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Article

Geography Geo-Wiki in the Classroom: Using Crowdsourcing to Enhance Geographical Teaching

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Abstract: Geo-Wiki is a crowdsourcing tool used to derive information, based on satellite imagery, to validate and enhance global land cover. Around 5000 users are registered, who contribute to different campaigns to collect data across various domains (e.g., agriculture, biomass, human impact, *etc.*). However, seeing the Earth's surface from above does not provide all of the necessary information for understanding what is happening on the ground. Instead, we need to enhance this experience with local knowledge or with additional information, such as geo-located photographs of surface features with annotation. The latest development in enhancing Geo-Wiki in this context has been achieved through collaboration with the University of Waterloo to set up a separate branch called Geography Geo-Wiki for use in undergraduate teaching. We provide the pedagogical objectives for this branch and describe two modules that we have introduced in first and third year Physical Geography classes. The majority of the feedback was positive and in, many cases, was part of what the student liked best about the course. Future plans include the development of additional assignments for the study of environmental processes using Geo-Wiki that would engage students in a manner that is very different from that of conventional teaching.

Keywords: crowdsourcing; Volunteered Geographic Information; land cover; Geo-tagged pictures; Climatology; Physical Geography; web based teaching

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1. Introduction

Crowdsourcing, Volunteered Geographic Information, and Citizen Science [1–3] are all terms applied to the recent trend in using the crowd to collect data and to carry out simple analytical tasks that can aid scientific research, e.g., making observations of birds, classifying galaxies, or determining the structure of proteins [4–6]. The potential of using citizens to collect environmental data has been recognized by the US government, the European Union, and numerous space and environmental agencies and has additional value for education, society and policy-making [7].

Geo-Wiki is one example of an increasing number of crowdsourcing sites. The focus of Geo-Wiki is on the collection of information about land cover using high-resolution satellite imagery from Google Earth. The driver behind the application is the need to improve global land cover datasets derived from remote sensing [8,9]. Global land cover is an important input for many environmental applications, yet recent studies have shown that there are large spatial disagreements between the main land cover products available [10]. At present, there are around 5000 registered Geo-Wiki volunteers, where the collective contributions have been used to create an improved global map of cropland [11] and to validate existing maps, e.g., evaluation of a map of land availability for biofuels [12].

Geo-Wiki has evolved over time from a single website focused on land cover to many different branches that have been customized for specific purposes, e.g., a biomass Geo-Wiki for visualization and validation of global biomass datasets; a cities Geo-Wiki for collecting urban morphology for climate modeling, *etc.* A Geo-Wiki mobile application has also been developed for collecting land cover and other thematic information on the ground to improve the amount of *in situ* data available for land cover calibration and validation. However, the application can be used for other purposes, e.g., by students, to input and share information within an educational context.

The aim of this paper is to describe the development of a branch of Geo-Wiki called Geography Geo-Wiki, which has been modified specifically to address challenges in teaching an undergraduate curriculum. The role of the Geography Geo-Wiki in teaching Physical Geography and Climatology, in particular, is discussed in the next section. This is followed by an overview of the Geo-Wiki tools developed for the classroom, and details of the assignments that students undertook as part of piloting these tools with undergraduate students. Student feedback from course evaluations is provided and then discussed in terms of how this will inform future developments.

2. Geo-Wiki as a Component of Geographical Teaching

One objective of a university education is to guide the student towards thinking in a new and more profound manner. The role of the professor has evolved from the outdated concept of a "big cup" filling a "little cup". Instead, current higher education has evolved towards providing the environment and the opportunities to move from "thinking like Aristotle to thinking like Newton" [13]. We want to encourage the student to challenge their intuitive sense of the world and explore new constructs. In a study of "outstanding" teachers, Bain [13] observed that a common thread is the understanding that "knowledge is constructed, not received". A frustration experienced by teaching staff is that information presented in a traditional lecture is modulated in the student's consciousness by existing mental models and experiences that will be unique for each individual; hence the teacher may not know what the student is

actually learning. "Deep learning" is the process by which each student is guided to build new mental models that will test their traditional expectations and forge new ideas.

For university level introductory Geography courses, the teacher's challenge is to encourage students' thinking to move beyond the common perception that the subject is one of identification of places and features (what we may call the vocabulary of the subject) to the understanding and exploration of processes (what we may call the syntax of the subject). This is vital if students are to become informed participants in policy and cultural debates that address environmental change and degradation—one core focus of the subject of Geography. In particular, they must comprehend their role as part of the system processes. The "plug and chug" approach of filling in formulae and memorizing schematics is not appropriate, nor does it encourage the students' intellectual development. Rather than memorizing facts, students must be presented with opportunities to explore new visual constructs of the planet that includes their role and activity in the evolution of the planet system. They should find out how things work and how their actions affect the future. To motivate the student to learn, s/he must be individually involved in the process of discovery.

This challenge coincides with increasing stress on preparing higher education staff to be better teachers. No longer is the traditional experience of graduate school research an adequate model for a university career. We can no longer emulate our own experiences. We are being encouraged to do things in a significantly different way from what we are doing now and provide a "learning-centered" education [14]. We need to create learning experiences for the students that are never forgotten.

The recent development of on-line mapping and display of a variety of spatial information resources offers a tremendous opportunity to address these objectives for Geographical teaching. Google Earth, Bing Maps, OpenStreetMap, and many other similar platforms have revitalized the cartographic stream of Geography by creating "Citizen Cartographers". This has fostered a new industry of spatially orientated "apps" and activities. These maps and apps have become the base for innovative visualization and analytic tools for information analysis. For a spatially oriented discipline such as Geography, this provides wonderful opportunities for student engagement, which can be defined as a "…dynamic process that consists of making sense and meaning out of new information by connecting it to what is already known." [15]. Using spatial constructs in new and innovative ways of studying geographical issues can contribute to significant 'active forms of learning' which is one of five core principles of excellence in teaching [14].

The Geo-Wiki tools discussed in this paper were originally developed for research purposes but there is also great potential for their use in education. Some recent Geography texts have used Google Earth as a platform for interactive assignments. The ability to combine remote sensing imagery, digital cartographic tools, *in situ* photography and supporting textual or voice documentation opens up new possibilities for student engagement and inquiry. We propose that they can be a transformative approach to incorporation of new technology that is becoming second nature to current students. They may incorporate social media that will build a sense of community amongst the students and engage them in the discovery of course content as revealed in their everyday activities. Traditional laboratory exercises are transformed into travel adventures that can be readily updated to incorporate, for example, regional impacts of recent volcanic eruptions or the impact of sea ice decline.

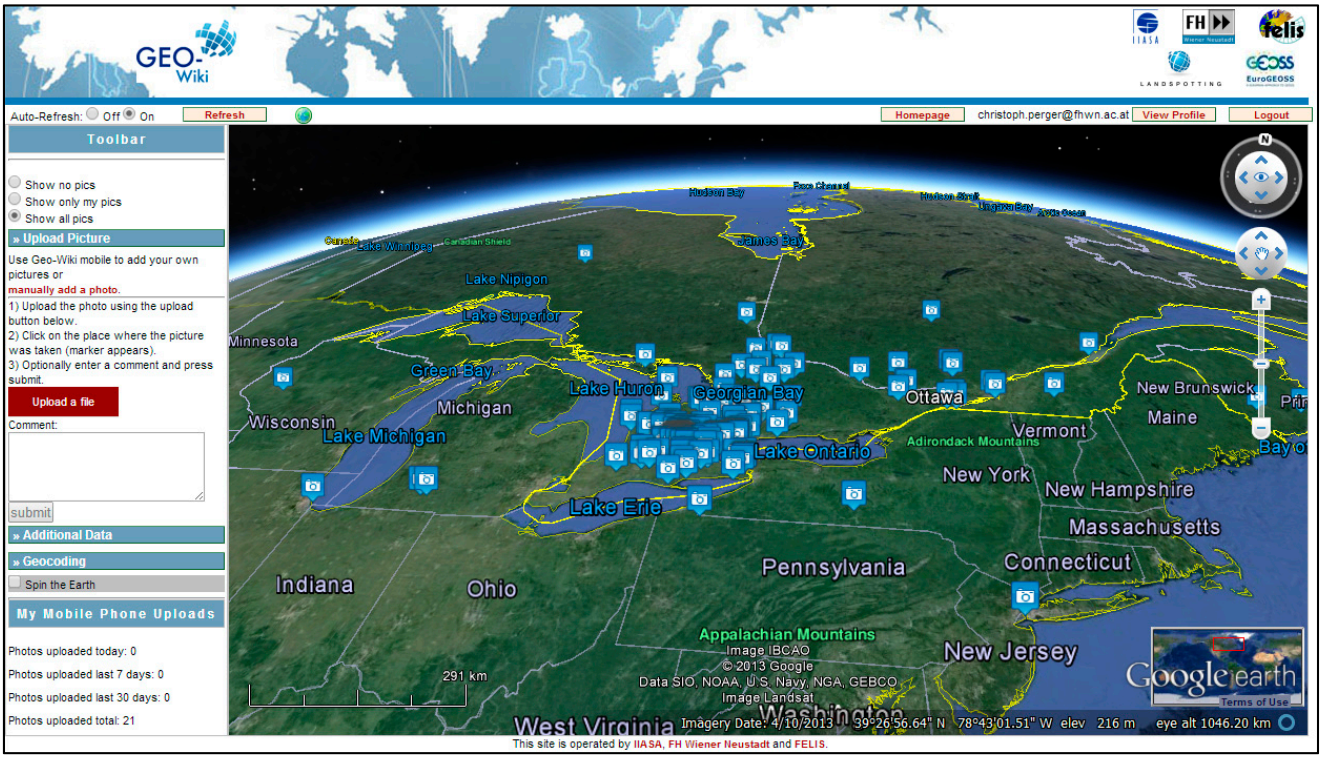
3. Geo-Wiki Crowdsourcing Tools for the Classroom

In this section we outline the two main tools that were developed for assignments in undergraduate classes given by the Department of Geography and Environmental Management at the University of Waterloo in Canada.

3.1. The Geography Geo-Wiki Online Application

A branch of Geo-Wiki was created called Geography Geo-Wiki, which currently has two main assignment types that have been piloted with students. The first assignment type is focused on sharing geotagged photos along with the relevance of the photo for the assignment. The interface was designed to be simple and easy to use since it was anticipated that this environment would be quite different to other assignment environments experienced by already stressed first and third year undergraduates. In addition to the Google Earth browser-plugin, which is used as the mapping component of the online application, there are just four main functions that are listed within the left hand column of the page (Figure 1).

Figure 1. The Geography Geo-Wiki user interface for the photo assignment type, with picture markers from the whole group in the Great Lakes region.



There is a toolbar that allows users to display or remove the photo markers on the map. It also allows users to decide whether or not to display only their own uploaded photos or all of the photos uploaded by the class community. There is also functionality that allows users to upload and geo-tag pictures, and to then add comments to describe the situation on the ground and the reason why a particular picture has value in the context of the assignment.

The link entitled ‘Additional Data’ allows users to show Google’s border and street layer so that they can orient themselves on the map while the “Geocoding” link allows users to enter an address or coordinates to quickly move to an area of interest.

Other users can view the uploaded pictures and information by clicking on the picture markers displayed on Google Earth. Clicking a marker will open a so-called “balloon window” as shown in Figure 2. The content of this window provides a small preview of the picture and the comment that a given user has entered, and also information about the user who uploaded the picture and the time and date of the upload.

The full resolution version of the picture can be viewed by clicking on the previewed photo. There is also a link on the bottom of the balloon window to rate this picture (Figure 3), which will then open in a new browser tab. Each submission will show its average rating and the number of users who rated it. The quality of the photos and the accompanying commentary are rated on a scale of one to five stars, which is then submitted to the system, where the overall rating is an average of multiple rating submissions. This feature is as an extension of well-known social media interaction protocols to help provide linkages between members of the class community. Indeed, we found that students were submitting more postings than were required as the Geo-Wiki became part of their typical social communication between friends. Building a sense of community within a class is an important component of an “active-learning” approach to teaching [15] and appears to be one attraction of this platform for the students.

The second type of assignment piloted with students involved much more interaction with the Google Earth imagery, as shown in Figure 4. Students were provided with a lecture on the study area and the relevant geographical features as well as reading materials to accompany the lecture. The assignment then consisted of a series of multiple-choice questions which students were then required to answer, along with justifications for their choices to demonstrate a deeper engagement with the material.

Figure 2. Example of a picture and information shown in a balloon window in Google Earth.

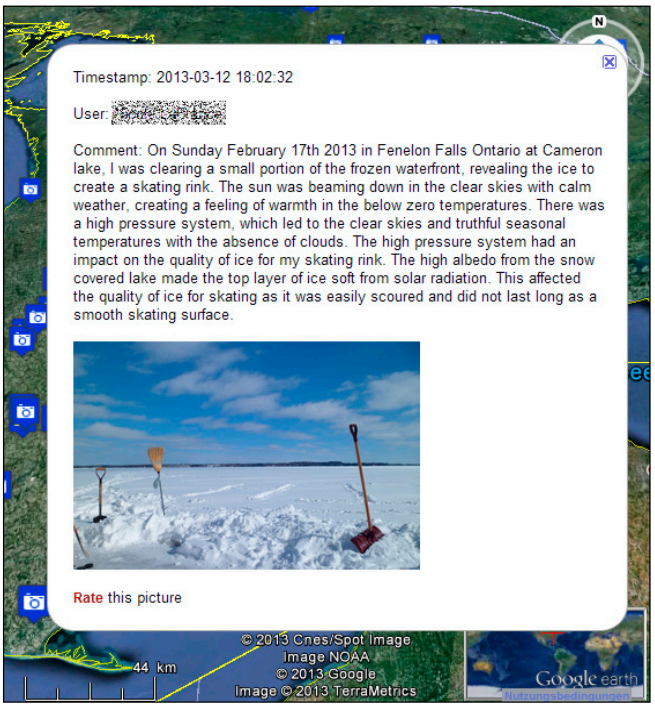
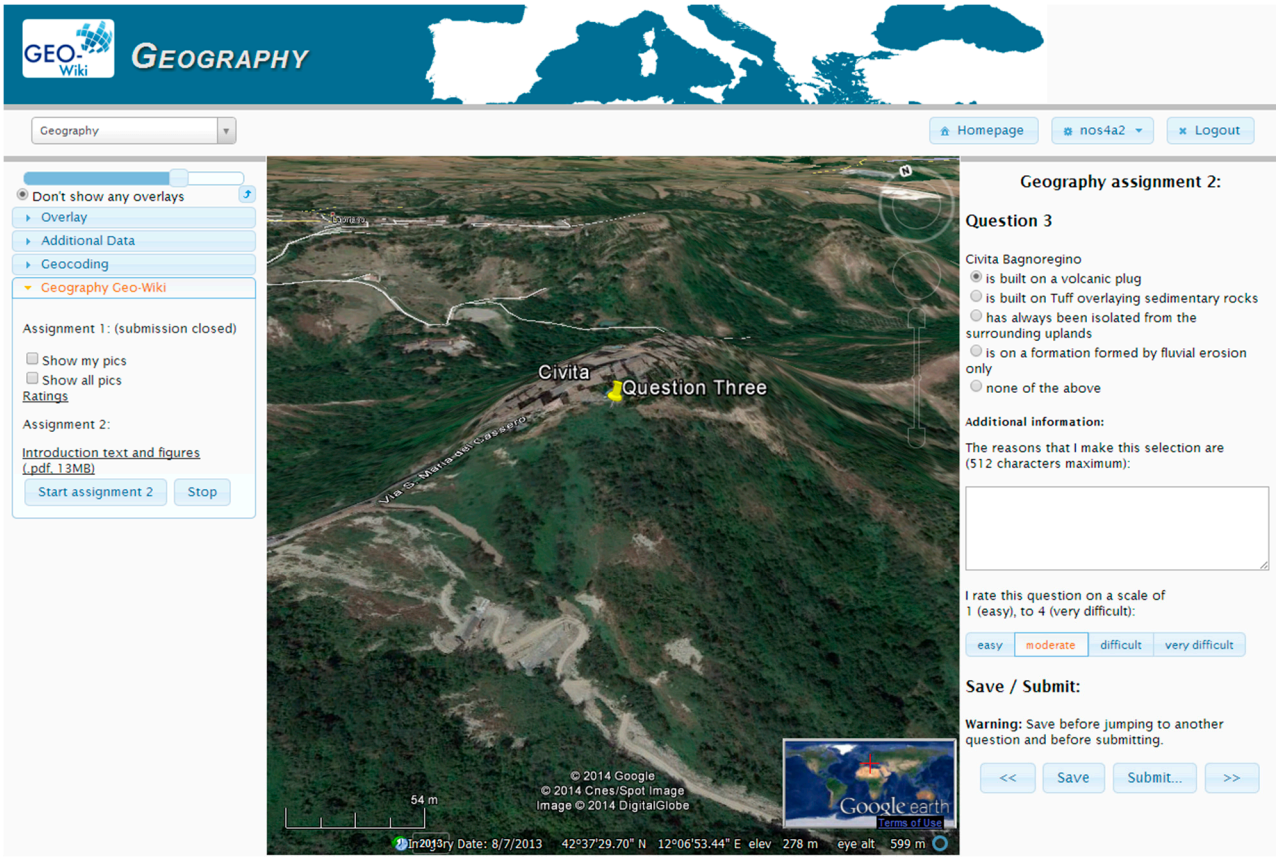


Figure 3. The rating page for an individual photo.

Figure 4. Example of a more interactive type of assignment utilizing Google Earth.

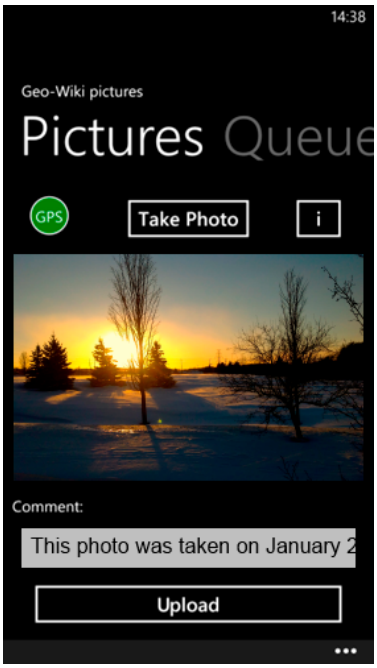


3.2. Geography Geo-Wiki Mobile Application

The Geo-Wiki pictures app (Figure 5) is a freely downloadable app for collecting geo-referenced photos with orientation, land cover or any other feature of interest and any other comments or measurements in the field. The legend can be customized so that any type of thematic data can be collected on the ground, e.g., crop type or tree species. The photos can be uploaded automatically using the data connection on the phone, or the pictures can be stored in the application and uploaded later when a Wi-Fi connection is found, in order to eliminate mobile data charges. In addition to this information, the app automatically stores and uploads metadata with the picture. Metadata includes the tilt of the smartphone and the compass direction in which the device was heading, as well as the GPS altitude and accuracy. All the photos and associated data are uploaded with the date and time of the image acquisition.

The app was originally designed for *in situ* data collection of land cover and other thematic information but has been used by students as part of the Geography Geo-Wiki exercise to collect and upload photos to Geo-Wiki. This tool was used in conjunction (but not exclusively) with the first photo assignment type described in the previous section.

Figure 5. The Geo-Wiki pictures app with an example picture, the optional classification and the comment and value fields.



4. Piloting of the Tools

Details of the Assignments

The Geo-Wiki tools were used in two different courses: a first year Physical Geography class taught for two terms and a third-year class in Climatology.

The purpose of the first assignment for the first year-class in Physical Geography and the third-year class in Climatology was to encourage students to take the lessons from the class into their daily

environment and develop the ability to observe and assess the impact of what is affecting their ongoing activities. Traditionally, assignments in texts have evolved around maps, airborne or satellite imagery or descriptions of events and features at some distant location. The learning process becomes associated with a formal and traditional publication-based environment as opposed to experiential learning. By using a mobile app it is possible for the student to engage directly with their environment and think about how s/he as an individual is affected by it. Furthermore, the study of Geography has fostered many notable photographers who use the medium to illustrate and understand the landscape and the people. Learning to express one's intellectual interaction with the environment through visual interpretation of that environment is an important learning process that is enabled with this app.

Each student was asked to take two pictures of Physical Geography related events and/or features that affected their personal day-to-day activities during the semester. Students were asked to document these photos, which were then uploaded to the Geography Geo-Wiki site for visualization, sharing, and assessment by the professor and others in the class.

The topic could be any aspect of Physical Geography covered in class. This could include the role of an esker on the campus in the development of the campus master plan, how students responded to cancelled classes and tests that resulted from the university closing during a severe winter weather event, or the spring flooding of a campus waterway and the impact on access to various areas of the university.

Students were given the assignment at the beginning of the semester and the deadline was before the class finished so that the results could be reviewed in class. The two postings were awarded five marks each out of a final grade of 100. A minimal effort of an original photo and an intelligent discussion got the five marks. Oddly, some students asked if they could use photos that were already online, and one student wrote the sum total of "Blah" to describe a winter day. That did not make the grade.

A tutorial was available on the interactive resource site for the class and was also covered in the lecture. If students did not have an iPhone, Android, or Windows device from which they could employ the app, cameras were available for sign-out from the faculty.

The entry that was top rated by classmates and any entry top rated through a review by the professor was each shown in the last lecture, and the author was awarded a university souvenir as a memento.

In two iterations of the first-year Physical Geography classes there were 391 students who uploaded a total of 52 photos by mobile phone and 636 photos using the web upload facility. Of the photos uploaded, 183 were rated by peers. We were surprised at the number that opted to not use the mobile phone application and instead use the web-based upload facility.

The third year meteorology assignment was more specific in that the students were to document a weather event that affected their activities on a specific day through the semester. The assignment had the same academic weighting and time-line as for the first year class. There was a similar reward for the class-judged and professor-judged entries. This was held during the fall term of 2012 when Hurricane Sandy and the unusual convergence with a significant mid-latitude cyclone over eastern North America produced severe weather that provided many examples for discussion.

In this class there were 111 students where six uploads were made by phone and 191 were made using the web. In this class, a much larger number of ratings of photos was made relative to the first year classes, *i.e.*, 616. These assignments were all implemented using the first assignment type within Geo-Wiki, *i.e.*, upload, rating and discussion of geotagged photos.

This past winter, a new first-year class was also given the second Geo-Wiki assignment type, *i.e.*, the more interactive one. The focus was on the analysis of information provided by the satellite imagery on the Geo-Wiki site through a series of structured questions, additional web resources and *in situ* photographs of the features to be examined. The student was provided with a background document available as a pdf on the site that explained the learning objectives, provided some context, photographs and on-line references for reading that was necessary to answer the questions. The student was then directed to a wizard that worked through a series of multiple-choice questions. For each question, the Geo-Wiki automatically zoomed into the site of interest and the student clicked on one of a series of possible answers. The student was then given a free-form box to enter up to 512 characters explaining why that choice was appropriate in terms of the background information learned. The student then rated the difficulty of the question on a scale of 1 to 4 through click boxes.

For this initial trial, the questions were of two types. The first focused on identification of the process evident from the satellite imagery and from resources provided for the point of interest. The second provided a variety of photographs of physical features and the student was asked to select the best choice that matched the process evident for the point of interest.

The assignment was graded based upon the number of correct answers. This creates an environment where unwanted collaboration can be rife and undetectable. The students were told that this was to be an individual assignment and shared answers were unacceptable. With increasing emphasis on personal responsibility and integrity in the university learning environment [16], the University of Waterloo has chosen to require a student to accept responsibility for that integrity by acknowledging a statement before the assignment is submitted for grading, found at [17].

The topic of this assignment is the role of human intervention in the evolution of the 'Dying' town of Civita di Bagnoregio in Central Italy (Figure 6).

Figure 6. View of the foot bridge to the medieval town of Civita di Bagnoregio taken from the current Civita di Bagnoregio on the surrounding plateau. Photo by E. LeDrew, 2013.

The region encompasses an interesting history of natural and human-induced erosion which has isolated it from adjoining landscapes—erosion which is undercutting medieval dwellings and which has created some urgency for rehabilitation of a recently recognized tourist attraction. It is an excellent example of the linkage between human activities, potential for human intervention and an interesting visual landscape that can be appreciated from satellite image analysis. It also has ties to comparable landscapes in the Cheltenham hills close to the University of Waterloo in Ontario, Canada, and the South Dakota badlands of the Prairies, all of which can be seen from Google Earth or similar platforms.

5. Results

Student feedback is a critical component in the development of the pedagogical value of the Geo-Wiki. At the end of term, anonymous course evaluations submitted directly to the department administrator are mandatory for all courses. In addition to the usual rating scales for a suite of predefined questions, there is a free form section asking what the student liked best about the course and what changes would be desired. Although nothing systematic can be discerned from these course evaluations, anonymous comments (approved for publication by the Office of Research Ethics at the University of Waterloo) and summary statistics are instructive. Future work will incorporate a structured questionnaire specific to this initiative to elicit responses to more specific questions about the pedagogical approach.

Before the students filled in their evaluations, the professor specifically asked them to include comments about the Geo-Wiki when and if the student thought they would be appropriate as this would be a good venue to provide anonymous feedback. Teaching assistants then administered the evaluation.

For the winter of 2013, in the Physical Geography class, students were given the single photo assignment noted in the previous section. Of the 63 students (out of a total of 110 evaluations) who entered comments in the section for writing on what they liked best about the course, seven cited the Geo-Wiki. Of the 61 students who had suggestions for change, eight made comments regarding the Geo-Wiki, which included (not corrected for punctuation or syntax):

- not a very effective assignment choice.
- easiness of Geo-Wiki.
- often malfunctioned.
- did not seem like a university level assignment.
- no Geo-Wiki assignment" (presumably for the future).

For the winter of 2014 in the same Physical Geography class there were there were two assignments including the photo assignment (number one) and the multiple choice questions (number two). There were 102 evaluations in total. Of the 87 that contributed comments to the "What did you like best about this course?" section, 27 cited the Geo-Wiki. Comments included:

- More Geo-Wiki! Great way to do critical analysis.
- I enjoyed the Geo-Wiki assignments…
- The integration of the Geo-Wiki into assignments within the course.
- I enjoyed the Geo-wiki assignments. I did experience some technical issues (…), however I enjoyed doing them nonetheless (especially taking pictures).

- I like the innovation you showed by introducing us to Geo-Wiki. I admire the effort you clearly made to incorporate new technologies in the course that enhance our education.
- The second Geo-Wiki assignment was an interesting exercise.
- The geo-wiki assignment was creative and for the most part challenged us to apply Physical Geography to our world. Assignment 1 was fun!
- The first Geo-Wiki assignment. It was very interactive.
- The photo Geo-Wiki was really cool.
- I think that the Geo-Wiki tool is great, it elaborates the course material. Students are able to involve in the real earth through geo-wiki.
- Geo-Wiki assignment 2 was really neat. Another similar "field course" would be a great addition.

Of the 74 who responded to the "Would you like to see any changes to the course?" section, 45 provided written comments about the Geo-Wiki. These included:

- Geo-Wiki is an awesome tool, however the second part needs to be revised so answers are little more clear.
- The second GeoWiki assignment was confusing because I found most of the questions were not covered in the reading that was provided.
- The photo assignment was definitely interesting.
- I would like to see the Geo-Wiki run more smoothly but its understandable why it didn't.
- The first Geo-Wiki assignment felt purposeless. Most of my time used on it was spend waiting to find a decent photo rather than thinking about the geographical concept that applied to it.
- More background info for Geo-Wiki assignment 2.
- The Geo-Wiki site was a good addition to the course, however glitches such as the site crashing need to be fixed.
- The support with Geo-Wiki.
- Geo-Wiki is a very cool tool to use. It should be linked to Learn' (the DesireToLearn on-line class teaching and grading resource used in the class).
- Geo-Wiki assignment 2 comment section unnecessary.
- Description section (box) is too small.
- Geo-Wiki assignments were glitchy which caused some stress and wasn't ideal.
- Have help forums regarding assignments that have to do with the Geo-Wiki. As it's a new concept, having pointers on the site itself would be nice.

In their comments, students recognized the growing pains typical of the development of a new course component and the issues associated with online learning. They were willing to overlook some of those issues during the early development. Most suggestions were helpful rather than scornful. Some were difficult to interpret, as can be expected from in-class written evaluations with a short time allocation.

One respondent noted that the Geo-Wiki allowed the student to view weather events in a new light. It was a new way of learning and provided some variety in the way to earn marks. It also earned the moniker of a "cool concept". From a teaching perspective, for some it provided a new and perhaps interesting way of learning new material, a way to bring some of the "field experience" into the classroom, and a linkage to the online communication environment often used by students in their daily activities.

On the other hand, some students did not understand how it aided in their learning, and some thought it "soft".

What is interesting and somewhat perplexing is the low use of the mobile device photo app *versus* uploading a photo from the computer. It appears that students prefer to either download the photo from the mobile device to the computer for final uploading to the Geo-Wiki, or use a more traditional digital camera.

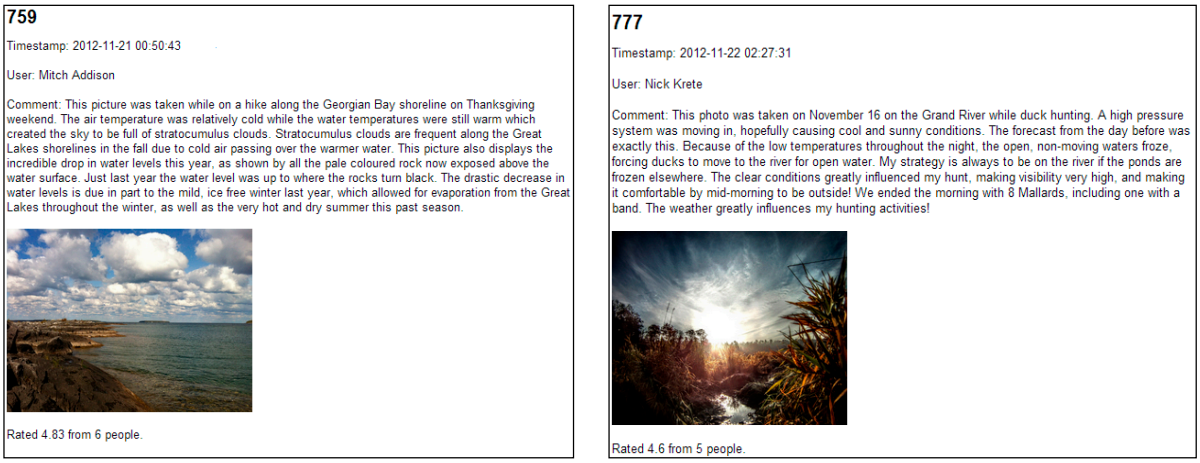
It is also clear that the instructions, background resources and questions have to be "bullet-proof". There is more preparation required by the professor and technical personnel than is the case for traditional in-class laboratory assignments. Typically these assignments have a mentor immediately available to address questions and clarify procedures. In the online environment students are not shy about emailing the professor at any time, including in the middle of a lecture, even though there may be several teaching assistants available. However, the email answers are one step removed from the personal interaction, may require several iterations for clarification of technical issues and a moderate time lag for a technical adjustment of software or access issues at the host end. Clearly this is a source of frustration by the student and will not be acceptable as the process matures.

Furthermore, the web itself holds challenges. We are not in control of the resources. What the professor may think is a suitable resource article on the web may not be so obvious a resource to the student if it has been edited or updated by the time of the implementation of the assignment. The map image online may be updated with a more recent higher resolution version that may be of a different time of the year, and this may happen during the semester.

We also have to think about how to be more articulate about the objectives and procedures of the exercise in the future. What we may think to be clear objectives and instructions in the assignment write-up or in the verbal discussion in class may have been modulated in the student's mind by the time they start the assignment away from the classroom and at a later time. The student may also have different expectations based upon other online experiences. Or the student may not have experienced the online culture that we anticipate, nor may they have the computer literacy in first year that we are growing to expect. We were surprised at the difficulty in following what we thought were clear instructions to register using their university email ID and found many used their off-campus email ID or created a new one. This made identification of individuals belonging to the class difficult. One student thought the process unfair since s/he was not "…a typical rich university student with all the newest technology". The message about the free availability of a digital camera for the course was lost in this case.

With the kind permission of the students, Figure 7 reproduces the two entries that won the popular and jury vote in the third year Climatology project. The impact on the Mallard duck population in the second illustration (number "777") was an outcome that was not anticipated.

Figure 7. The winning entries in a third year Climatology course based on (**a**) jury voting and (**b**) as judged by the professor.



(**a**) (**b**)

6. Conclusions

In higher education, the publishing model is changing from traditional and expensive hard copy texts to online and interactive tools that can provide a richer educational experience. Every new offering from a publisher has extensive web support facilities for the student and teacher that may include visual animations of technical concepts, video clips or links to external video and text resources, self-study modules, and self-administered tests. There is at least one example of a supplementary laboratory text using Google Earth as a map for paper-based questions with answers submitted to a publisher's online system.

The technical and application development of the Geo-Wiki described in this paper is at a stage where it is suitable for further development as a pedagogical tool that may be a natural fit to the social media culture of current undergraduates and be an important contribution to the future of online teaching resources.

As discussed in section two, the overarching objectives of this initiative were to improve the learning experience through:

- leading the student to think in a new and more profound manner.
- presenting the student with opportunities to explore new visual constructs of the planet that include their role and activity in the evolution of the planet system.
- involve the student in the process of discovery.
- create new learning experiences for the student that are never forgotten.
- develop opportunities for student engagement through active forms of learning.
- build a sense of community within the classroom for the student.
- engage the student in the discovery of course content as revealed in their everyday activities.

The two Physical Geography and Climatology assignments described herein were designed with these objectives in mind. This is clearly a first step. This first step has been sufficient to obtain initial user feedback needed for subsequent development. Feedback was obtained both in terms of the technical aspects of the delivery and adjudication as well as the pedagogical value of the approach. Although not as systematic as would be expected from a structured survey, course evaluations, as well as verbal and experiential evidence, will help with improvement for the next implementation. The Google Earth-based

approach is well suited to the spatial nature of Geographical inquiry and the use of social media technology and mobile platforms appears to be embraced by the undergraduates. The rapid rate of implementation of a module using online resources means that we can promptly incorporate natural events of human consequence, such as the impact of a major hurricane, catastrophic landslide or major flood, into the curriculum.

This has been the first phase in a larger plan. The ultimate objective of this initiative is to develop a series of assignments for the study of environmental processes that would use the Geo-Wiki as a platform to post photographs about a feature or event, store background documentation, and pose specific questions through an online wizard. The questions would be answered using a combination of this information and the Google Earth-based satellite imagery and cartographic resources.

We plan to develop a series of such assignments for both courses. The pedagogical value and engagement experience will be evaluated through ongoing structured feedback from the students. Additional assignments will be created once a protocol is developed in response to the student feedback and the academic objectives of the course.

In this study we have worked through some of the technical and administrative issues of using Geography Geo-Wiki in large class settings. The students recognized the challenges and accepted them as part of an effort to improve their learning experience. An encouraging portion of the feedback was positive and in many cases the Geo-Wiki was part of what the student liked best about the course.

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Author Contributions

Christoph Perger is the Software Designer responsible for the implementation of Geo-Wiki modules and smartphone applications.

Ellsworth LeDrew designed the curriculum, assignments and defined the pedagogical objectives. He collaborated on the pedagogical approach to the use of the Geo-Wiki.

Linda See contributes to the high level implementation of Geo-Wiki and the development of new applications. She has also collaborated on the development of the pedagogical approach adopted.

Steffen Fritz is the founder and principal investigator of the Geo-Wiki project and has collaborated on the development of the pedagogical approach adopted.

Conflicts of Interest

The authors declare no conflict of interest.

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