform was still processing the queue of the previous lab.

In order to solve this problem, we recommend the lab instructors to limit the number of experiments to only fifteen per group as it seems to be efficient in the first lab. An-

other solution to this problem would be the introduction of reservation following the schema developed for OMF [9]. Finally, based on our experience, we do not recommend to use this platform with such a concentrated schedule unless the lecturer is able to expand the computation resources available beyond the default configuration of a single client and server.

4.2 On the evaluation forms

The evaluation forms gave us some important indications about IREEL. The main finding of these forms is the students' perception of the teaching capabilities of this newly introduced tool. As expected, students gave high ratings to our e-learning platform for concept understanding as a whole and when compared to the Wireshark's labs. In the comparison cases, it seems, based on the correlations with the lab and question descriptions, that the organisation of the lab on a single web page has been well received and helped the students to identify the concepts the labs were meant to emphasise.

The most surprising finding of the forms concerns ratings of our platform as a self-learning tool. Indeed, since our platform is a web-based e-learning platform which is accessible anytime and from anywhere thus providing students a longer hands-on time and more flexibility with the tool, we expected to receive good feedback for the self-learning aspect.

In order to explain this finding, we propose two hypotheses. The first is linked to the correlation between the general UI interface and the self-learning tool ratings. As shown in Table 5, there is a significant correlation between these ratings, which could be due to a lack of separate IREEL manual instead of online documentations and online how-to.

The second hypothesis to explain students' self-learning appreciation is related to the way students marked our platform when compared to Wireshark labs and can be called a "Google effect". This proposed effect concerns the tendency whereby students may not read online document or manual but go directly to Google or other search engines to find similar labs to answer the questions. Indeed, even if we consider Wireshark as a good teaching tool, we may not also consider it as a effective self-learning tool as students usually cannot modify the underlying network topology nor redo the experiment once the lab is finished. The main difference between the two tools resides in the large community of Wireshark users and therefore it was considered more beneficial for the student to compare what they were asked to do with what other students or researchers did using this tool.

In order to improve the self learning aspect of our platform, one solution, in addition to provide an off-line manual, might be to allow more modularities to the student. For example, we could not specify all the parameters they need to configure and instead give them a range for each of them.

5. CONCLUDING REMARKS

Based on both quantitative and student-opinion based metrics, we have presented a comprehensive, and exhaustive, study of the IREEL e-learning platform. Based on the quantitative data we obtained, we found that our platform is robust even when stressed to a very high degree, for example we conducted nearly 5500 experiments in less than a week. We have also been able to better quantify the number of experiments to configure in a span of 2 hours in order to

give a better quality of experience to the students and thus avoid multiple configurations of the same experiment.

The analysis of the evaluation forms was very positive overall, as the students rated that our platform was more effective to promote the understanding of specific and general concept than Wireshark-based labs. Nevertheless, students did not rate it as highly for a self-learning platform. We hypothesised that students might have found Wireshark to be a better self-learning experiences because they were able to compare their experience with this tool with other Internet users.

We plan to reuse this tool in the second semester of 2011 in a similar class environment. This would provide further support for the proposed "Google effect" hypothesis. Furthermore, we plan to use this platform in a more advanced course where the students will have to develop their own protocols and test them through the web interface using the next generation of IREEL based on the OMF portal [9].

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