Connecting Undergraduate Students as Partners in Computer Science Teaching and Research

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It is all too easy for students to see only the classroom and the PowerPoint face of University; many imagine that their Lecturers have long vacations and remain unaware of the research behind the scenes. This leads to the false dichotomy of teaching and research at University. Such Firewalls between teaching and research are unhelpful and under increasing challenge. We have argued elsewhere (Gordon and Brayshaw, 2008) on the importance of student-led enquiry based learning in Computer Science, linking research to teaching; connecting undergraduate students as partners can lead to an enhancement of the undergraduate study experience and allow students to see other sides of the university. Such holistic perspectives may better inform academic career choices such a Postgraduate Study and academic career aspirations. Furthermore, involvement in teaching and course development has many potential benefits. Such involvement may be in the form of peer mentoring of fellow students or the use of advanced years teaching in lower year laboratory based classes. This paper will consider these, such as the importance of peer-to-peer interaction and the impact of the different power structures that it enables. Three case studies involving students at 3rd year project, undergraduate intern, and MSc Project Level will be used for illustrative purposes. All three case studies have actively involved students in core parts of the Universities teaching and research activities, producing usable software systems to support these efforts. We see this as a continuing engagement process to enhance the undergraduate learning experience.

Introduction

So what do you do for the rest of the year?

There is a long standing issue of Orwellian doublethink that concerns universities – are they teaching establishments or places of research? This often boils over in frustration when as research active staff you are asked "Do you just do the job for the long holidays?" A key element to all this is showing students that there is more to University than lectures, libraries, laboratories, and undergraduate learning – it is important in there general education to give them a more holistic model of the institution they are attending. This story is complicated by the Orwellian doublethink that Universities are both a place whose principal activity should be teaching whist at the same time maintaining the view that their principle activity should be research.

Generalising from what they know from a school context undergraduate students often think that once teaching and term time is over then the job is essentially done.

Clearly one highly successful route through university a university journey is to have a great time, get a great degree, find a super job, and earn lots of money. However there is another, equally valued, route that involve taking a higher degree and leading to a university based career. The importance of seeing the research side of the University is one that should be shown to undergraduates leading to an understanding of what University research is. Research is a word that can mean different things on different levels – your can research the best way to boil an egg, or use can use google to research a high school essay – these activities all fall under the common understanding of research. Undergraduates oftern cannot see beyond these searching/foraging for existing knowledge activities. The common definition of research for many is the collection and assembly existing knowledge to fulfill the acedemic assessment requirements they are challenged with. That their Professors/Lecturers are "researching" over the summer is anecdotallly reported are finding out more stuff to teach them and travelling to do so. There is clearly a need to show the true side of the story and the other definitions of "research".

Connecting Teaching and Learning

Teaching and Research can be partners – particularly when then goals of the reearch to be undertaken is of a pedagogic nature. Engaging students in the process of improvingng course content, student experience, and delivery experience and one way of delivering this approach. This can be done in actual context of a live course. The research can be contemporaneous with the course delivery and studemts can be instumental in the design and implemenation of this change. Action research (Carr and Kemmis, 1986)) makes students active agents in the change process – it works as follows. A traditional scientist identifies a set of dependant and independant variables, they then devise a series of perturbtaions to those variable, and then, from the point of view as a detached oberver, watch how those variable behave. However those variables can also be watch from inside the process of change. This is Action Research. A particular application of this work in education is by Freire (1938) who tried to break down the classic teacher-student barriers and reform power relationships between the two. New students shoud not be seen as empty vessels to be filled with knowledge by the teacher but as the student and the teacher are both co-learners. His approach lead to Participatory action research which aims to involve all participants as co-researchers – an esessentially fluid process where input and prior knowledge and experience is egually valied from all those taking part. The learner is an agent of change and able to their future world.

Peer learning (e.g. Boud et al, 2001) is another shared activity that can be supported by collaboration; but this is an activity that needs to be managed. Students in the classroom – both undergraduate and postgraduate can add a great deal to the student experience. However the nature of this peer interaction is a varied one. However what constitutes peer learning can be a very varied experience (Goldschmid and Goldschmid, 1976; Griffiths et al 1995) and may involve, for example, senior students (or post grads or staff) helping juniors,

same year partnerships, buddy schemes, group work, study/reading groups, peer assessment, or community activities. As we noted above sometimes the teacher-student relationship can often put some students off asking questions or seeking help, either by not wanting to sound stupid, or being diffident in approaching their lecturers/professors. Fellow students a bit further on in their course or post-graduate students do not come with the same baggage and my therefore be more approachable. Indeed because of the often recent experience of learning the very same material they may way have insights and advice the is highly relevant and a long forgotten experience for those who are teaching. Undergraduate student can take an important part in both teaching and learning in Computer Science labs as well as running peer-on-peer support groups and self-improvement groups. There closeness to the learning experience themselves can be a valuable insight to those that follow. When teaching is the context of the research being undertaken there contribution is again of most value.

Enquiry Based Learning and Teaching Computer Science

Enquiry Based Learning (Vygotsky, 1934; Bruner, 1961; CILASS, 2016) is where learning is undertaken by the student in a self-directed manner – not in a directed chalk and talk style. The nature of the task or problem is open – there is not a strict or single way of solving it. Through the efforts of their enquiry they must learn the nature of the problem and what methods of exposition and solution they can use. Central to this approach is self-analysis and critical thinking. The teacher acts like a research supervisors, not providing solutions but acting as a facilitator to their students' progress. Enquiry and research can be done on many levels – the vocabulary and what research means will be very different from a first year undergraduate to that of final year or indeed a post graduate. They all can research and enquire but at levels appropriate to the level of development using the concepts that they currently have acquired. Enquiry Based Learning allows students to be partners and fellow explorers in the learning space. Indeed it empowers them to be fellow researchers and learners in their own right. We have argued elsewhere that Computer Science lends itself to this topic --- indeed this is often what neophyte Computer Scientists do naturally of their own accord (Gordon and Brayshaw 2008).

Flipped Learning and New Partnerships

Another new model of learning the breaks down the barriers of classical classroom based teaching is Flipped Learning where students study new material by themselves, e.g. at home and then work on project and groups tasks in the classroom. The Flipped Learning Network (FLN) (https://flippedlearning.org/) define it at

> *"Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter"*

In the context of connecting undergraduates as partners in teaching it clearly breaks down the type of unhelpful issues Freire (ibid) raises. The dynamics interactions can be used as the

starting point of collaboration. However if it is to be successful then the partnership has to be of a certain type. The teacher has to act more as a guide and facilitator, providing feedback and flexible assessment the FLN argue – just leaving it to the dynamics of the classroom without the professional input of a teacher will not bring success by itself.

Where to Use New Partnerships

The notion of Connection is one of engagement throughout the student journey. Indeed it can start from the initial point of contact – the initiation of the contractual bond between student and university. In the past we have used community websites (http://www.wherewouldyouthink.com/) to provide a continuous link from Open Days, through the course of the student journey, to an alumni source of information. That bond can be a partnership relation that starts from a school encounter to reach through to graduation and beyond. Enquiry based and Flipped Learning provide new mechanisms in which in connect and engage in new partnerships.

You can look to use this collaboration is various parts of the journey, for example we use at Hull undertake the following:

- Enquiry Based Learning Sessions from Year One onwards
- Project Based Sessions (UG and MSc): Case Study One and Three.
- Student Internships (Year Long – e.g. embedded within a research group where they can be attached for a longer period and take on larger projects):
- Short Summer Internships: where they can undertake small projects with the research groups: Case Study Two

The case studies will illustrate some of these activities.

Three Illustrative Case Studies

Case Study 1: A Pedagogically Motivated Inquiry Based Tutor for C#

Learning by being told is a classic method of instruction and this has been used in many tutoring systems for learning programming languages e.g. The Lisp Tutor (Anderson et al, 1984). This model clearly shows the classical roles of teacher and student. Traditional Socratic dialogues can then be, augmented with classical models of misconceptions (e.g. Anderson and Jeffrey, 1985), to teach and debug the students learning. The teacher directly instructs the student. It also assumes that the teachers model of the world is a superset of the tutees which is not necessarily true (Moyse and Elsom-Cook, 1990). An alternative method, and one that make use of enquiry, is to let the user explore via discovery (Papert, 1968). This work aimed to let students explore a rich world and by exploring it to discover things about it. The notion is that if you acquire new knowledge by extending your existing mental models and vocabulary you will truly understand the new thing that you have learnt. This work should be viewed in context with contemporary chalk and talked approaches or ones emphasizing strong learning by associated, e.g. programmed Learning (Skinner, 1965). This seems like an idea world providing that students discorded what you hoped they would and in the time that you have allowed. It also assumes bright and motivated students to do this. As a pragmatic compromise Elsom-Cook

(1990) proposed Guided-Discovery Learning where the student is guided into making the appropriate discoveries so whilst learning in their own context, mental model, and vocabulary this could be ordered, structured, and time factor included. In the above context, and synthesizing ideas from Enquiry Based Learning, Butterworth and Brayshaw (2014) produced a C# Tutoring System first the first 20 hours of a First Programming Course. The student wrote the whole course themselves, drawing on the experience of others who had designed first programming courses. The very act of writing your own first programming course for the first year naturally raised may design and structuring issues. A guided discovery rationale for the delivery of the material was adopted. The following snapshot shows a typical tutorial screen.

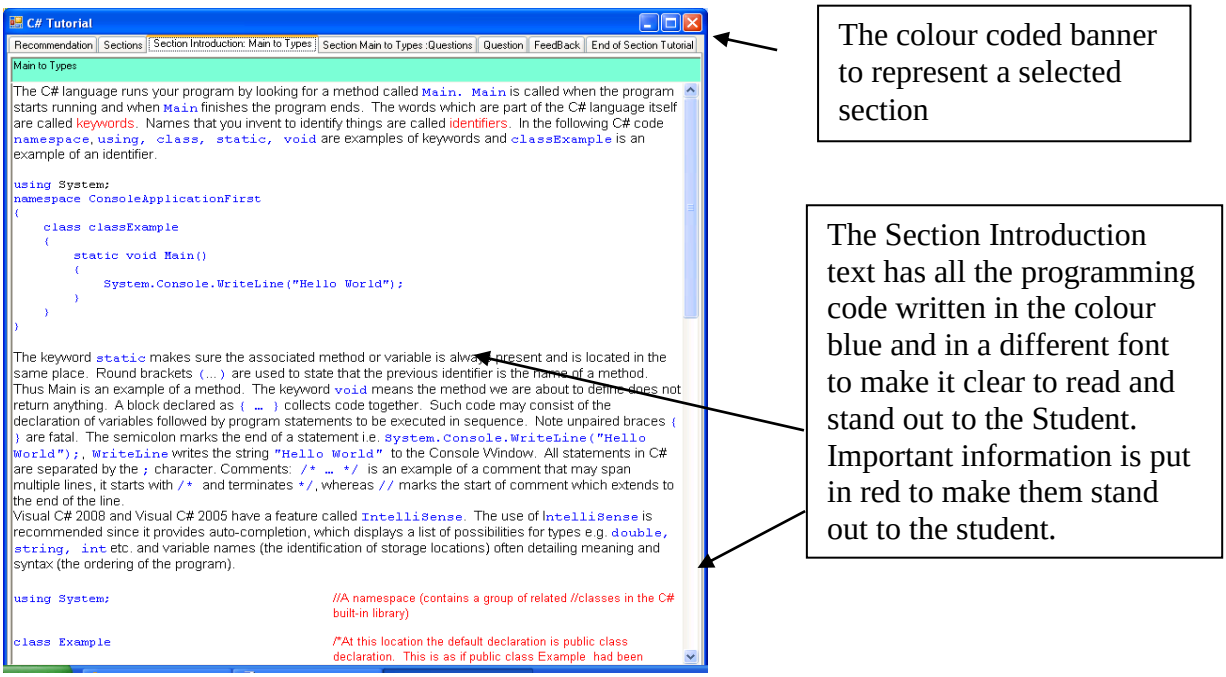


Figure 1 Material from the C# tutor. All the material and the presentation was designed by the student.

In addition to Student Designed Curriculum it soon became apparent about the role analytics can take in course design and delivery. To this end a Student Designed Management and Analytics was implemented as shown below.

Work Evaluated using Heuristic evaluation. The Experts used in the evaluation were Lecturers who had experience of delivery computer programming courses at Undergraduate Level. On the basis of these evaluations a new revised version of the C# Tutor was implement. The heuristic evaluation was reported along with two other PhD evaluations (Brayshaw et al, 2014))

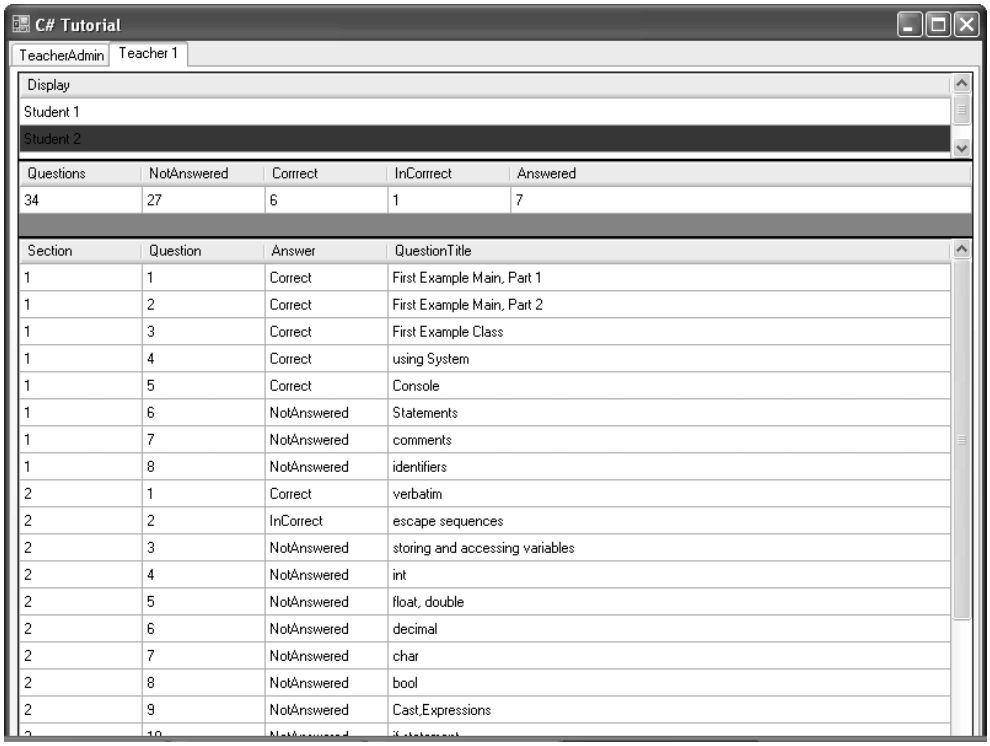


Figure 2 Analytics to show the students progress with the material and how this view could then provide teacher's with insights into progress

Case Study 2: Learning and Gaming in Media Enriched MOOC

For the second Case Study we developed a MOOC that we then used on our second year Undergraduate AI course and subsequently evaluated. A key feature was to exploit the potential the MOOC provided in terms of media delivery of the course and to include elements of gamification into the course. Gamification is the inclusion of elements that have game dynamic like properties like scoring, puzzles, or fun tasks. The system was implemented in EdX (ref). The basic screen is shown below. The main topics in the course are shown down the left (the course itself was already written) and thus presented a navigation bar. Here we see a snapshot mid-way through an exercise where the student is required to click on the stopping condition of the recursion.

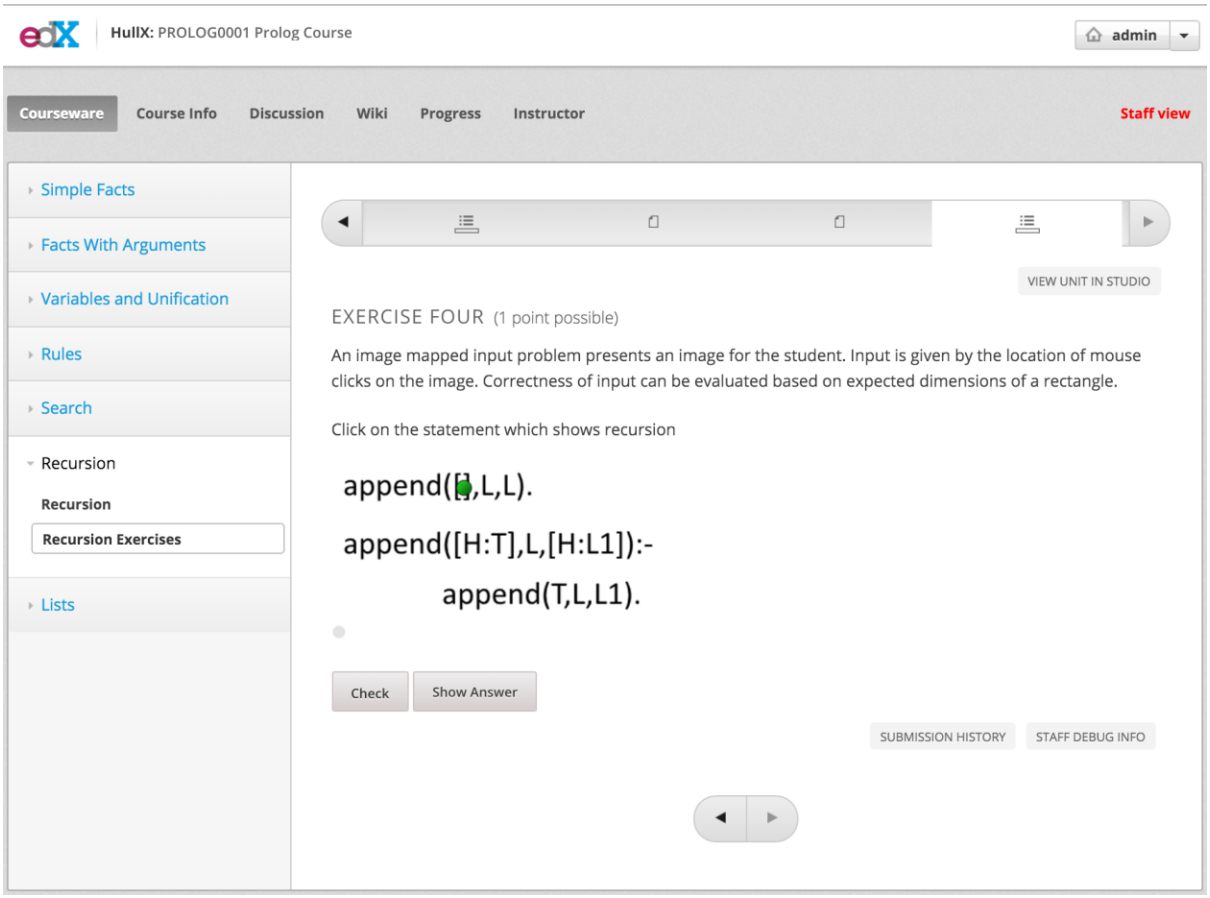


Figure 3 Brayshaw and Balaghan showing the navigation bar on the right to element of the Introduction to Prolog course and a sample exercise taking place on the right hand side.

Media Enriched Using YouTube Animations

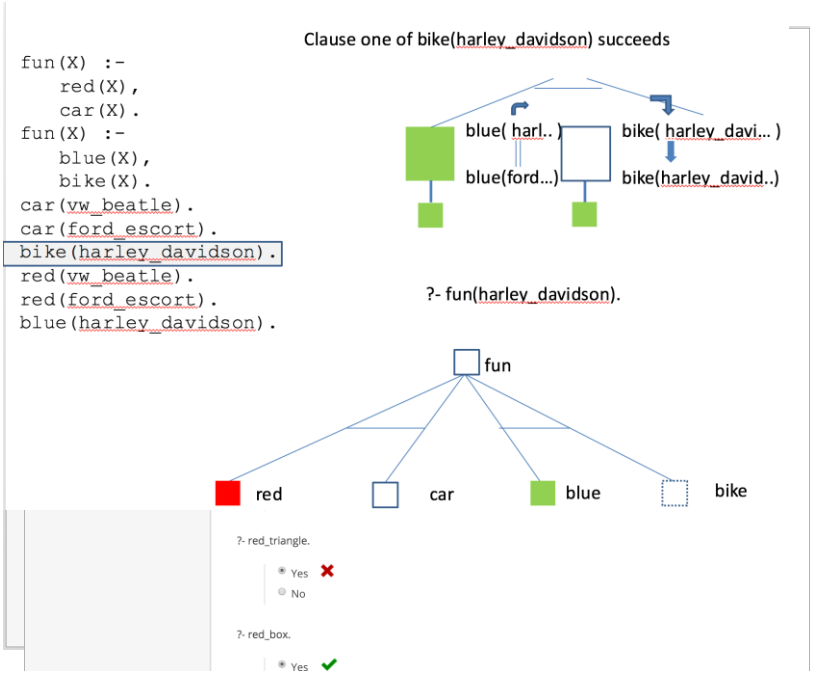
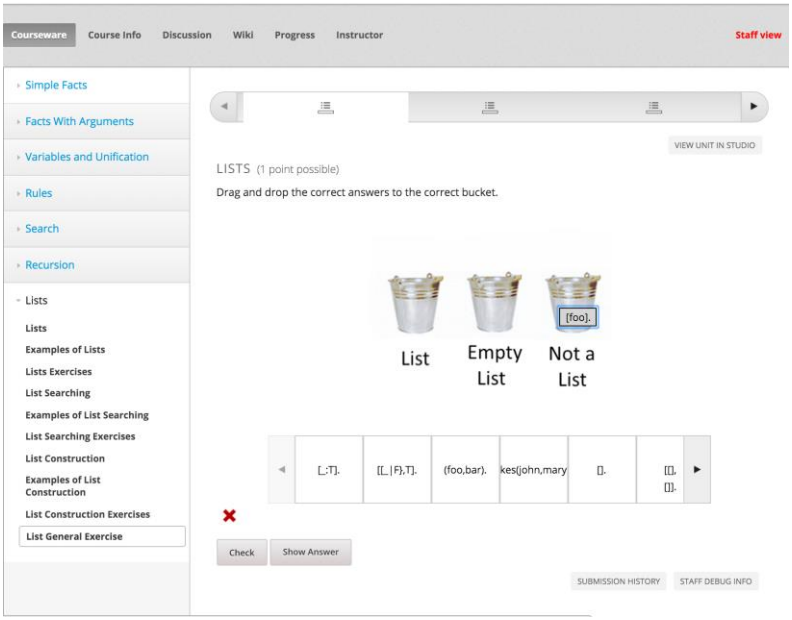


Figure 4. Showing the program code on the left. The line of code currently being executed is shown on the left. The goal tree is shown towards the bottom of the screen and at the top is a Fine-grained view showing individual clause head unifications.

To further add to the user experience Software Visualisation of the Prolog Virtual Machine. This was done by using TPM (Brayshaw and Eisenstadt, 1991) a visual model of the behavior of Prolog. This account was here tightly coupled to the program itself in the animations produced by the first author and delivered via YouTube.

MOOC and Motivation



Timeliness, Novelty and Game Elements

Figure 5 A simple sorting game.

As we said before an element we wanted to include is gamification. Figure 4 illustrate one sort of interaction. The same is to correctly identify which items are lists and which are not. Along the bottom are a series of symbols, some are in lists, others are not. The game is to correctly place these items in one of three bins. One bin is marked List, the next Empty List (a list containing nothing), and the last Not a List. The goal is thus to correct put the right things in the correct bins.

The system was successfully used in 2014/15 for a two Semester Course on AI to teach the Prolog part of the course. An evaluation was undertaken with broadly positive results. The whole project was then written up and reported in Brayshaw and Balaghan, submitted). The student involved went on to do postgraduate work.

Case Study 3: Social Computing and Personalisation

Navigation and seeing the woods for the trees is a common problem as we have to deal with large information spaces online. This is also the case in the world of Social Media. This project was undertaken with an MSc student and aimed to take an existing Adaptive Information Retrieval technique to produce Smart Twitter Portal (Mounota and Brayshaw, 2015)

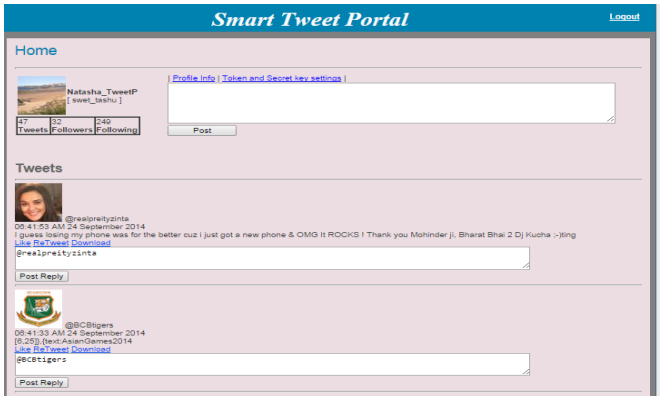


Figure 6 Screen Snapshot of the Smart Twitter Portal (Mounata and Brayshaw, 2015)

The portal allow the user to tailor their social media and personalize it to their own interests. It uses their own behavior with the material they look at to priorities subsequent views of incoming Tweets. The system was evaluated with 12 users and an overall 91.7% for the relevance of tweets it displayed. The student later went on into an academic career.

Conclusions and Further Work

The three cases studies illustrate, at different locations in the student journey, potentially how to connect teaching and research. The emphasis on case studies One and Two has been on the Inclusion of students in Core University Activities from Teaching and Research. The approach can also be important for recruitment by showing prospective students the difference in activities that goes on a University compared with schools and how, for example by a suitable intern program, they can become active participants in a fuller range of activities.

This in turn can lead to helping with Engaging and Motivating using partnership to promote this and improve the Undergraduate UX. Wagner (2016) argues this involvement may help confidence in female undergraduates which in turn might redress the gender gap in Computer Science. Increasing engagement and participation should help performance, satisfaction, and retention. Indeed partnerships may be widened to include others from beyond the confines of the University. Preece (2016) discusses using collaboration and Citizen Science in the context of improving Human Computer Interaction. Such a hybrid approach could be used in the future for expanding teaching and research partnerships to include players from beyond the confines of the campus, maybe including suitable industrial locations.

Flipped Learning

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