ABSTRACT
Given the increasing popularity of smartphones and their accompanying applications, a number of Higher Education (HE) institutions in the UK are offering a mobile applications development module as part of their undergraduate degrees. Each institution has its own method of implementing such a module and will also have certain restrictions to work within.

This paper reports on the author’s experiences of delivering a Mobile Application Development module to 3rd year undergraduate Web Systems Development (WSD) students and the challenges faced in developing an alternative curriculum for a module originally intended for Computing students with experience using the Java programming language. Module evaluations indicate that the alternative curriculum provided to WSD students was well received and the practical hands-on tutorials used in the delivery of the module give students a sense of empowerment and the confidence they need to succeed.

Categories and Subject Descriptors
K.3.2 [Computer and Information Science Education]: Computer Science Education.

General Terms
Design, Experimentation, Human Factors

Keywords
Mobile Web Design, Curriculum and Delivery, Best Practices, Smartphones, Implementation

1. INTRODUCTION
In 2010, smartphones outsold PCs 101 millions to 92 million thus making the smartphone market much larger than the PC market [1]. We live in a world today were the mobile device is seen as the primary mechanism for people to access the Internet [2] as people require access to information on the move, rather than being confined to a chair and a monitor. It is also suggested that over a period of seven days, 60% of the population who own a mobile device will have used their device to access the World Wide Web [3]. With this, it is no surprise that demand has increased for highly skilled developers to craft applications for a variety of mobile devices to enable businesses to reach customers in all corners of the world. For the most part, many mobile applications that are developed are considered to be ‘native’ applications, in that they are developed for a specific platform and have access to the hardware of a device through the use of Application Programming Interfaces (APIs). Whilst this is considered to be the norm with a number of marketplaces available today in which to market these applications, it becomes much more challenging when trying to develop an application for multiple platforms.

Condor and Darcy [4] argue that the mobile development community is at a tipping point in that mobile users demand more choice, more functionality and more opportunities for customization whilst mobile developers want the freedom to develop powerful mobile applications with minimal roadblocks. It seems that the idea of developing just for one platform is no longer enough.

Recent advances in Web technologies (including HTML5, CSS3 and JavaScript) [5][6][7] have enabled the development of mobile applications, which are created using Hypertext Markup Language (HTML), Cascading Style Sheets (CSS) and JavaScript. These applications, known as mobile Web applications, can then be deployed to multiple platforms including Android, iOS, Blackberry and Windows Phone and even the desktop PC, through a Web browser. More recently, the developments of HTML5 now enable Web developers to access the native hardware of a device and thus allowing mobile Web applications to function just as well as their native counterparts.

2. MODULE OVERVIEW
The Mobile Applications Development module is a 12-week, one semester module offered as part of the final year BSc (Hons) Computing and BSc (Hons) Web Systems Development (WSD) programmes at Edge Hill University. Students who study Computing can choose the module as an elective for their final year studies whilst for final year WSD students it is a core requirement.

The module runs for 12 weeks (1 semester) and consists of a 1-hour lecture to discuss associated theory and a 2-hour practical lab session, where students can put into practice the theory they have learnt. Pre-requisites for the module require students to have an understanding of HTML and Object Oriented (OO) programming principles, which are covered during 1st and 2nd year studies for Computing and WSD students.

Students are required to complete two assignments during the module; CW1 involves the students producing a 4-page academic paper on a topic related to mobile application development whilst CW2 asks the student to plan, design and develop a mobile application intended for the Android platform based on a given scenario.
2.1 Previous Implementations
In previous years, the module has only been available to final year Computing students. During the module, students developed mobile applications using the Java programming language. Students were introduced to J2ME and the Eclipse IDE to design and develop their mobile applications, which would be deployed via the Symbian (Nokia) platform. These applications were then tested on a limited number of mobile devices that were available within the department.

For this year’s implementation of the module, as well as delivering the module to both Computing and WSD students, it was decided that students would develop applications for the Android platform. To facilitate this, the department purchased a number of devices (both tablet and mobile) to allow students to develop using the Eclipse IDE, the Java programming language and the Android SDK.

2.2 Fundamental Issues
When discussing the logistics of the current module delivery, a number of issues were raised regarding the content, and application of knowledge.

Firstly, the pre-requisite knowledge of WSD students was considered and how appropriate it was to developing mobile applications in the Java programming language. Currently, WSD students are taught OO programming principles in the second year of their studies using ActionScript 3 and the Adobe Flash environment. Here, students are required to develop an object oriented ‘Web-site’, which demonstrates an understanding of the principles they have learnt throughout the module. This is very different to their Computing counterparts, who develop applications in Java using the Eclipse IDE as part of their 2nd year OO programming module, thus giving them a good insight to the language before they embark on their third year studies.

Secondly, since both sets of students were studying the same module, they also had to complete the same pieces of work and achieve the same set of learning outcomes. Whilst CW1 (academic paper) would not present many problems, CW2 asks the students them to develop a mobile application for the Android platform based on a given scenario.

A number of options were discussed as to how to proceed. One option was to carry on as planned, running the module from a purely programming aspect and asking the students to develop mobile applications using Java and the Android SDK. This presents an issue in that whilst the programming principles taught to the two groups of students in previous years are the same, the methods of implementation are very different. WSD students are not exposed to the Java programming language in any great detail (beyond a six week block in 1st year studies) and thus may be hindered in their ability to achieve high marks on the module if developing applications in the same way as Computing colleagues.

Another option discussed was to create a new module to allow the WSD students to study an alternative to Mobile Application Development and utilise the skills they had developed over the first two years of their course. However, due to time constraints, this option was not feasible and thus not considered.

A final option was presented by the author which would allow the Computing and WSD students to study the same module, but develop mobile Web applications based on the skills and knowledge they had acquired, using HTML, CSS and JavaScript.

2.3 A Viable Alternative
By allowing WSD students to develop mobile Web applications, it meant that both Computing and WSD students could ‘study’ on the same module, complete the same assignments and still achieve the same learning outcomes. There would be no need to develop an alternative module and the learning outcomes allowed for some movement in what students would create for the mobile application. What was needed now was a curriculum for the WSD students, which would allow them to write a conference paper and also allow them to develop a functional Mobile Web Application, comparable to what the Computing students would produce.

3. DEVELOPING A MOBILE WEB APPLICATIONS CURRICULUM
When deciding on the curriculum content, it was important to consider the learning outcomes and assessment requirements of the module. An emphasis was made on using similar content within the Computing and WSD sessions to ensure that both sets of students were able to complete the required assessment and that they would not be disadvantaged in any way.

One of the main reasons for this was due to the first assignment - the academic paper. Students needed to conduct research first, in order to have the necessary information in which to produce their paper. Regardless of whether students were approaching this from a ‘native’ mobile application (Computing students) or a ‘web’ mobile application (WSD students) aspect, they would be faced with some of the same issues regarding security, bandwidth (if making use of any Web services) and device constraints to name but a few. Thus it would be conceivable to imagine a Computing student and a WSD student producing an academic paper, which talked about the same issues.

Another aspect to consider was to ensure that discussion of the relevant technologies and frameworks were included within sessions to allow WSD students to create their application. A curriculum covering aspects of Web design for mobile devices was of great importance, along with examples on how they could potentially access the native hardware of the device being used to provide a true mobile experience.

3.1 Curriculum For WSD Students
Taking into account all the factors discussed previously, it was decided that the topics listed below would form the basis of the curriculum for WSD students:

- Overview and Challenges of Mobile Computing
- HTML5 Features (Storage, Connectivity, Offline, etc.)
- CSS3 (Styling, Transitions, Transforms & Animations)
- Strategies for Web Design
  - Graceful Degradation [8]
  - Progressive Enhancement [9]
  - Hardboiled Design [10]
  - Mobile First [12]
- JavaScript Libraries and Frameworks
  - jQuery, jQuery Mobile, Sencha Touch, PhoneGap, Appcelerator Titanium, ExtJS, Mobilize.js, etc.
- Cross Platform Deployment and Marketing

Material used as part of the sessions on HTML5 and JavaScript were developed based on the case studies and tutorials available at
The seminar activities required students to pick one paper each week from a series of published conference papers (four were provided each week) on areas related to mobile application development and the use of Web technologies to create mobile applications. Students were then asked to write a half page (A4) précis of the paper and then present it the following week as part of a discussion with the rest of the group. Each student was asked to read their summary to the group and provide a unique point about the paper that had not already been discussed (since there were only four papers presented each week, the same paper was talked about on more than one occasion each week).

During the later part of the module, the focus was shifted to the second assignment; the development of a mobile Web application. Development. Over a period of five weeks, students participated in a series of tutor led practical sessions in which they were introduced to a number of features that they could utilise in the development of their mobile application, including Geolocation, Application Cache, Local Storage, Responsive Design and the use of jQuery Mobile as a framework in which to guide their development. During these sessions, the tutor and students would work on examples together, developing code in a step-by-step process. The tutor would begin to write the code (which students could follow along with), explaining the functionality of the early parts of the code, and then asking questions about what the next steps would be. These questions typically lead to the development of pseudo code first, before the production of functional code after further discussion with the group.

4.1 Developing A Scenario For The Mobile Web Application

It is estimated that worldwide mobile payment transactions will surpass $171 billion in 2012; a rise of 62% from $106 million in 2011 [13]. It has also been reported that mobile coupon redemption is ten times bigger than traditional coupons [14]. With this, a scenario was devised for the WSD students for the mobile application build in that they were required to develop a ‘voucher code’ style application and produce documentation, which detailed this process (designs and a narrative discussing the frameworks and design strategy they adopted). The scenario and requirements for the application are detailed below.

‘Pete and Dave’s Discount Codes’ is a fictitious business which supplies customers with a list of vouchers from a variety of retailers, offering discounts on products and services. They have requested a mobile application to be developed to allow them to share these vouchers with a larger customer base. In regards to functionality of the application, users should be able to select one of these vouchers and redeem it against a product or service. Depending on the device they were using to access the application, the voucher code would be displayed in one of two formats. If the user accessed the application from a mobile device, a Quick Response (QR) code (mobile devices) would be displayed which the user could then present in store to be scanned. If the user was viewing the application on a tablet device, then a text code should be displayed which could also be used in store.

Other requirements for the mobile application included the use of a number of HTML5 and CSS3 related features including:

- Geolocation (e.g. to allow the user to find the nearest store)
- Local Storage (e.g. to save a voucher to the device)
- Application Cache (to allow for offline viewing of the application)
- Responsive Design (i.e. the application should make use of available screen estate on both mobile and tablet devices and as such, the layout of elements should be appropriate to the device e.g. through Media Queries)
- CSS Transitions
- An application icon and start screen (for iOS devices)
- An ability for the user to filter the vouchers either by ‘Eat’, ‘Stay’ or ‘Shop’
- An .apk file to allow the application to be installed natively on Android devices.

In order to proceed with the assignment, a number of supporting files and resources were made available to the students to aid them in the development of their mobile Web application. These included:

- A MySQL database containing a list of vouchers (along with associated details e.g. vendor name, voucher title, description, code, start date, end date, etc.)
- A PHP connection file to allow the students to access the database to retrieve the vouchers, and a PHP file which queried the database to return in JavaScript Object Notation (JSON) format a list of vouchers which could be viewed on mobile devices (and another for tablet devices)
- A series of images containing the QR codes to be used in the application (these were linked to file paths held in the database)
- A series of images to depict each of the retailers in the database (should the students wish to use them).

One of the primary reasons to output the database content in JSON format was so that students could avoid using PHP files to create their applications. PhoneGap (the framework which would be used by the students to create the .apk file) does not parse PHP and by exporting the data to JSON format, it meant that they could use JavaScript and HTML in which to format the content, thus allowing PhoneGap to create a native Android application file.

4.2 Building A Mobile Web Application

Students were engaged in the development of the application from the very beginning and seemed to benefit from the practical tutorial sessions provided as part of the module delivery. Whilst the majority of the students opted to use the jQuery Mobile framework in which to develop their application, a number of
students chose to develop purely in HTML5, CSS3 and JavaScript, which was pleasing to see. Many of the students adopted an ‘agile’ approach to the development of the application, starting with designs for the mobile (Fig 1) and tablet (Fig 2) versions of the application, whilst also considering the structure that their ‘pages’ would have (Fig 3).

Armed with their designs, the students set about the development of their applications using their chosen languages/framework. Whilst some students had issues during the development stages, all who submitted their application managed to produce an application which included an application icon, allowed users to view QR codes and also provide some form of Geolocation (most were limited to just finding the current location of the user.) Students who were able to implement the features indicated above achieved the minimum pass mark required for the practical aspect of the assignment.

It was also interesting to see how students worked with the requirements for the application and the range in terms of the design and functionality of the applications submitted was pleasing to see. A number of students managed to embrace some of the more technical elements of the assignment (Application Cache, Local Storage) to craft successful mobile applications (Fig 4 and 5) which worked extremely well when tested on mobile and tablet devices.

4.3 Feedback From Students
Upon completion of the module, students were asked to complete a short evaluation of the module, indicating their experiences of the work they completed. Of the 31 students registered on the module, a total of 26 students responded to the evaluation representing an 84% completion rate.

The evaluation was split into two parts; the first listed five closed questions to obtain quantitative data, whilst the second included four open questions in which to elicit qualitative data. The responses to the quantitative questions were limited and aligned to a 5-point Likert scale of “Strongly Agree”, “Agree”, “Neither
Agree or Disagree”, “Disagree” and “Strongly Disagree”. For the qualitative questions, students were allowed to write their own responses.

When analysing the quantitative data, answers to each of the questions were reduced a numeric value according to the responses on the Likert scale. Answers of “Strongly Agree” were awarded a 5; “Agree” answers were awarded 4, and so on with “Strongly Disagree” answers being awarded a value of 1. Scores were then aggregated across the 26 submitted evaluations to provide an average mark for each question. For each question in the qualitative section, answers were grouped together based on common themes/categories in which an answer would only fit into one.

4.3.1 Quantitative Evaluation
The first question asked whether the module was useful in helping them understand the concepts of Mobile Application Development. A score of 4.50 (highest – 5, lowest – 3) indicates that students agreed with statement that they material that they had learnt during the module had been extremely useful to them. The next question asked whether the students believed the content and delivery of the module aided the development of their mobile application. Students responded with a score of 4.41 (highest – 5, lowest – 3) suggesting that the practical sessions provided during the course were extremely useful to the students. Students were then asked about their confidence in developing other mobile applications after completion of this module. A score of 4.27 (highest – 5, lowest – 3) indicates that the students believe they have the necessary skills and knowledge to develop mobile applications in the future.

In regards to whether students felt that the module was intellectually challenging for them, a score of 4.50 (highest – 5, lowest – 3) suggests that the content was at an appropriate level to both simulate their interest in the subject and required them to demonstrate the higher order learning skills required of a 3rd year undergraduate student. The final question in this section asked the students about whether they felt the work they they completed for CW1 (academic paper) helped them to complete CW2 (mobile application build). A score of 3.86 (highest – 5, lowest – 2) suggests that students were undecided on this with most suggesting that it did, but there were a number of students (3) who felt that the academic paper did not help prepare them for the build.

Given the range of topics discussed as part of CW1, the author questions whether the students who scored this question with a score of 2/3, chose a topic that was not related to mobile Web application development. This is evident in a small number of papers submitted which focused on specific aspects of Mobile Application development, such as Geolocation, security and the Wireless Application Protocol (WAP), whilst the majority focused on mobile Web applications, the differences between Web and native applications and a small minority also discussed the notion of ‘hybrid’ applications; those which take advantage of the benefits of both Web and native applications. Perhaps those students who discussed these topics were appreciative of the process required to create mobile Web applications, along with the frameworks and technologies needed to develop.

4.3.2 Qualitative Evaluation
The first two questions were based around eliciting student experiences of the module and focused on their perceived level of difficulty of the module, how much they enjoyed studying on the module. The last two questions focused on what the delivery on the module, asking students what they think worked well and should be implemented next time and what did not work and should be discontinued.

For the first two questions, the answers provided can be grouped into three distinct but related categories, loosely linked to Blooms Taxonomy of learning [15]. The three categories identified are detailed below along with some student feedback.

a) Acquiring new knowledge (Comprehension) – here the students highlighted their experiences around their learning during the module.

The hardest thing for me on this module was:

“Learning responsive design” (#13)

“Learning to adapt design from desktop to smaller space” (#8)

I enjoyed doing the following the most:

“Trying to implement jQuery Mobile” (#17)

“Using the PHP files within the build” (#11)

b) Development of the Mobile Web Application (Application) – here the students highlighted their experiences around the development of their mobile Web application.

The hardest thing for me on this module was:

“Writing the IEEE paper” (#1)

“Developing my writing style to match the IEEE format” (#4)

I enjoyed doing the following the most:

“The academic paper” (#9)

“Writing the paper” (#17)

When asked what aspects of the module they think work well and should be continued, out of the 13 responses to the question, the students were mostly unanimous in their response in that the practical tutorial sessions in which the tutor talked them through the code they were writing and developed sample applications together should be kept. It was clear from the sessions in question that the students felt a sense of empowerment from having instant validation of the code they were producing from the tutor with one student stating “the seminars following lecturer writing code was a good method of learning” (#4). Students also appreciated the distribution of the published academic papers during the early stages of the module, which helped them with their first assignment.

Finally, when asked what they think should be changed for next year, only ten students made a suggestion. The majority of these were related to the scenario used in the application build, with some suggesting that it was “Too complex and too big” (#4) whilst one suggested “Let the app subject be the student’s choice”
When deciding on the scenario for the assignment, the author considered this last suggestion, but the choice was made to implement this ‘voucher code’ scenario to aid the students who would struggle to develop their own ideas for applications. In addition, the scenario also allowed a minimum specification for functionality to be developed to ensure that students were exposed to a number of different aspects of mobile application development. This may not have happened had students chosen their own idea and the required functionality also ensured that students knew what they needed to do to achieve a pass mark on the practical element of the assignment. The development of the supporting files which were given to help the students should have ensured that the application build should not have been too complex, but from the applications submitted, it appears that a number of students chose to modify/amend these files to suit their own programming style.

Other suggestions from the students indicated that they would like to have had more practical tutorial sessions in which they could follow the tutor as they were coding, a refresher on using JavaScript and the Document Object Model (DOM) and running the module over two semesters instead of one. Whilst these are all valid suggestions, time restrictions both in-module and on the course as a whole mean that none could feasibly be implemented. As mentioned previously, five weeks were set aside for practical tutorials during the module and the students study a module on Java Script during their 2nd year.

5. CONCLUSIONS

This paper has reported on the experiences of the author in providing an alternative curriculum to be run as part of Mobile Application Development module, allowing WSD students to create cross platform mobile applications, utilising the skills and knowledge they have acquired during their first two years of study. The results of the evaluation indicate that this has been well received by students and it is believed that the content, delivery and assessment strategy in place works well to allow students to achieve a high mark in the module.

Given that the lower order skills of knowledge, comprehension and application are typically showcased in 1st and 2nd year studies, it is no surprise that students had some difficulty in analysing and synthesising information for their academic paper, since these are skills which are tested during 3rd year studies. One important point to note is that this was the first and only point in their undergraduate degree that these students were required to write an academic paper as if they were submitting to a conference. The author believes that this is a skill that students should be exposed to in other modules on the programme, since a number of students do progress on Masters and PhD level study. In addition, perhaps more time should be devoted during the module to allow students to practice articulating the theoretical knowledge they have acquired, since this is just as important as the practical aspect.

The increase in the number of mobile devices available on the market today, it appears that teaching students how to develop applications for one particular platform in ‘a one size fits all’ method is no longer a viable solution. Businesses want applications that can be deployed ‘cross-platform’ and by teaching students to develop application in this way can only serve to improve their employment prospects when they finish their degree.

The curriculum and delivery method outlined earlier in this paper has proved to be a success and received well by students and the author strongly recommends that anyone wishing to implement a similar course should consider adopting a similar strategy for delivery.

6. REFERENCES


