RELEASING AN EDUCATIONAL ANDROID APP

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Abstract

This paper explores the process and challenges of creating an educational app for android devices. The Heat Loss Calculator app was initially conceived to allow researchers to quickly calculate building heat loss by entering the U-values of different building element fabrics. Selecting lower U-values equates to the various insulation improvements which can potentially reduce heat loss and improve energy efficiency. During early development it became clear that the app would also be a useful learning tool for students. Therefore, it was designed with this wider audience in mind, with the intention of publishing it in the public domain. Issues encountered during development and some that became apparent after release on the Google Play Store will be discussed. The user experience will be evaluated by means of an online survey of students and by using the app in a group session in the classroom. The feedback will be examined to inform how the app can be improved.

INTRODUCTION

In 2016 Leeds Sustainability Institute pursued the idea to embed current research experience into an educational app for android devices. Its purpose is to help researchers, students and professionals explore the potential energy efficiency of different building element fabrics. The Heat Loss Calculator introduces the concept of calculating heat loss from the varied materials used in house building. The aim of the app is to quickly calculate building heat loss and how much various insulation improvements could potentially reduce it by reducing U-values.

In the Calculator page, the user can enter values in m^2 for the size of the areas of the surfaces of a building. U-values are initially displayed at a worst-case scenario of having no insulation; the user can select other U-values from drop-down menus. When the “Heat Loss” button is pressed, the areas are multiplied by the U-values and total heat loss is calculated, displayed next to the “TOTAL (W/K)” text. The app features a user guide in which terms used in the calculations are explained. Links are provided to the relevant UK Building Regulations and teaching resources. This concurs with the ideas of Zydney and Warner (2016) to ensure sufficient background material and extra learning is supplied within the app or users directed to other useful sources.

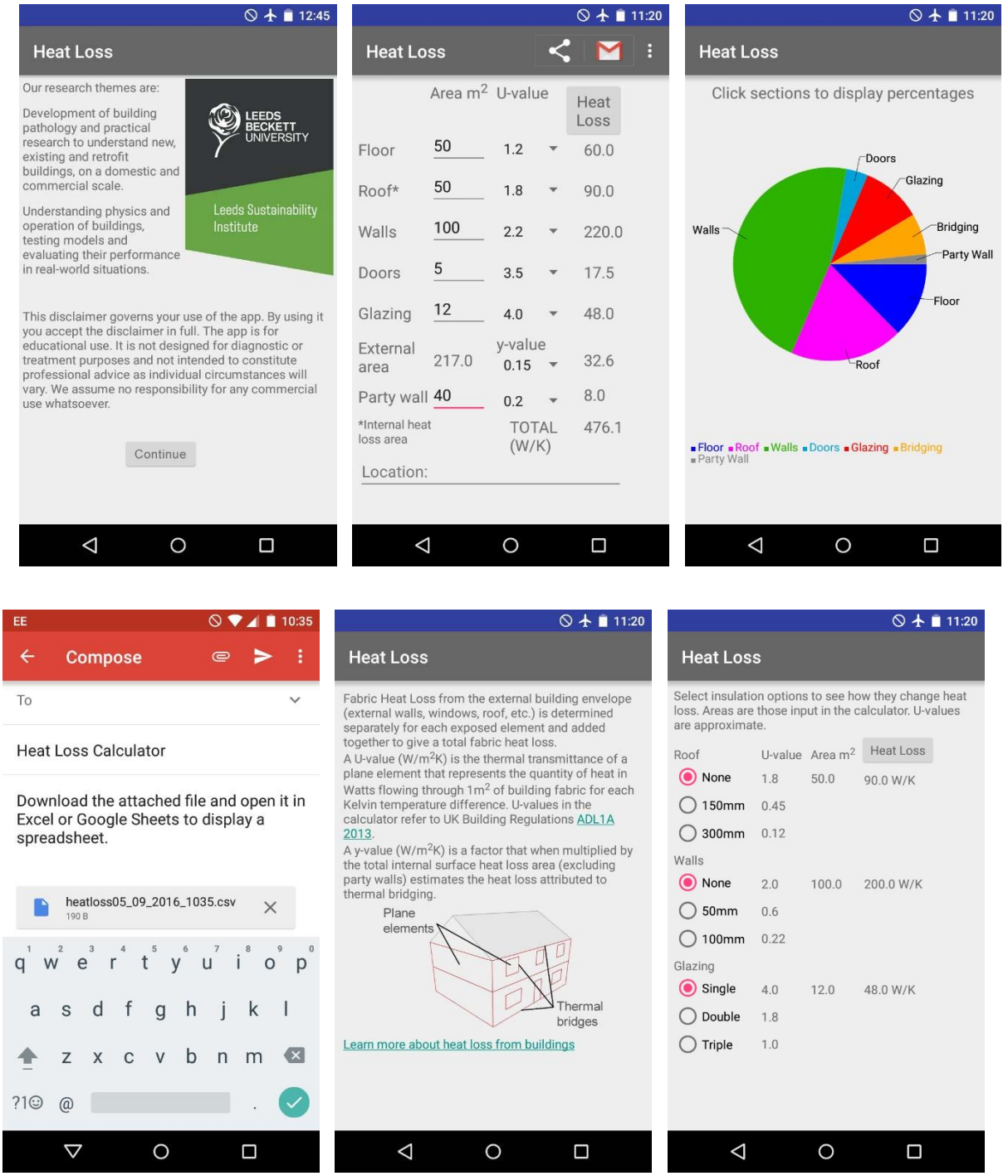

Figure 1. Screenshots of an early version of the Heat Loss Calculator app

A reliable method of sending data out from the app via email was sought. It was decided to achieve this by writing a new Comma Separated Value file (.csv) to a “Public” folder within the Android Operating System (OS) every time any of the values were changed in the calculator.

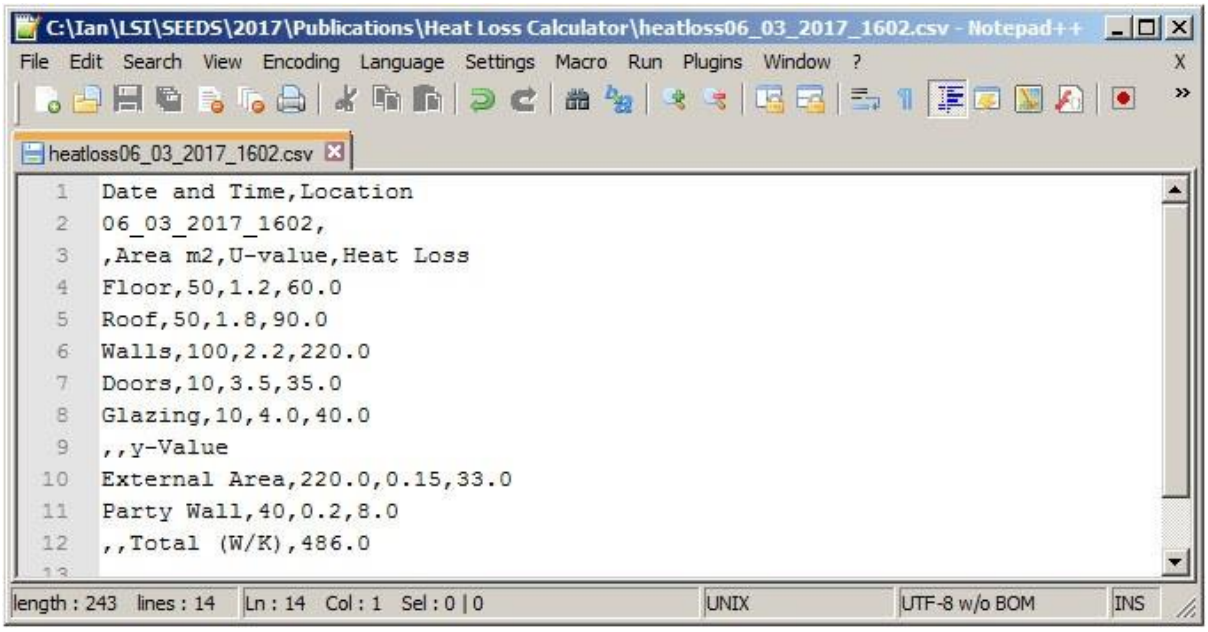

Figure 2. Java code within the app writes a .csv file when values are changed in the calculator.

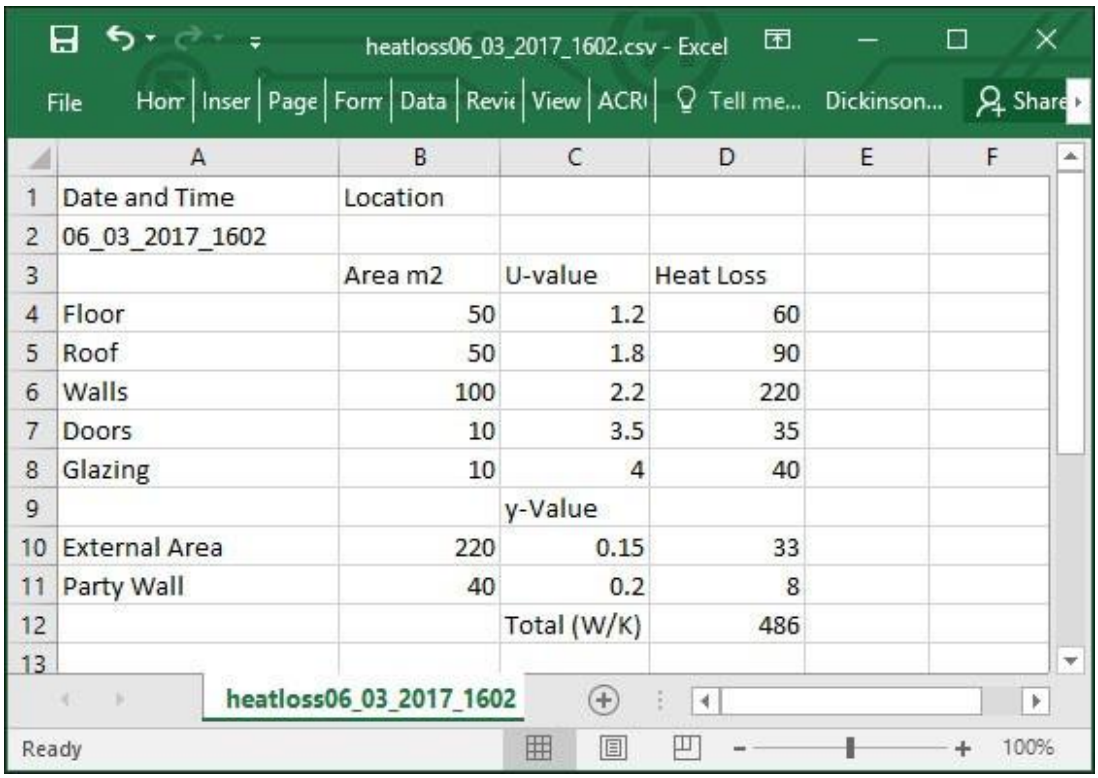

Figure 3. Once imported into Microsoft Excel or Google Sheets, the .csv file is displayed as a spreadsheet.

The folder structure of the android operating system was examined to see which would be the most suitable folder to write the file to. The 'Downloads' folder was initially chosen, as this existed in all the android phones and tablets that the app was tested on prior to release. Also, it is a “Public” folder, i.e. it can be written to by apps.

Alpha testing was carried out on various android phones and tablets used by colleagues. The Webopedia web site defines alpha testing as, "A very early version of a software product that may not contain all of the features that are planned for the final version. Typically, software goes through two stages of testing before it is considered finished. The first stage, called alpha testing, is often performed only by users within the organization developing the software."

A problem was identified only after the initial release of the app on the Google Play Store. The 'Downloads' folder is not in the same location within the file structure of all android devices. The app crashed when the device attempted to open the calculator if the Downloads folder wasn't in the location specified by our code. We withdrew the app from the Play Store until a solution could be found. A reliable Public folder location was found to be the Cache folder of the app. A 'Try/Catch' method was added to the code as a backup in case the file writing failed. The app initially attempts to run the 'Try' method of writing the file. If it fails, then the 'Catch' method writes the calculator data as text into the text area of the email.

Beta testing was then carried out through the Play Store with a group of approximately 10 friends and colleagues who had expressed an interest in the app. The Webopedia web site defines beta testing as, "A test for a computer product prior to commercial release. Beta testing is the last stage of testing, and normally can involve sending the product to beta test sites outside the company for real-world exposure or offering the product for a free trial download over the Internet." The beta test group all successfully installed the app and no crashes or bugs were reported. In retrospect it would have been wise to have performed beta testing prior to releasing the app on the Play Store.

Inukollu et al. (2014) argue that one of the reasons for low quality apps from a Software Development Life Cycle point of view is that not enough testing is done. "App developers are more fixated on functional aspects of the app and hence they sometimes ignore security and performance testing, which are the key components of any app." Lessons were learned by our team in the importance of beta testing the app. However the major variations in screen size and pixel density/ screen resolution between the many types of Android devices presents a challenge for the developer to test and publish the app in a format that is optimised for all users. Graphics and text can be defined with code to display at different sizes depending on the device. To an extent this can be modelled on android devices of varying screen dimensions and screen densities in the Android Studio software. However, after releasing the app and testing it on the phones and tablets of colleagues, an issue that had not previously been considered became apparent. Android has various settings for the display of font size. If the font size was set to maximum, the launch button was pushed off the bottom of the screen. If it was set to minimum, then text and graphics were pushed out of place. A compromise was reached to make the app screens display correctly across all devices. With the constantly evolving nature of mobile devices, this will remain an issue.

A poor review was posted on the Play Store stating, "*The home page freezes and there's no links to do anything*."

The Play Store user account allows the account holder to see the type of device on which the reviewer installed the app. The app had been tested prior to release on the same model of device used by this reviewer and the error described was not observed. The W3C Mobile Accessibility Guidelines state that a variety of methods allow the user to control content size on mobile devices with small screens. At the browser level these methods are generally available to assist a wide audience of users. At the platform level these methods are available as accessibility features to serve people with visual impairments or cognitive disabilities. The methods include the following features at the OS level:

- Set default text size (typically controlled from the Display Settings)
- Magnify entire screen (typically controlled from the Accessibility Settings).
- Magnifying lens view under user's finger (typically controlled from the Accessibility Settings)

We presumed that the error may have been caused by one of the reasons above. Perhaps the user's OS settings had pushed the 'Continue' button off the bottom of the screen. The button was moved higher up the page and the app was re-published. We posted a response to the review on the Play Store stating: "*Sorry to hear you've had problems with the app. We've moved the 'Continue' button higher up the home screen in case it was not visible on your device. Thanks for your feedback*." Two months later another poor review was posted on the Play Store stating, "*didnt (sic) do anything just stayed on home page rip off.*" Clearly, the 'Continue' button on the home screen was either not being displayed or not working on some devices. It was replaced with a Menu dropdown link from the Home page to the Calculator page, which has hopefully fixed the problem.

Ma et al. (2103) argue that, "The usability of mobile applications is critical for their adoption because of the relatively small screen and awkward (sometimes virtual) keyboard, despite the recent advances of smartphones." Because traditional laboratory-based usability testing is often tedious, expensive, and does not reflect real use cases, they propose a toolkit that embeds into mobile applications the ability to automatically collect user interface (UI) events as the user interacts with the applications.

Other reviews of the app included the following:
"*…i found the fact that you input your own u-values a bit confusing and think it would be helpful if there was at least a U-value guide (cavity wall U-value = X)…*" "*I found the app very confusing. Could give more details of how to use and what each element is*."

The work by Zydney and Warner (2016) showed that "Researchers need to make more explicit connections between the instructional principles and the design features of their mobile learning environment in order to better integrate theory with practice". This reasoning informed our decision to design the app for surveying researchers and students, who have an understanding of U-values and building construction. There is a link provided within the app to the UK Government document "Conservation of fuel and power: Approved Document L", which states building regulation in England setting standards for the energy performance of new and existing buildings. The various documents linked to from this web page give U-values

for the wide variety of building materials used in dwellings and non-domestic buildings for both existing and new-build construction. The information provided is of a technical nature, thus it is a valid criticism of the app that it is not easy to use without some knowledge of the subject. Inukollu et al. (2014) argue that various causes for the failure of an app include minimum/no knowledge of user demands and expectations and a lack of knowledge of the target audience. However, reviews of the app demonstrate that focussing solely on the target audience can result in a negative experience for those who fall outside the target audience.

METHODOLOGY

The app is being used as a teaching tool by Level 5 students on the Detail Design, Planning & Property Development module of the BSc (Hons) Building Surveying within the School of Built Environment & Engineering. The module requires students to explore the roles of a building surveyor in relation to planning, design and finance with regards to a commercial property acquisition and to a specific site development. Students are instructed to use the app to carry out a heat loss assessment of the building as part of an overall building survey.

Ownership of android devices among the student group

A presentation of the app was made to the student group. It was found that of the 15 students who attended the lecture, only two had android devices. The rest were using iPhones. This was surprising, as according to the International Data Corporation (IDC), Android held an 85 percent share of the worldwide smartphone market in the first quarter of 2017, whereas Apple held a 14.7 percent share.

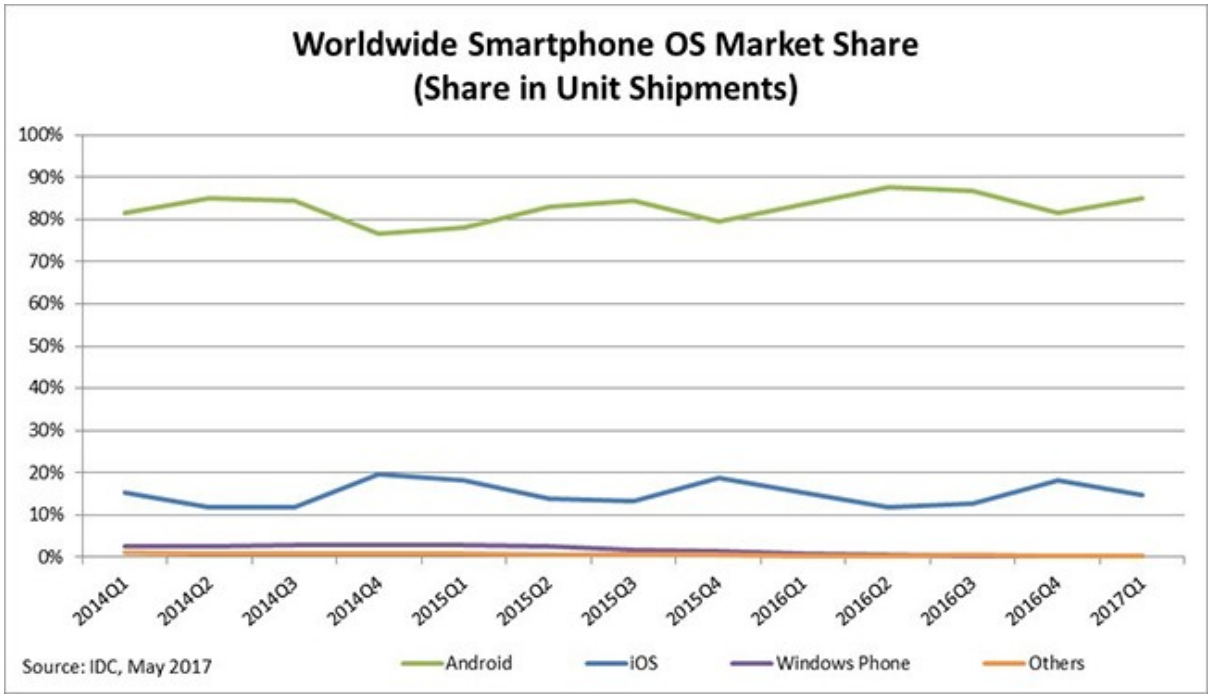

Figure 4. Worldwide Smartphone OS Market Share. Source: IDC, 2017

A method of giving access to the app to students not having access to android devices is to use the Bluestacks android emulator, which can run on a computer running the Windows operating system. However, this is not an ideal solution as it requires the user to either have a Windows laptop with them while they are performing the building survey, or otherwise making written notes of the dimensions of the building and inputting them later into the Bluestacks emulation of the app.

The ideal scenario would be to rebuild the app for the Apple mobile device operating system, iOS by rebuilding it in X Code. Google announced the open source release of J2ObjC, a Google-authored translator that converts Java classes to Objective-C classes for iPhone/iPad applications. This method was investigated as a method of reducing development time, however it became clear that one must learn how to use the iOS SDK (Software Development Kit) in order to create the Graphical User Interfaces (GUI). Currently, time constraints make this impractical for our team, however it may be pursued in the future.

A solution for the developer faced with implementing mobile apps across multiple platforms may lie in HTML5. Sheldon (2018) states that, “Many organizations are turning to HTML5 mobile application development to streamline the implementation of apps and reduce cost and complexity. Under the right circumstances, HTML5 apps provide an enterprise with a simple alternative to native app development, especially as more HTML5 development frameworks emerge.”

Online survey

An online survey was created to obtain student feedback. An invitation to complete the survey was sent to all students studying the Surveying module within the School. This produced no responses. A further attempt was made to generate some response by asking the 15 students in the group mentioned above during the presentation. This produced four responses, providing the comments shown in Figure 5.

Did the app enhance the written guidance in the module document and on MyBeckett (the University’s Virtual Learning Environment)?	• Somewhat, it clarified how to use it more. • Definitely, the written document was much easier to follow and understand after the app was used. • Gave me a greater understanding of thermal bridging in accordance with plane elements.
Please evaluate your experience of using the app.	• Further explanation within the app of what the roof area encompasses, as well as what the external area is, before the calculation this is confusing as you think you need to enter an amount. • Easy to follow, straight forward and simple. Quite difficult to find and install if you're not on android. • It's easy to use and downloading the app was straight forward.

Did you experience any difficulties in installing or using the app?	• • Yes, it wasn't easy with Bluestacks. • Quite a long process installing the app for now android users. It's easy to use and downloading the app was straight forward.
How could the app be improved?	• More choice of u values. • The app is good, I just think it could look more aesthetic to the eye.
What developments might you or others find useful?	• More u values • Change of resolution, the page looks too busy.

Figure 5. Online survey responses

Although this feedback was informative, responses were very brief and did not give a great deal of insight into how the students are using the app. An improved student response was clearly required to gain useful feedback for research and to draw any meaningful conclusions.

Group work

During earlier work trialling a virtual reality surveying application (available on the Virtual Site website), discussed by Ellis et al. (2006), one tutor had used the exercise in a student group session, which he believed to be beneficial, stating, "*Working at the PC can be very lonely for a student. It [the surveying exercise] seemed to work better in class, as it promoted a lively discussion. Whilst I have no evidence to back this up, I think that some of these students went back to the exercise after class and gained more from it*." There has been much research on group work, and as an example Kitzinger (1995) gives some of the benefits of focus groups. We decided to use a classroom group work approach to gain feedback for the Heat Loss Calculator app. We did not intend to conduct rigorous focus groups for this work, but found that using a final year cohort of undergraduate students, split into six groups with facilitators shows some of these benefits, such as a greater willingness to discourse, as suggested by Kitzinger (1995).

A brief initial presentation of the app was made to a group of Level 6 students studying the Interprofessional Studies module. Students who take the module are from BSc courses of Architectural Technology, Building Surveying, Quantity Surveying and Construction Management (Project Management). They have all studied U-values and heat loss from buildings during Level 4 of their courses. Several weeks later, the students used the app in group work and their reactions were recorded with their permission with audio recording devices (android apps and MP3 recorders). Out of a group of approximately 50 students, only one student owned an android phone, the rest were using iPhones. Prior to the session, the app had been installed on five android tablets; the one student with an android phone also installed the app at the start of the session. The students were split into six groups of approximately eight students in each group; academic members of staff briefly demonstrated how to use the app and then let them continue doing a heat loss survey, with occasional assistance from staff.

Student responses during group work

Group One
After the group had been using the app for several minutes and had entered some U-values, they were asked by a member of staff if they had any comments. One student said, "*I'm not quite sure I understand when the app would be used. Do you design it (the building) and then do the calculation (with the app)?"* It was explained that the app was designed for University researchers doing property surveys, to quickly show householders where heat loss was coming from. Once this was explained to the student, the purpose of the app became clear. A description of the app is given on the Google Play Store, however it had not been envisaged that someone would try to use the app without having read the description.
Because of this comment and reviews of the app on the Play Store, we decided to provide some basic instructions in the introductory text on the Home page.

Group Two
A student suggested the app would be improved by the incorporation of a U-value calculator, as the user might not know the U-values of the building being surveyed. As discussed in the Introduction section of this paper, links are provided within the app to UK Government documents in which U-values are given for the wide variety of building materials. A U-value calculator is fairly complicated and probably needs to be published as a self-contained app. U-value calculators are available online or as apps; some are published by construction/ insulation companies. Although linking to one of these would improve the usability of the app, it would imply endorsement of the company. If the UK Government were to publish such a calculator, that would be an ideal resource to link to from within the app. The text of the Home page of the app was amended to advise the user that U-value calculators are available online.

Group Three
Reluctance among the group to using android devices (as opposed to the iPhones which the vast majority of the students own) was shown by a student's first reaction to looking at the app being, "*I don't know how to use an android*." When the students were discussing with an academic colleague (an iPhone owner) how to switch between apps to check if the audio recorder app was running on the android tablet another student said, "*It's so un-user friendly*." It could be argued that this reaction is because over many years, students have learned how to operate Apple devices, rather than there being an inherent problem with android devices. A long-term android user might have the same reaction upon first using an Apple device. When this group had finished using the Heat Loss Calculator app, one of the students said, "*Shall we stop recording?*" at which point one of the students switched between the open apps and the recording stopped. One might conclude that android is not "so un-user friendly", once the user becomes familiar with it.

Prior to the group work, the Calculator page of the app had labelled the calculated total area field as "External Area". A change was made to the app after a student pointed out that "*When you're working out thermal bridging… you would never do it from your external dimensions*." Though a heat loss survey can be performed with either internal or external dimensions, to

avoid being unnecessarily specific about this, the label was changed to “Total Area” and a footnote was added to explain that the “Total Area” excludes party walls.

Group Four “*Because you can’t get the app on the (Apple) App Store, I used the Bluestacks emulator. But it just would not work for me. So if I had a criticism it would be that it is not available for Apple. I’m guessing there are cost implications there*.”
“*The pie chart would be better if the percentage was (displayed) next to the name (i.e. next to the section labels) on the pie chart, rather than having to click on the sections to see it. And have a Back button rather than press the (navigation) button in the actual app*.” To which another student responded, “*I think that’s purely because we are iPhone users. I think Android users would instinctively use that button to go back*.”

Group Five
“*The one thing I’d say would have to be changed (to improve the app) would be to make the drop-down U-values editable*.” In the original release of the app, the U-values in the dropdown menus were set at pre-determined values. Construction industry/ insulation professionals have also suggested making the U-values editable. The method of creating the drop-down menus was with android Spinners, which call pre-determined values from an
.xml file. These values cannot be altered at runtime. It will be investigated to discover if it is possible to make values editable with a different android method.

Group Six
Referring to the pie chart, students commented, “*The colours look a bit weird. A bit too vibrant*.” “*A bit bright*.” W3C Web Standards (Accessibility Requirements for People with Low Vision) state that, “Many people with low vision have extreme sensitivity to light (called photophobia). Bright light makes it difficult or impossible to see, and causes eye pain and headaches.” As a result of this student feedback and after reading the W3C Web Standards, we decided to reduce the brightness of the pie chart colours. Further reading highlighted issues associated colour blindness for comprehending pie charts. Okabe and Ito (2018) have proposed a set of colors that is unambiguous both to colorblinds and non-colorblinds, displayed in Figure 6.

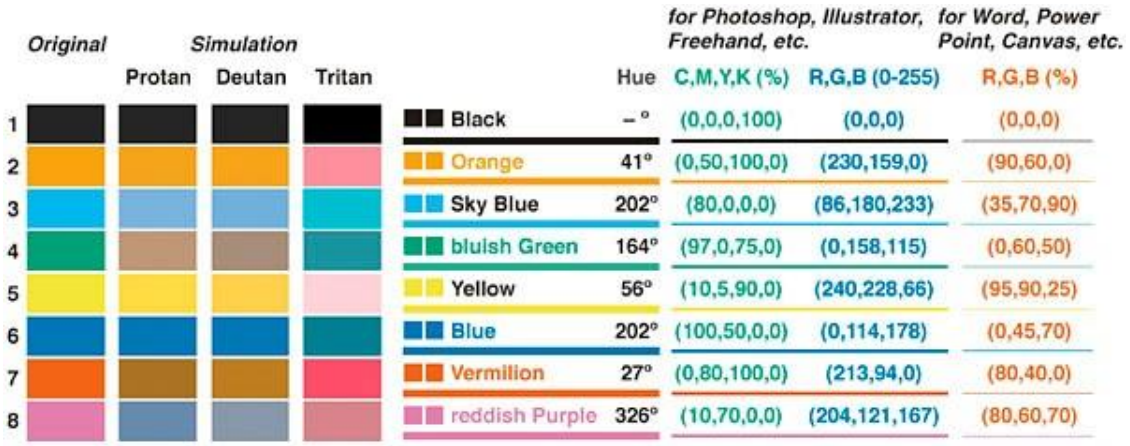

Figure 6. Colorblind barrier-free color pallet

This set of colours also fulfil the requirement of not being excessively bright, so they were used for the pie chart in the app.

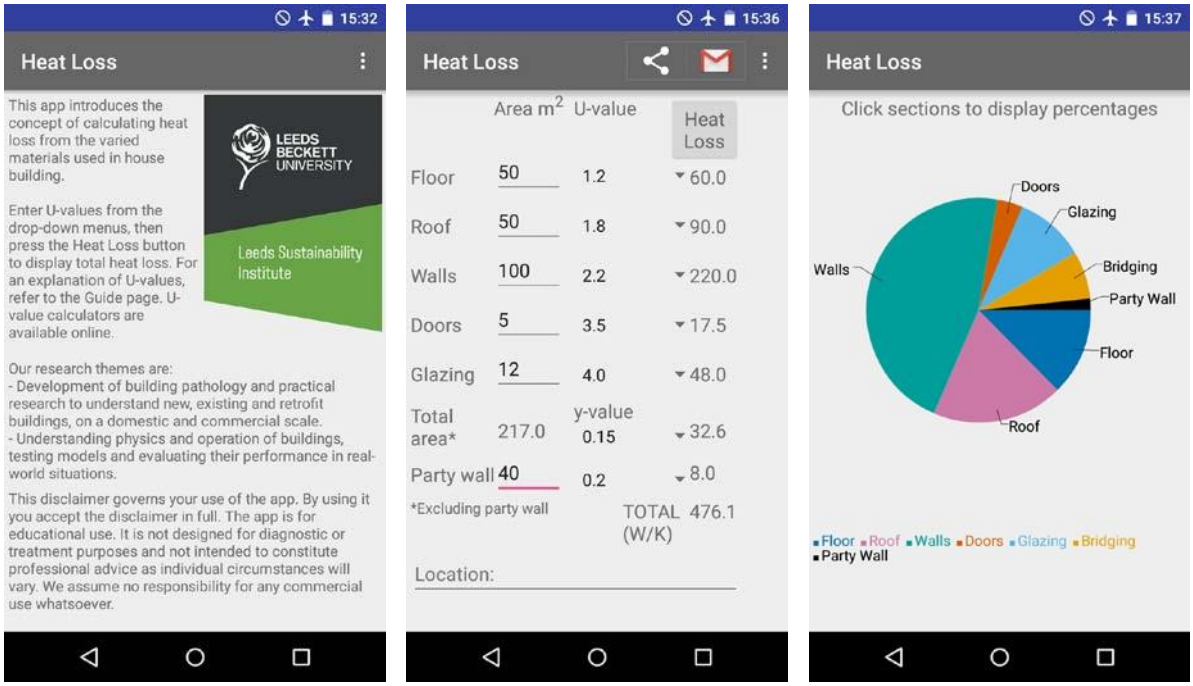

Figure 7. Screenshots of the app after the amendments were made.

CONCLUSION

From our experience, the ideal scenario for introducing e-learning tools to students is through a classroom group session, as suggested in Ellis et al. (2006) and further evidenced by our findings in this research paper. Group work seems much more effective than online surveys for gaining useful feedback. As can be seen from the types of responses to the two methods in the Methodology section, online surveys tend to produce one-sentence responses. Students are more forthcoming during group work; its conversational nature brings up issues and debate that individual working may not. Hsu and Ching (2013) have shown the interest in educators and students developing mobile apps to enrich learning environments. Although this app was not developed by students, asking students to test it can help in its iterative fine-tuning.

Thorough testing prior to release is vital to the success of an app. Alpha testing (generally within the publishers' organisation) and beta testing (external to the organisation) should be performed before releasing the app. Criticisms and suggestions for improvements are also likely to be made after the app has been released. Student group work produced several ideas for improvements that were subsequently included in the app. Group work prior to release of the app can be a useful testing method for the developer.

Creating e-learning resources as apps for mobile devices presents difficulties for the developer. The two dominant operating systems in the market, Android and iOS, require apps to be written in different development software (Android Studio and iOS SDK respectively) and in different computer languages (Java and XCode respectively). Writing an app for both operating systems entails duplication of significant amounts of development work. It may be advisable for the developer to take the approach of asking the student group which devices they are using before embarking upon writing the app. In the authors' case, this may have led us to decide to write the app for iOS. However, this may have reduced its potential use outside of the University, given the figures for worldwide smart phone sales. Student reports of difficulties when trying to run the app on Bluestacks make that an impractical solution. HTML5 app development may present a solution to this issue in the future.

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