

Implementation of interactive tutorials using iPads in Physics

Faculty of Sciences | Department of Physics

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Context

The iPad is an example of a disruptive technology (Christensen 1997) that has revolutionized our access to information, the sharing of multimedia content and the way we interact with digital data. In addition, the App Store provides a number of high quality educational apps. It is therefore natural to ask what impact this versatile device might have at the higher education level. To answer this question a number of universities have initiated iPad projects.

A methodology for iPad usage in a first-year physics module was proposed (Van der Ventel and Newman 2014) and is based on the idea that there are four key areas where the iPad can make an immediate impact in the educational environment. In this case study they specifically focus on the "Interactive classroom" component.

The efficacy of group work is indubitable in stimulating critical thinking and promoting the development of problem-solving skills (Hicks 1996, Flannely and Inouye 1998, Distler 2007, Schmidt, Van Der Molen, Te Winkel & Wijnen 2009, Currie, Biggam, Palmer & Corcoran 2012, Davies 2014). A relevant question is thus if the iPad could have a positive impact on the dynamics of group work during first-year university physics tutorials. Seventeen iPads were loaned by Core Computer Group, Authorised Distributor of Apple products, and Digicape, a local reseller of Apple products. Four apps namely, *Nearpod*, *Stick Around*, *BookWidgets* and *iCircuit* were used on these devices, of which three is discussed below.

Learning and assessment activities

This iPad project was run in the fourth quarter of 2014 in the non-calculus-based Physics (Bio) 154 module. It is a service course with an initial enrollment of about 720 students. Each language group has three lectures per week. During the fourth quarter there were four tutorials with three tutorials sessions per week.

A set of problems as preparation for the tutorial session was given a week before the time, with the actual set of tutorial problems available on the preceding Friday on SUNLearn. The tutorial officially ran from 14h00 till 16h00 with a 45 minute test starting at 16h00. During a tutorial session the students would be divided into three main groups namely (i) the iPad

group, (ii) the non-iPad group and (iii) the "special needs" group. The latter comprises students who were, based on their Matric and Physics (Bio) 134 mark, identified to be in need of additional assistance. The students who belonged to the special needs group had their own dedicated tutorial assistants and did not participate in this iPad project.

Since we had four tutorials spread throughout the fourth quarter, it meant that we could cover all 190 participating students if we allocated at least 50 students in the "iPad group" per tutorial afternoon. Table 1 provides a summary of how apps were distributed across the 4th quarter.

Tutorial Session	Topic	Apps
Tutorial 5: 22/09, 25/09, 26/09	Electrical forces, fields and potential	<i>Nearpod</i> , <i>Stick Around</i> , <i>BookWidgets</i> (for survey)
Tutorial 6: 06/10, 09/10, 10/10	Resistance, electrical circuits and Kirchhoff's laws	<i>Nearpod</i> , <i>iCircuit</i> , <i>BookWidgets</i> (survey and tutorial)
Tutorial 7: 13/10, 16/10, 17/10	Membrane potential	<i>Nearpod</i> , <i>Stick Around</i> , <i>BookWidgets</i> (for survey)
Tutorial 8: 20/10, 23/10, 24/10	Magnetic forces and fields	<i>Nearpod</i> , <i>BookWidgets</i> (for survey)

Table 1: Distribution of apps used for the tutorial sessions.

Learning environment

Nearpod (www.nearpod.com) is an app which is freely available from the App Store but the free version only allows 50 participants. This app is extremely well suited for group work and is based on the idea of creating a *Nearpod* interactive session via Wi-Fi. To start the *Nearpod* session the lecturer would first sign onto his/her *Nearpod* account and obtain a unique pin. The students can then become part of this session by signing on with this unique pin via their iPads. The presentation, which the lecturer created, is then downloaded onto each of the iPads which form part of the particular session. The lecturer has full control over the session as the progression through the slides is completely controlled by the lecturer on his/her iPad. Since access is obtained via Wi-Fi, the participants need not be in the same physical location and thus this app can truly revolutionize



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distance learning. The success of the session is unfortunately totally WiFi-dependent and therefore the speed and carrying-capacity of the WiFi connection must be thoroughly tested. Experience has shown that a weak or inadequate WiFi connection can totally destroy a session and lead to a sense of frustration and anger for all (lecturer and students) involved.



The *Nearpod* app was used for group work and all the questions in the tutorial were recast in multiple-choice format. In the figure we show a typical screen for one of these multiple-choice questions. If one taps on the question it will fill the whole screen. You can toggle between a full-screen view of the question or just a ribbon-view. The answers are listed below and the student can make a choice and then move on to the next question.

Consider Fig. 1 on the tutorial sheet. What is the correct combination for the direction of the force on the conductors?

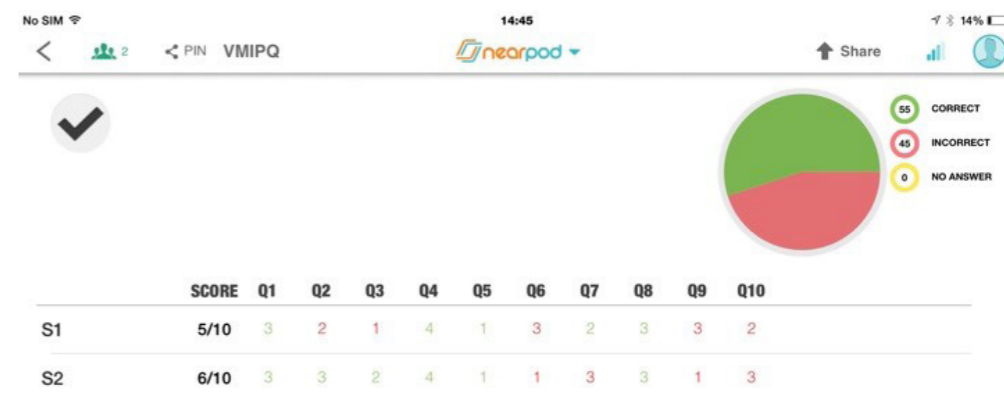
Consider Fig. 1 on the tutorial sheet. Choose the correct combination for the direction of the force on the conductors.

Direction	1	2	3	4
A	↘	↑	×	→
B	↘	↑	×	←
C	↘	↑	×	$F=0$
D	×	↓	↑	•
E	•	↑	↓	$F=0$

Vraag/Question 1



On screen, the lecturer sees the results while the students are busy with the questions.



It illustrates the list of students and the answers they give for each question, using green or red for correct or incorrect answers, respectively. The pie chart shows the distribution for "correct", "incorrect" or "no answer". The feedback is done in real-time and thus the lecturer can immediately see which groups are struggling, which questions are problematic and thus interventions can be made immediately. Here the role of the tutorial



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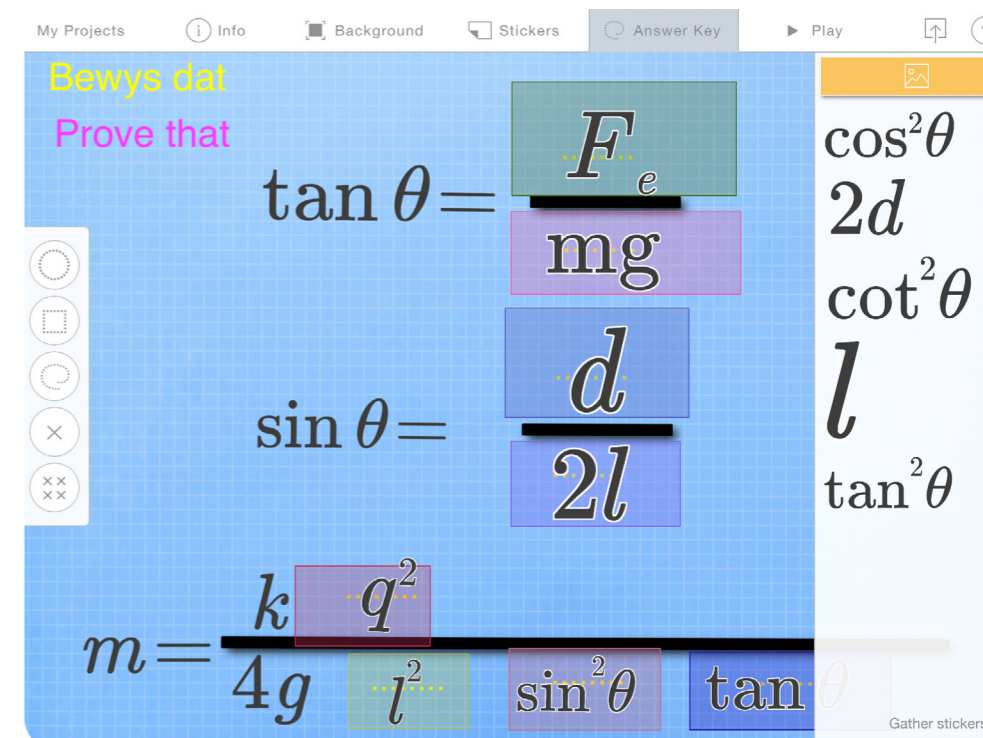
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assistants becomes critical. The instant feedback allows one to monitor the progress of the class as a whole and a judicious choice of multiple-choice questions can be very insightful. Our strategy during the tutorials session would typically be to let the groups work on a few problems and then stop to assess the progress. Those questions with red answers were reviewed and care was taken to thoroughly explain the solutions. A complete memorandum of the tutorial was made available on SUNLearn after the Friday tutorial session. At the end of the session, it is possible to generate a report containing some statistics regarding the session, for example how the answers are distributed across the groups and the number of correct answers per group and for the whole class.

Reflections on the *Nearpod* sessions:

- There were no intricate features of the app that the students had to master. They could immediately focus on the physics questions.
- The sessions greatly fostered interaction between the students in the group (see results of survey later).
- The nature of the multiple-choice problems allowed students to immediately identify where their problems with the work lay. This places a great burden on the lecturer to ensure that the problems are well chosen. In addition, modifying a problem in physics (which often-times necessitates a number of algebraic steps) is not that straightforward, even at first-year level.
- The lecture hall used was not really optimal for group work. A venue with a flat surface is preferable.
- Four students per iPad seem to be the limit before it becomes difficult for everyone to see the screen.
- There is a certain "fun" factor when using the iPad during group work.
- Great care should be taken when displaying the distribution of answers for the different groups. Students in a group should not feel as if they are being "identified" as giving the incorrect answers.
- A good practice is to let the students do a few problems and monitor the progress of the class as a whole. Based on the distribution of answers one can then either proceed or first pause and review one or two questions. The great advantage of the *Nearpod* app is the immediacy of the feedback. Within the first 30 minutes or so, the lecturer and the class can have an indication of the level of mastery of the work.

Another app, called *Stick Around* (<http://stickaroundpuzzles.wikispaces.com>) was used for group work. This app allows one to create multiple-choice questions in a pictorial way. This is done using the idea of "answer keys" or "puzzle pieces". The use of this app can be quite challenging for the instructor since it is not always that obvious how to pictorially present a problem which entails a number of algebraic steps. The easiest method though, is to implement the solution of the problem in the project creator and then remove "pieces" of this solution and define them to be the "puzzle pieces". This app works very well with pictorial problems such as force diagram or circuit analysis (in a Physics context). The figure shows two screen shots of the *Stick Around* puzzle.



The figure illustrates one problem which was divided into two parts. In the first part the puzzle was to identify the various forces acting on the masses. The answers appear as "stickers" which can be dragged from the white ribbon on the right-hand-side onto the canvas. The second part of this problem entailed a number of algebraic steps before the students can



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reach the final answer (an expression for the mass in this case). Here the three relevant expressions are given with placeholders for the stickers or puzzle pieces. These examples illustrate that conventional questions can still be asked within the **Stick Around** environment, provided a little effort is put into modifying the question. Note that it still tests the basic skills required of this problem namely (i) drawing a correct force diagram and (ii) algebraic manipulations to reach an expression. However, asking this question within the **Stick Around** environment adds a certain “fun factor” which must not be ignored and which renders the tutorial session a more pleasing experience for the student. Support for this statement is shown in the results of the student survey.

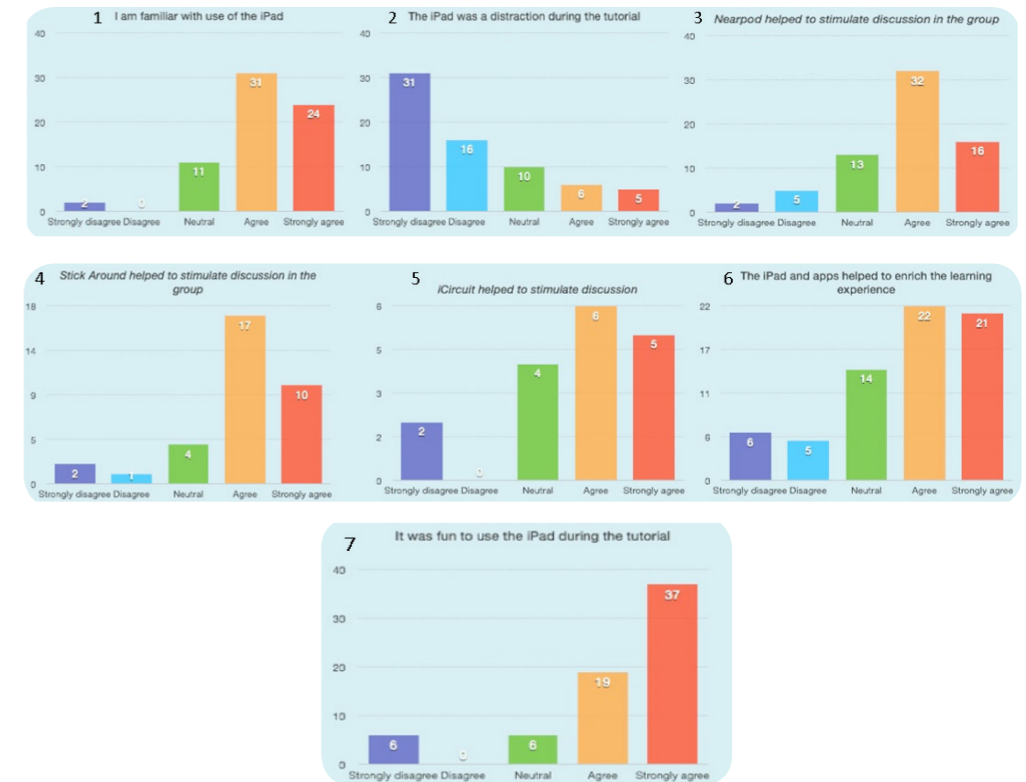
When using **Stick Around** the following must be kept in mind: the app allows the student to immediately check the answer after placing the puzzle piece. It occurred a few times that a group would place the stickers, check the result and then use a “trial-and-error” approach until the result is completely correct. This is where the lecturer and tutorial assistants must step in and discourage such an approach. **Stick Around** can greatly enhance discussions in the group but the role of the facilitator remains paramount.

Student experience

To ascertain the success of this pilot program a short survey was conducted after each iPad tutorial session. The **BookWidgets** app (<https://www.bookwidgets.com>) was used for this purpose. The students were asked to evaluate the following statements on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree):

1. I am familiar with the use of the iPad
2. The iPad was a distraction during the tutorial
3. **Nearpod** helped to stimulate discussion in the group
4. **Stick Around** helped to stimulate discussion in the group
5. **iCircuit** helped to stimulate discussion in the group
6. The iPad and apps helped to enrich the learning experience
7. It was fun to use the iPad during the tutorial

The results shown in the figure are only from the Thursday sessions.



Analysis of the other data is still in progress. Question 4 only applies to tutorials 5 and 7. Question 5 only applies to tutorial 6. The students sharing an iPad were asked to reach consensus on each question.

The results are of course qualitative, but it is remarkable to see how many students agree or strongly agree that they are familiar with the iPad. A few did bring their own iPads and chose to use them during the tutorial sessions. There were also a few personal iPad minis and iPhones used by the students. It could be that these students who are familiar with the iPad come from a household with at least one iPad, even though they do not have one for personal use.

The overwhelmingly positive response to **Nearpod**, **Stick Around** and **iCircuit** in stimulating discussion in the group is a very encouraging feature of this pilot project. This is definitely worthy of further research, as peer-instruction is a very important part of the learning experience. Note that of these three apps, **iCircuit** had the steepest learning curve which had to be



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mastered before the app could be used. This had to be done within the 2 hours allocated to the tutorial and yet the students felt that it has a positive impact on the learning experience. This app is very comprehensive when it comes to circuit analysis and it testifies to the fact that a high quality app can have a direct impact on learning. In general the students felt that the iPad and apps enriched the learning experience. The simple “fun factor” when it comes to learning should also never be discounted and this is born out by the survey results.

General

The *Nearpod* app can positively impact group work and student-lecturer interaction. It can also revolutionize distance learning since all that is needed to be part of the session is a good WiFi connection. This app also allows instant feedback and both student and lecturer can be fully aware of the level of proficiency on a particular subject. All work can be uploaded to the cloud and synchronized across devices allowing instant access and the learning process can thus continue 24/7. The Apple ecosystem offers a big opportunity, i.e., it provides an authentic way of learning in an increasingly connected world. The textbooks, iTunes U and apps allows for a personalized learning environment. Assistive technology features are included standard and free of charge with the iPad. Content is experienced in an engaging way and the built-in apps allow for content creation. iTunes U offers an exciting opportunity for the University to develop both internal and public content. Students can access this content, which is hosted by Apple, anytime.

The iPad is however, very expensive and in an African context, this probably counts as one of the greatest weaknesses of implementing this device. Of course this is not totally insurmountable as one can always appeal to government or private-sector institutions for sponsorship. In addition, any tablet implementation might be viewed as expensive if it is perceived as an additional expense. If the project is assessed holistically though, and one considers what it can replace, e.g. printing costs, depreciation on printers (not to mention the advantage of using the devices in the first place) the cost of learning per student may remain the same or even decrease, while providing a better learning environment. The cost of the device must not be considered in isolation, but rather the total cost of learning per student. Unfortunately iPads are destructible devices and also prime targets for

theft. However, the device has a number of built-in security features to prevent unauthorized access and secure user data.

There are however, a number of factors which threaten widespread iPad usage within the African context. Firstly, there is the large number of students in a classroom. The reality is that we will most probably never reach the stage where each student will have an iPad to use in class. This is due to the fact that the majority of students do not have the financial means to purchase an iPad. It would be however, unwise to disregard the opportunities this device offers for education within an African setting. Governmental or private sponsorship could address the price-issue. Another possibility is that the higher education institution negotiates a special price-plan with one or more service providers that would allow students to purchase iPads at a reduced cost or arrange repayment over a longer period of time. The other alternative could be a deliberate decision by the institution to fund iPad rollout as was done at the University of Western Sydney (Rankine and Macnamara 2014). Coupled to the price of the iPad is the fact that a “knee-jerk” reaction might cause faculty or students to settle for lower-end tablet devices which do not offer the full support as Apple does. For example it was found that lower-end netbook tablets have as a major disadvantage due to the limited computing power they offer (Loch, Galligan, Hobohm and McDonald 2011). Wi-Fi access and the high cost of internet usage are also major threats to iPad usage.

Finally, the use of the iPad however, places a great burden on the instructor to ensure that apps enhance the learning experience. The motivation behind choosing apps must be very clear and the instructor must be thoroughly proficient in the use of the apps. If one decides to implement the iPad then there will most assuredly be a need to revise how the questions are posed and this can be quite time-consuming. The next phase in this study would be to devise more quantitative performance indicators to evaluate the impact of this versatile device in the higher education learning environment.

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