Human Computation (2014) 1:2:165-175

ISSN: 2330-8001, DOI: 10.15346/hc.v1i2.7

Using a Citizen Science Approach in Higher Education: A Case Study Reporting Roadkills in Austria

FLORIAN HEIGL, University of Natural Resources and Life Sciences Vienna, Austria

JOHANN G. ZALLER, University of Natural Resources and Life Sciences Vienna, Austria

---

ABSTRACT

Citizen cyber-science as a crowdsourcing method is gaining popularity around the world especially in projects dealing with environmental issues. Many European universities are faced with increasing student numbers along with unchanged numbers of advising lecturers and professors. Thus, a challenge for natural science educators is to teach and transfer knowledge despite weak lecturer-to-student ratios. In search for a solution to this problem, we applied a citizen science crowdsourcing approach in an obligatory course of the Bachelor programme of Environment and Bio-Resources Management at the University of Natural Resources and Life Sciences Vienna, Austria. The project, called BOKUroadkill, engaged students in reporting roadkilled animals they observed during their daily routine over a period of three months. Data collection was carried out via a freely available, customized mobile app (EpiCollect) that ran on students' private devices or via an additional online reporting form for students without smartphones or tablets. After three months, 109 students reported 1,236 animals killed on roads, analysed roadkill patterns, and provided feedback on the project. Based on this feedback, we developed a new online platform extending the project for all citizens to participate (www.citizen-science.at/roadkill). Based on our experience with BOKUroadkill, we conclude that a citizen science approach in higher education is suitable for (1) courses with weak lecturer-to-student ratios, (2) addressing important elements of motivation for learners and (3) familiarizing students with scientific research. Our results indicate that citizen cyber-science projects can well be developed as student projects initially before extending the project to a broader public.

---

1. INTRODUCTION

Mobile technologies (e.g., smartphones, tablets, phablets) are becoming increasingly important in our daily lives. Europe is among the continents with the highest smartphone penetration (The Boston Consulting Group, 2013) where in some countries such as Austria, 88 percent of the 16 - 24 year old inhabitants use mobile devices with internet connections (Statistik Austria, 2013).

At many European universities there is a trend towards increasing student numbers without a consecutive increase in the number of lecturers and professors (Education, Audiovisual and Culture Executive Agency, 2012). This poses a problem especially for courses in natural sciences which thrive on an applied approach by demonstrating different organisms in laboratory courses, making experiments, or guiding field excursions. Therefore, a challenge for natural science educators is to teach and transfer knowledge at weak lecturer-to-student ratios and maintain student experiences with the natural world.

To maximize student learning in the natural sciences despite weak lecturer-to-student ratios, we used a citizen cyber-science approach and took advantage of the increasing Smartphone penetration among students for the benefit of both education and science. We believe that citizen science with its crowdsourcing character in combination with mobile technologies is a perfect methodological approach to be implemented in tertiary education. Citizen science by definition links professional scientists with the general public to achieve goals focused on education, outreach, and science (Irwin, 1995; Silvertown, 2009; Bonney et al. 2009; Dickinson et al. 2012). Moreover, citizen science as an educational approach can stimulate intrinsic and extrinsic motivation involving challenge, control, sensory and cognitive curiosity, imagination, competition, cooperation and recognition (Ciampa, 2014).

Applying citizen science methods in natural science education benefits both students and teachers. By including smartphones, a student can use a familiar device both to communicate with friends and peers and to participate in scientific projects, which may lower the barrier to engage with scientific research. On the other hand, teaching scientists benefit from this approach by (i) engaging many more students at the same time and (ii) by making teaching more attractive to them because these students can actually collect data for a scientific project over a great geographical range or at high intensity that would be difficult without this citizen science approach (Gura, 2013; Bonney et al., 2014). From this it follows that a negative development such as weak lecturer-to-student ratios could take a turn for the better in higher education.

We conducted a case study asking whether citizen science is an appropriate tool for higher education in ecology courses. We addressed the problem of animal roadkills to test whether it is possible to connect education and applied science. Animal roadkills are familiar to everyone and also demonstrate human influence on the environment in a drastic way. Moreover, the topic of animal roadkills can be used to explain ecological processes and animal behaviour (e.g., migration of animals for mating and foraging and territorial behaviour) while raising student awareness of human road traffic behaviour.

2. MATERIALS & METHODS

The project was called BOKUroadkill and was conducted over 12 weeks (6 March – 3 June 2013) as part of a semester-long course entitled "Biology of Terrestrial Animals" in the Environment and Bio-Resource Management Bachelor Programme at the University of Natural Resources and Life Sciences, Vienna. The course consists of a lecture, a laboratory, a field excursion and a student project. In the lecture, students get acquainted with the theoretical background of animal biology and ecology. In the laboratory, students learn animal identification skills and how different ecosystems are characterised by specific groups of animals. During the field excursion, students are guided through three different ecosystems near Vienna (a riparian forest, a backwater and a grassland) where they collect and describe animals (e.g., invertebrates, vertebrates) inhabiting these ecosystems. For the student project participants are required to write a brief scientific report on a research question. Three different project choices were offered during the semester, including participation in BOKUroadkill. Students were required to successfully complete all four parts of the class to earn credits for the course; in 2013, 233 students chose BOKUroadkill for their project work. The assignment called for students to report roadkill findings during their daily life using either a smartphone app or a custom-made online-form.

2.1 Data collection and validation

Data collection was enabled by utilizing EpiCollect, a generic framework, consisting of mobile phone software and a web application (Aanensen, Huntley, Feil, al-Own, & Spratt, 2009). EpiCollect for Android and iOS allows multiple data records to be entered and stored on a mobile phone (text variables, GPS position, photo, etc.) and to be sent to a central web database. Data on this web database can be displayed and analysed, along with previously collected data, using Google Maps or Google Earth. Similarly, data from the web database can be requested and displayed on the mobile phone, again using Google Maps. Data filtering options allow the display of data submitted by the individual field workers or, for example, those data within certain values of a measured variable or a time period. In the BOKUroadkill form, we encouraged students to upload a photo of the roadkilled animal and additionally included 20 queries regarding the classification of the roadkilled animal, the surrounding landscape and the weather conditions when the roadkill was found (Table 1). In order to include participants without smartphones, we additionally created an online reporting form using the university's e-learning system based on Moodle (BOKUlearn, learn.boku.ac.at, Figure 1), which was synchronised with the central project website using a Hypertext Transfer Protocol. The online reporting form was only accessible for BOKU students after login at the university's website. Data collected on the smartphones are stored locally on the device until synchronised with the central project website. All data collected by BOKUroadkill are stored in a free and open repository, namely the Google AppEngine (https://code.google.com/p/epicollect/).

Table 1. **Explanation of data fields in the mobile app and the online form of BOKUroadkill.**

Field Properties	Data Field	Required	Mobile Phone	Online Form
Free Text Field	Date of observation	x	x	x
	Observer name	x	x	x
	Species name		x	x
	Number of individuals		x	x
	State		x	
	Country		x	
	Speed limit		x	x
	Temperature		x	x
	Notes		x	x
Dropdown Menu	Observation time	x	x	x
	Animal class	x	x	x
	Animals age		x	x
	Street type		x	x
	Traffic intensity		x	x
	Precipitation		x	x
	Surroundings	x	x	x
	Waterbody	x	x	x
Other	Location	x	Via integrated GPS	Via Google maps
	State			Automatically via Google maps
	Country			Automatically via Google maps

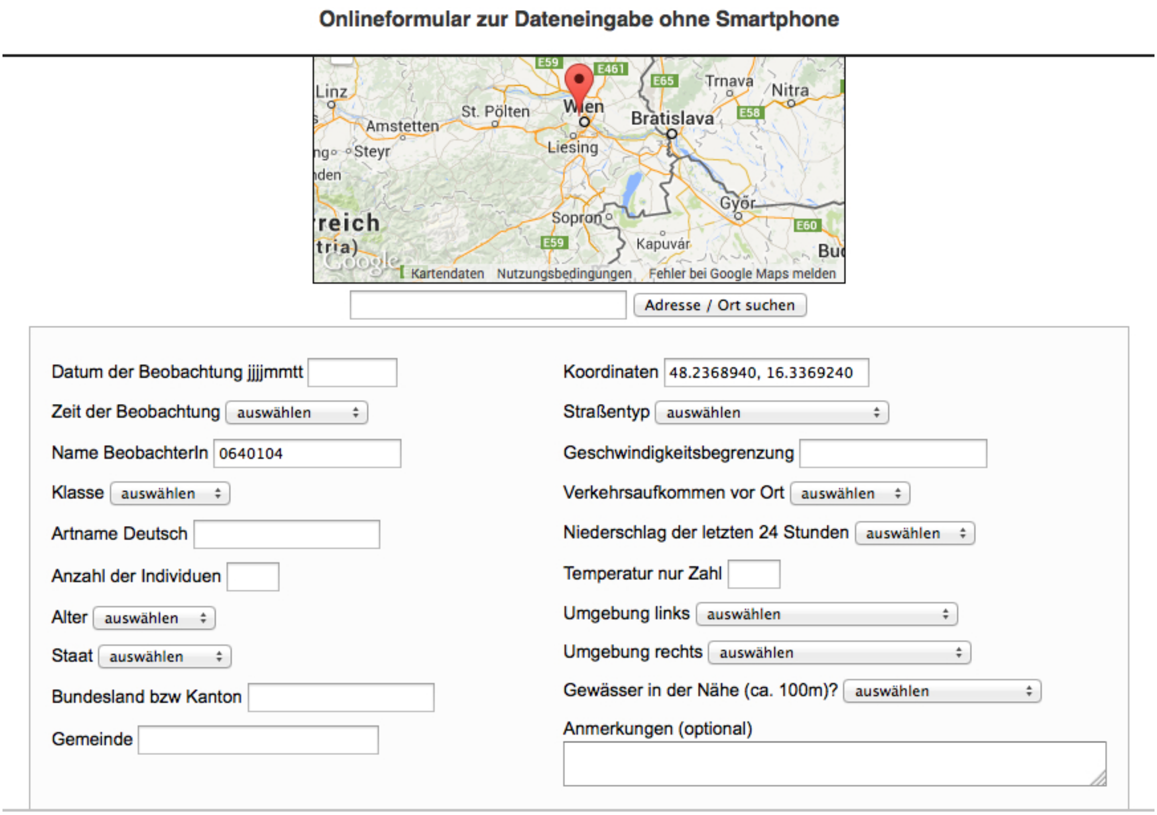

***Figure 1*. This figure shows a screenshot of the online reporting form in the e-learning system including a map for locating the roadkill and queries regarding the classification of the roadkilled animal, street category, traffic, weather and surrounding landscape.**

2.2 Data Validation

At least two people of the project team validated all entered data for plausibility. In stage one, during data collection, records were checked for errors; records were approved or corrected for inclusion or discarded. In stage two, after data collection was finished, the total database was again checked for errors. Misidentified species were verified when a photo was available; in cases where species discrepancies were too great, the record was removed from the database. Duplicate submissions (e.g. a roadkilled animal was observed by two students) would have been encountered when identical coordinates for roadkills were combined having similar dates; in such cases the record with the newer date was discarded.

The original dataset of the submitted observations is maintained at the EpiCollect server and at local computers at the Institute of Zoology, University of Natural Resources and Life Sciences, Vienna.

2.3 Student's data analyses and feedback

All verified data were accessible for participating students who were required to analyse the data and write a one-page scientific report. Therefore, students generated a hypothesis based on the theoretical background provided in the lecture. Afterwards they tested the hypothesis by analyzing the data in relation to the hypothesized factors influencing roadkill patterns (e.g., speed limit, surrounding landscape). The results needed to be illustrated by a graph, described and discussed in 200 words maximum. Additionally the students had to provide a half-page feedback survey related to their experience in working with the app and the overall feasibility of the project within the course environment. We collected the feedback surveys using the university e-learning system based on Moodle (BOKUlearn) and summarized the feedback to inform an implementation in follow-up projects.

3. RESULTS

In stage one of the data validation, we had to correct or discard individual records only. Most corrections were necessary regarding typing errors or different spellings in the free text fields (e.g., the county name Niederösterreich was written Niederoesterreich, Niederöstereich or NÖ). Other errors were misidentified species, mostly amphibians which were misidentified as reptiles (Figure 2) and vice versa; these cases were corrected when a photo for verification was available. No duplicate submissions were found. After stage two of data validation, 96.7 percent of the submitted roadkills were approved for inclusion. Therefore, the scientific integrity of the provided data from the students was assured through expert validation.

Figure 2. An amphibian (*Salamandra salamandra*), which was misidentified as reptile

Of the participating 233 students, 109 students (47%) reported 1,236 animals killed on the road during the three months project duration, the remaining students did not encounter any roadkill during the duration of the project (Table 2).

Table 2. Taxonomic group and number of roadkills reported by students during the project (6 March to 3 June, 2013).

Taxon	Individuals
Amphibians	352
Reptiles	17
Mammals	236
Birds	114
Miscellaneous	517
Total	1236

After data collection and verification, 78% (N = 182) of participating students submitted their homework assignment and provided feedback on the project (Table 3). In general, students felt that that there was a good relation between the necessary effort in participating in the project and the things they learned and credits they earned. In particular, 54 students stated that they gained large personal benefit from the homework assignment, which involved roadkill data analysis. Additionally, 57 students reported increased sensitivity and awareness towards roadkill.

However, several students (N = 35) also complained about device errors and technical difficulties when using the app or synchronizing data to the EpiCollect server.

Table 3 - Summary of queries and responses comprising student feedback to BOKUroadkill. The number of student responses to each query is shown in parentheses.

Query	Comment/answer
Time/effort expended on project	Adequate (82) High (1)
Data preparation as homework	Large personal benefit (54) No personal benefit (8)
Utility of the online data form (in Moodle)	Self-explanatory (62) Confusing (10)
Personal benefits and knowledge gain	High (30) Low (8)
Relevance of the project for nature conservation	High (46) Low (1)
General positive points	Increased roadkill awareness (57) A good way to learn scientific working (35) Offer of an online alternative for non-smartphone users (22) Using smartphones in education increase learning progress (15) I increased roadkill awareness among others (10)
General negative points	Malfunction of the app (e.g., synchronisation problems, screen freeze) (35) Road type and road safety limiting scope of data collection (29) Difficulty in finding roadkills (17) Laborious online form (14)

4. DISCUSSION

Citizen science programs have the potential to promote ecological understanding and an appreciation for the interconnectedness between humans and the environment (Reynolds & Lowman, 2013). In contrast to most other citizen science projects that are conducted in informal science education (ISE), we employed a citizen science project in formal science education (FSE) at a university during a course within a Bachelor programme. The relationship between the goals of scientists and non-scientist participants is very different in the ISE projects (Bonney et al., 2009) compared to FSE scenarios (Berkowitz, 1997). Following Zoellick, Nelson, & Schauffler (2012) the biggest difference is the need to achieve specific research and learning outcomes in FSE settings requiring logic models.

In BOKUroadkill we combined the citizen science crowdsourcing method and natural sciences higher education for the reasons described in the introduction, but did we succeed in meeting the education goals? Were the students more interested in the topic after they participated in the project? Following the criticism of L. Annaevs Seneca in 62AD that we don't learn for life, we learn for school ("Non vitae, sed scholae discimus"), we did not want the students to learn just for the exam, but rather we wanted them to think discretely about ecological problems and their solutions. Students' feedback statements indicated that we indeed reached our education goals: The students expressed the feeling that they learned scientific working in an applied way – from defining a hypothesis, to gathering data, analyzing data, making graphs and interpreting the findings. The project increased their roadkill awareness when gathering data and thinking about the findings. In addition, participants found that over the course of participating in this project, they became more sensitized to wildlife and conservation issues and will more likely share this awareness with others. In this way, students acted as knowledge multipliers increasing the topic of the project and citizen science in general.

On the other hand, student feedback showed they had some difficulties with the software (EpiCollect) and the digital form on our website. It remains to be seen whether the updated version of the software EpiCollect+ (http://plus.epicollect.net) with more features and many software bugs fixed will be less prone to errors. Based on the feedback provided by the participating students, we developed a new online platform where all citizens can participate. In the new project Roadkill at www.citizen-science.at/roadkill, we simplified the online form and made it open for every operating system. Similar to EpiCollect, the participants get immediate feedback after entering data by an interactive map (based on OpenStreet Maps) and some basic statistics (e.g., number of roadkills, overview of roadkilled taxonomic groups etc.). Additionally, all registered participants can take part in the data validation in a discussion forum; this also helps beginners in identifying roadkilled animal species. This is in contrast to the data validation in BOKUroadkill, where just two to three members of the project team checked the submissions. Overall the new platform is much easier to handle than the project based on EpiCollect and is expandable to various future citizen science projects.

5. CONCLUSION

Based on our experience with BOKUroadkill, we conclude that a citizen science approach in higher education is very suitable for addressing important elements of motivation for learners: challenge, activity, curiosity, control, imagination, cooperation, competition and recognition (Malone & Lepper, 1987). In BOKUroadkill, every student could choose his or her level of challenge by working with more or less complex datasets. The level of activity was met by short-term and long-term goals; we set clear goals for the student project and also aggregated the observed data into a database for long-term monitoring. Using their own mobile phones, the students could actively take part in science, interactive feedback was provided immediately by pinpointing the roadkill location on the map – this fostered curiosity. Also, students acknowledged the fact that at least parts of the data they collected will be published in peer-reviewed scientific journals and that their effort resulted in valuable pieces of new information to scientific knowledge. Students also had the full control over the time, place and effort of their participation effort, from just analyzing some data to proposing a hypothesis, collecting data and interpreting them. Roadkill is a very clear topic and through illustrations on our new website (Fig. 3), we encouraged students to also use their imagination to think about underlying causes for roadkills in new ways which might ultimately generate innovative scientific questions and problem solutions. Since citizen science depends strongly on cooperation, the cooperation element was obvious in our project. However, for ethical reasons, we did not want to foster competition in BOKUroadkill, because monitoring killed animals should not be seen as a game where the participant reporting the most roadkills might be seen as the winner. Finally, the participants get recognition by reporting roadkills, because every data entry creates a pinpoint on a map and contains the name of the person who entered the data.

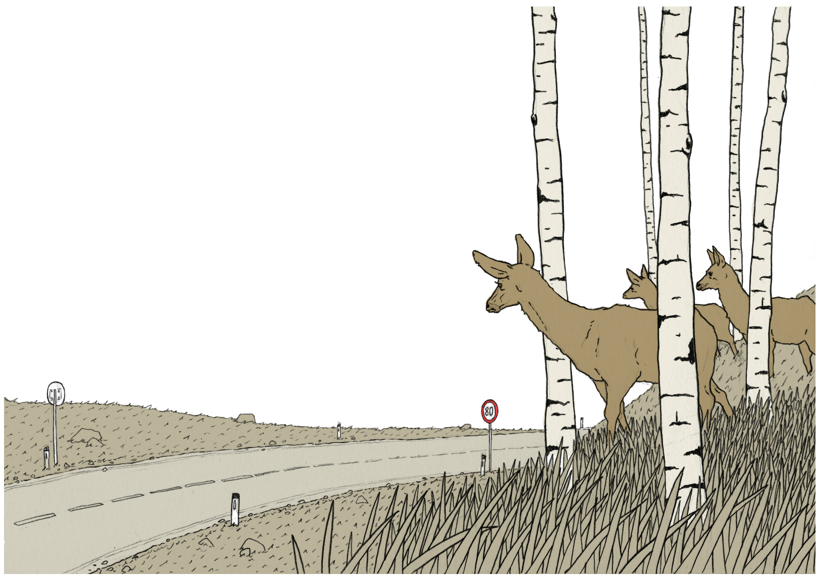

Figure 3. Example illustration from the new project website.

Taken collectively, in this project we demonstrate that a citizen science approach could be used to familiarize hundreds of students with scientific research methods while additionally collecting valuable data for ecological research. As many universities are challenged by steadily weakening lecture-to-student ratios in natural sciences, educators are encouraged to take advantage of the mobile devices used by students and embed citizen cyber-science projects in their courses.

6. ACKNOWLEDGEMENTS

We are grateful to Simon & Benjamin Dauth for help with programming the app and in supervising participating students and. We are deeply grateful to Horst Hellmeier for his illustrations and Julia Freinschlag for designing the project logo. The BOKU Institute of Zoology financially supported the set-up of www.citizen-science.at.

7. REFERENCES

Aanensen, D. M., Huntley, D. M., Feil, E. J., al-Own, F., & Spratt, B. G. (2009). EpiCollect: Linking Smartphones to Web Applications for Epidemiology, Ecology and Community Data Collection. PLoS ONE, 4(9), e6968. doi:10.1371/journal.pone.0006968

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy. BioScience, 59(11), 977–984. doi:10.1525/bio.2009.59.11.9

Bonney, R., Shirk, J. L., Phillips, T. B., Wiggins, A., Ballard, H. L., Miller-Rushing, A. J., & Parrish, J. K. (2014). Next Steps for Citizen Science. Science, 343(6178), 1436–1437. doi:10.1126/science.1251554

Ciampa, K. (2014). Learning in a mobile age: an investigation of student motivation. Journal of Computer Assisted Learning, 30(1), 82–96. doi:10.1111/jcal.12036

Education, Audiovisual and Culture Executive Agency. (2012). The European Higher Education Area in 2012: Bologna Process Implementation Report.

Dickinson, J. L., Bonney, R., & Bonney, R. (2012). Citizen Science: Public Participation in Environmental Research. Cornell University Press.

Gura, T. (2013). Citizen science: Amateur experts. Nature, 496(7444), 259–261. doi:10.1038/nj7444-259a

Irwin, A. (1995). Citizen Science: A Study of People, Expertise and Sustainable Development. London: Routledge.

L. Annaevs Seneca. (62AD). CVI. In Liber Septimvs Decimvs Et Octavvs Decimvs.

Malone, T. W., & Lepper, M. R. (1987). Making Learning Fun: A Taxonomy of Intrinsic Motivations for Learning. In Aptitude, Learning, and Instruction (Vol. Volume 3: Conative and Affective Process Analyses, pp. 223–253). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Reynolds, J. A., & Lowman, M. D. (2013). Promoting ecoliteracy through research service-learning and citizen science. Frontiers in Ecology and the Environment, 11(10), 565–566. doi:10.1890/1540-9295-11.10.565

Silvertown, J. (2009). A new dawn for citizen science. Trends in Ecology & Evolution, 24(9), 467–471. doi:10.1016/j.tree.2009.03.017

Statistik Austria. (2013). Europäische Erhebung über den IKT-Einsatz in Haushalten 2013.

The Boston Consulting Group. (2013). Mobile Economy Europe 2013 (p. 136). Retrieved from http://gsmamobileeconomyeurope.com/GSMA_Mobile%20Economy%20Europe_v9_WEB.pdf

Zoellick, B., Nelson, S. J., & Schauffler, M. (2012). Participatory science and education: bringing both views into focus. Frontiers in Ecology and the Environment, 10(6), 310–313. doi:10.1890/110277.