OBSERVING THE SKY WITH SMARTPHONES

REPORT ON A PEDAGOGICAL DEVELOPMENT PROJECT AT THE FACULTY OF SCIENCE AND TECHNOLOGY AT UPPSALA UNIVERSITY IN 2016

Erik Zackrisson & Kjell Olofsson

Astronomy Division, Department of Physics and Astronomy

INTRODUCTION

While cutting-edge research in observational astronomy usually requires access to large international telescopes, trained astronomers are still expected to have at least some basic knowledge of the night sky as it appears to the naked eye or when looking through a small telescope. Quite remarkably, this is a skill that astronomy students at Uppsala University in recent years have not received any training in, at any level.

The reasons for this are purely practical – while such exercises have existed in the past, they are work-intensive and notoriously cumbersome to schedule, especially for large student groups, as they require good weather, dark skies and usually access to a small telescope. The brightness of the night sky during summer also severely complicates the use of such exercises in summer courses in Sweden.

There is, however, a modern solution to this problem. A large number of free astronomy application programs (apps) utilize the compass, gyroscopes and accelerometers of smartphones and tablets (e.g. Ipads) to provide the user with an augmented reality view of the part of the sky at which the device is pointed. Apps of this type allow for simulated observations and effortless identification of celestial objects under any sky conditions – even observations carried out in the daytime and observations of objects that are located below the horizon.

The goal of the project *Observing the sky with smartphones* was to develop a set of exercises that make use of free, multi-platform smartphone/tablet apps and that would be suitable for implementation in the basic-level courses Orienteringskurs i astronomi (5 ECTS), Universums byggnad (5 ECTS) and the Bachelor-level course Astrophysics I (5 ECTS) with only small changes to existing course curricula. These exercises were meant to allow astronomy students to develop a general familiarity with the night sky. More specifically, these exercise should provide:

- Hands-on experience in identifying bright astronomical objects
- Knowledge on how to tell the difference between a star and a planet
- An introduction to one of the spherical coordinate systems used in astronomy
- Insight about how the night sky changes with observer position and over time
- Insight into the difference between astronomy and astrology (and why astrology is not considered a science)

A number of publications already report on the use of handheld devices (smartphones and tablets with GPS capabilities) in university-level astronomy courses at international universities (e.g. Gill & Burin 2013, Physics Teacher 51, 87; Meißner & Haertig 2014 Physics Teacher 52, 440). However, unlike the case for smartphones in high school astronomy courses – for which exercises are available through the science-on-stage initiative (http://www.science-on-stage.eu) – detailed exercises suitable for university-level astronomy courses do not appear to be publicly available.

While research into the effectiveness of specific approaches is very limited, the use of smartphones/tablets for sky observations fall under the category of augmented reality - based learning systems, for which there is a rich body of literature indicating that such tools are efficient in clearing up misconceptions about sky phenomena (e.g. Tian et al. 2014, International Journal of Computer Theory and Engineering 6, 396). To the best of our knowledge, smartphones or other handheld devices have not yet been incorporated into astronomy course curricula at any other university in Sweden.

PROJECT DESCRIPTION

In 2016, smartphone/tablet exercises were developed for the three courses Orienteringskurs i astronomi, Universums byggnad and Astrophysics I. The exercises differ slightly in content between the three courses but always contain 5-6 subtasks that need to be solved using a suitable device. The whole exercise should not take more than two hours in total to complete. To ensure that the students would be able to complete the exercises regardless of platform and operating system, a number of free astronomy apps available for Iphone/Ipad, Android phone/tablets and computers (Windows, OS X, Linux) were tested. The exercise text features recommendation on the most suitable software for each platform. For students who do not own a smartphone/tablet/computer, a browser-based option was also included that could be operated from a public computer, e.g. in a public library. A pen-and-paper option (based on a much older exercise) was also offered as a last resort, for those that simply could not get any of the recommended softwares to work.

Examples of exercise subtasks:

- Locate a sequence of famous stationary (stars) and moving (planets) objects in the sky and note their celestial coordinates in the equatorial system
- Investigate the change in the apparent orientation of constellations when the observer position is changed from the northern to the southern hemisphere
- Study the position of the Sun and Moon at the time of a historical solar eclipse
- Explore in what way the actual position of the Sun on your birthday differs from the astrological sign you are usually assigned in western horoscopes

A questionnaire to be completed at the end of the courses (with identical questions for all courses) was also developed to gauge the learning outcome of the exercises. This questionnaire was designed so that it could be completed regardless of whether the course made use of the exercises or not. This way, it would be possible to test for general knowledge about the night sky both in test groups (which had been subjected to the smartphone exercises) and in control groups (which had not).

The exercises have so far been implemented in Orienteringskurs i astronomi and Astrophysics I, but are still waiting to be implemented in Universums byggnad, since the exercises were not ready when this course was given in the summer of 2016.

Overall, the exercises have worked well, with only some minor technical difficulties noted. Most of our students seem to have access to smartphones or tablets, but not all of these have the gyroscope and accelerometer capabilities required for these astronomy apps to run. In these cases, solving the exercises from a computer appears to have been an acceptable alternative. So far, nobody has resorted to the pen-and-paper option. Some minor modifications to the exercises will be required in coming years, since it appears that a bug (possibly activated due to a software upgrade after the exercises were first tested) seems to prevent the time-travel option to function properly in one of the recommended apps – this app does not properly render the total solar eclipse that occurred in the northern part of Sweden in 1945.

EVALUATION

EVALUATION METHOD

Learning outcome

To assess the learning outcome of the smartphone exercises, a questionnaire was developed with 5 questions about naked-eye observations of the night sky. The idea is to apply this questionnaire both in courses where the smartphone exercises have been used and in those where they have not, in order to check for any gain in student knowledge due to the exercises. To make sure that as many of the people completing the questionnaire have actually done the smartphone exercises, it was decided to distribute it during the written exam. Please note, that since the questionnaire in practice steals some time from the actual exam (although no more than 5-10 minutes), it is clearly stated that it is voluntary to fill it out, and that this should not be attempted before the exam has been turned in. Although this will naturally result in a reduced number of questionnaire being handed in, this was still considered the most practical solution.

The five questions are:

1) You are standing under a starry sky and spot a bright celestial object that does not appear to be moving. Do you know how to identify this object using a smartphone or tablet? (Yes/No)
2) Do you know how to tell the difference between a star and a planet in the night sky just from looking at it? (Yes/No)
   In case of a positive answer, the student is also asked to explain how to go about this
3) Do you know the names of any of the three brightest stars (other than the Sun) in the northern hemisphere?
   In case of a positive answer, the student is asked to list these names.
4) The student is provided with a list of 7 objects and is requested to mark those that can be seen from Sweden without binoculars or a telescope (there are only 3 correct answers).
5) Do you feel confident that you can identify the North star in the night sky? (Yes/No)
   In the case of a positive answer, the student is also asked to mark it on a sky chart.

The ability to pinpoint the North star is important, since this is likely to be the only potentially life-saving skill that astronomy students at this level (or at all) are likely to acquire. If you are lost in the wilderness under a starry sky with an uncharged phone, the north star will allow you identify the direction north and can therefore help you find your way back to civilisation. Please note, however, that the ability of finding the North star in a 2D sky chart is not quite the same skill as finding it in the night sky – it is quite possible that students may be able to find it in the sky without succeeding on the star chart, and vice versa.

So far, this questionnaire has been used in all three courses Orienteringskurs i astronomi, Universums byggnad and Astrophysics I. However, it is only in Orienteringskurs i astronomi, which was given twice in 2016, that we currently have data from this questionnaire both before and after the introduction of the smartphone exercises. The analysis below therefore only applies to this course.

Student satisfaction

Student satisfaction was also measured as part of the course evaluation in Orienteringskurs i astronomi (where the exercise were considered compulsory). The students were then asked to grade these exercises on a scale from 1 (worst) to 5 (best). Based on a question on the actual exercise sheet, it seems that the average time required to complete the exercises is indeed less than two hours, as intended. The students that did not have access to suitable hand-held devices seemed content with completing the exercise on a computer. Some students that had access to suitable devices still reported slight technical difficulties due to deficiencies in the ability of the app or device to navigate properly, but with only a few exceptions it seems that the exercises could still be completed.

RESULTS

The results from the questionnaire (measuring student knowledge) and the course evaluation (measuring student satisfaction) measurement both suffer from small-number statistics, due to the limited number of students that chose to fill out the forms.

Based on 16 replies in the course evaluation of *Orienteringskurs i astronomi*, fall 2016, the average grade for the smartphone exercises was 4.47 out of 5, which was slightly better than the course as a whole (4.25 out of 5). Hence, these exercises are considered good to very good by most students.

The questionnaire indicates positive learning outcomes for a couple of topics, but also several topics for which the measured change is too small to be statistically significant given the small sizes of the test and control groups. With ≈15 students in each group, we here consider changes of ≤17% to be insignificant, since there is a significant probability (≈1/3) that such changes are simply due to random sampling effects.

Positive outcomes:

- Before the introduction of the smartphone exercises, 53% (8/15) of the students claim to know how to identify celestial objects using a smartphone or table. After the introduction of these exercises, this fraction has risen to 100% (16/16).
- Before the introduction of the smartphone exercises, 80% (12/15) of the students claim to be able to identify the North star in the sky, but only 47% (7/15) can actually demonstrate this on the sky chart. After the introduction of these exercises, a similar fraction (88%; 14/16) claim that they can do it, but the fraction that can get it right on the sky chart has increased to 69% (11/16).

Cases without clear-cut improvement:

- When asked to mark the astronomical objects that can be seen from Sweden using naked-eye observations, the fraction of correct and incorrect answers are very similar in the test and control groups. A total 30 correct (79%) vs. 8 incorrect (21%) options were marked before the introduction of the smartphone exercises and 39 correct (83%) vs. 8 incorrect (17%) after the exercise were introduced. Considering that one of the smartphone exercises required the students to infer that the Alpha Centauri system (our nearest star) definitely cannot be seen from Sweden, it is rather disheartening that the fraction marking it as visible in the questionnaire (40% before the introduction of smartphone exercises and 31% afterwards) did not drop more than it did.
- When asked whether they know the names of any of the three brightest stars visible in the northern hemisphere (excluding the Sun), the fraction dropped from 80% (12/15) to 69% (11/16) after the smartphone exercises were introduced. The fraction of correct to incorrect replies among those that claimed to know some of these did not change appreciably (79% percent correct before and 83% correct after the introduction of the exercises).
- Before the introduction of the smartphone exercises, 47% (7/15) of the student claim to know how to tell a planet and a star apart through naked-eye observations. After the introduction of these exercises, this fraction changed to 62% (10/16).

DISCUSSION

Based on the outcome of the questionnaire, it seems that the exercises developed are highly successful in providing the students with technical know-how, as the fraction of students that think they are able to identify celestial objects a using smartphone or tablet doubled when the exercises were introduced. When it comes to astronomical knowledge retention from the exercises, the results are more mixed – with only insignificant increases (≈15%) in the fractions of students that can tell stars apart from planets and the fraction that can pinpoint the North star on a sky chart. Why ≈1/3 of the students still believe that the Alpha Centauri system (containing our closest neighbour stars and our closest Earth-like exoplanet candidate) is visible from Sweden, even though they all handed in an exercise solution where they arrived at the opposite conclusion, is a bit puzzling.

It must be kept in mind these results are limited by small-number statistics (only 15-16 participants in the test and control group). The reliability will increase when the poll results from the Universums byggnad and Astrophysics I courses are in. To put the statistics on an even more secure footing, the sizes of the test and control groups will however both need to increase. While the former is accomplished simply by retaining the exercises and questionnaire for a number of years, the latter requires that exercises are withdrawn from use on some occasions when these courses are given.

It will be particularly interesting to see the results from the course Universums byggnad, which out of these three courses is the one that content-wise is the most detached from actual astronomical observations. Indeed, the control-group questionnaire from this course indicated that 0% (0/19) of the students were able to locate the North star. We are of course hoping for a significant improvement once the test-group results are in.

We foresee that the exercises will live on in the three courses Orienteringskurs i astronomi, Universums byggnad and Astrophysics I, as they are perceived as fun and rewarding by the students (based on grade 4.47 out of 5 in the course evaluation of Orienteringskurs i astronomi and free-text comments on the exercise sheets). The correction of the exercises is not very time-consuming (4 hours per course) and the technical problems associated with these exercises are minor. The fraction of students that need technical support to complete the exercises moreover appears to be very small. The students that lack access to a suitable handheld device have completed the exercise on a stationary computer. So far, no one has opted for the pen-and-paper substitute exercise.

SUMMARY AND CONCLUSION

The project has been successful in the sense that the exercises and the evaluation questionnaire were developed and implemented according to schedule. The evaluation suggests that the exercises are effective in providing the students with the technological know-how required to identify celestial objects and to find the North star. Improved learning outcomes in other areas appear too small to assess given the limited sizes of test and control groups. The statistics will, however, improve with every course in which the exercises are used.