VGI in Education
– from K-12 to Graduate Studies

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Abstract. Volunteered Geographic Information (VGI) is making its way into an increasing number of fields within geographic information science. This development has raised a need to cover VGI at various educational levels, which has led to a number of new classes on VGI ranging from elementary through secondary school to undergraduate and graduate university curricula. In this paper, we give an overview of the state of the art of VGI in education at these different levels. We outline different ways of introducing VGI in class. Specifically, we have investigated the long-term effects of using VGI in education to find out whether students who have come across VGI in class remain interested in the topic and engage in the communities. For this purpose, we have created a survey that was circulated among students of past VGI classes at different levels. The evaluation of the 202 completed surveys gives an overview of motivations and impediments with respect to different VGI platforms. We conclude with recommendations for the future development of curricula covering Volunteered Geographic Information.

Keywords: Education, Survey, Spatial Learning

1 Introduction

Geographic information systems (GIS) and applications such as location-based services have made their way to the general public. Education systems in many different countries have realized their relevance and potential and have therefore developed new strategies to implement the use of geographic information as an integral part in their curricula, mostly starting in secondary schools (Bartoschek, 2010). The general aim is to foster competences such as spatial orientation, spatial learning and thinking, while using GIS as a support system (National Research Council Committee on Support for Thinking Spatially, 2006).

More recently, Volunteered Geographic Information (VGI) (Goodchild, 2006) has started playing an increasingly important role in the teaching curricula at different educational levels, from elementary and secondary schools (together referred to as *K-12 education* in this paper) through undergraduate to graduate classes at universities. The idea of using VGI in education has already been around since 1995, long before the term *Volunteered Geographic Information* was coined. At this time, Al Gore initiated the *Global Learning and Observations to Benefit the Environment*[1] program (GLOBE) that supports students and teachers in investigations of environmental issues. GLOBE is still operative and currently supported by NASA and the US National Science Foundation, among others. Evidently, this innovative idea took close to 15 years to be adopted on a broader scale.

The authors of this paper have gained experience in teaching at all the mentioned levels: Thomas Bartoschek has been coordinating the GI@School[2] program and worked with students in elementary and secondary schools, mostly in short projects in the context of geography or computer science classes and by training (future) geography teachers. Carsten Keßler has been teaching various classes covering VGI, including Introduction to GIS and project seminars around OpenStreetMap. In this chapter, reports on the personal experience we have made in teaching these classes serve as an entry point to a detailed review of the current use of VGI in education. We give an overview of the literature on the use of VGI in education followed by a classification of the multiple ways in wich VGI is being used in learning and teaching: (1) students working with VGI collected by others, (2) students producing VGI and (3) students developing VGI-related applications. Based on this classification, we give an overview of classes covering VGI taught at K-12 and university level.

The main contribution of this chapter, however, is a survey with 202 students from all age groups that have participated in VGI related classes at some point. In this survey, we have investigated the long-term effects of using VGI in education. We were particularly interested in which VGI projects the students were familiar with and how they learned about them; in which of them they have already actively participated and whether they are still doing so; and finally what their incentives for participation are. The analysis of the completed surveys has shown interesting correlations between the given answers and participants' age and gender, respectively. These insights can help to improve the curricula for future classes by matching the motivations for participation of broader student groups.

In the next section, we give an overview of the literature on VGI in education, followed by an overview of our personal experience and a classification of VGI in education in Section 3. We then outline our survey and provide a detailed breakdown of the results in Section 4, followed by conclusions in Section 5.

2 Related Work

Education systems all over the world have realized the relevance and potential of GIScience. New strategies have been developed to include Geographic Information as an integral part in the curricula, mostly starting in secondary school (Bartoschek, 2010). Moreover, the use of computers and mobile devices with positioning technologies such as GPS receivers, smartphones, and tablets in classrooms is increasing. By connecting both facts, the way for Volunteered Geographic Information in K-12 education should be an easy one. However, there are few publications on the use of VGI in the classroom and most publications related to VGI

[1] See `http://globe.gov/about`.
[2] See `http://www.gi-at-school.de`.

in the area of education focus on OpenStreetMap. The same applies to VGI in undergraduate and graduate studies.

An analysis of publications from the *Learning with Geoinformation* conference series, held yearly since 2006, shows that VGI-related topics first came up in 2009 (4 out of 30 articles), but never reached a high level of articles (see Table 1) and were even decreasing again while other topics (GIS, remote sensing, mobile applications) have remained consistently present.

Table 1: Breakdown of papers presented at the *Learning with Geoinformation* conference series by topic area.

	VGI related	GIS	Web-based GIS	Virtual globes	Remote sensing	Geo-information	Mobile	Spatial thinking	Other	Sum
2006	**0**	6	1	2	0	2	1	1	3	16
2007	**0**	7	5	3	1	5	1	0	0	22
2008	**0**	8	2	3	4	2	1	2	1	23
2009	**4**	8	2	4	4	1	2	1	4	30
2010	**3**	8	1	2	4	2	3	1	3	27
2010	**4**	6	3	2	5	2	1	1	3	27

Tschirner (2009) speaks about the way from classical wall maps to OpenStreetMap in Geography classrooms, but does not give any examples. Wolff (2009) also refers to OpenStreetMap, and argues that the use of OSM in school or university fosters early experience with geodata and geoinformation and can be very motivating. Stark (2009) presents his project *Map your World*, where swiss high school students use PDAs and GPS-receivers to contribute to OpenStreetMap and OpenAdresses, a VGI platform for collecting geocoded address data for analytical use. Schubert (2010) introduces a concept for a didactic seminar in geography education, where VGI (OpenStreetMap again) is a small part of the curriculum. Wolff (2010) presents VGI projects for undergraduates in geography and history where historical objects, such as monuments, are integrated into OSM. Andrae et al. (2011) show possibilities of collaborations between universities and high schools in the creation and application of a web-based portal for POI collection. Hennig (2011) proposes a system for participatory spatial planning, where students in high school and university contribute data via ScribbleMaps[3] to enhance city development processes in Salzburg, Austria.

An analysis of the titles and abstracts of talks at the annual international OpenStreetMap conference *State of the Map* since 2006[4] shows that there were hardly any education or learning related topics, except for the papers presented by Rieffel (2010, 2011) and a talk by Hale (2010) reporting work with US school children mapping their neighborhoods. The OpenStreetMap Wiki offers a page[5] dedicated to education where some projects are listed, mostly in High Schools. The page defines the role of OpenStreetMap as follows:

"*OpenStreetMap is being used within education, in schools, universities and colleges in a wide range of disciplines. Some projects involve only the use of existing*

[3] See `http://scribblemaps.com/`.
[4] See *YEAR.stateofthemap.org*, e.g. `http://2011.stateofthemap.org`.
[5] See `http://wiki.osm.org/wiki/Education`.

OpenStreetMap data and others result in additional data within the OpenStreetMap dataset. The OpenStreetMap project has relevance to geography, mathematics, ecology, community planning and technology. Students are able to not only observe and record their mapping explorations, but can also contribute data to the project. Contributing to OpenStreetMap can be used when teaching computing skills, gaining valuable knowledge in the fields of GIS, planning and community development" (OpenStreetMap, 2012).

Besides that, an OpenStreetMap curriculum[6] is being presented that focuses on introducing the topics that OSM addresses: mapping, open source technologies, crowd sourcing and community efforts. The curriculum consists of four units: State of Mapping, Crowd Sourcing, Introduction to OpenStreetMap and Integrating OpenStreetMap. These can be applied in high school or university. There is also a page on using OSM in home education.[7] Topics such as understanding maps, experiencing GPS technology, understanding the local environment, and elementary school lesson plans are briefly outlined.

OSM also plays a role in another recent education project addressing map design and complexity. While the level of detail in OSM has generally reached an acceptable level of detail, the map design is addressing adults. The level of complexity and symbology are therefore not suitable to learn reading and understanding maps. The development of map literacy and spatial understanding of children will benefit from an OSM version especially designed for children, following their perception and representation patterns of space (Rieffel, 2012).

Finding courses related to VGI at university level has turned out to be difficult, mostly due to course titles and descriptions that do not give insight into all topics convered in the courses. It is hence impossible to claim completeness for the list of courses mentioned here; the classes mentioned in the following cover those that we could find information about online.

The City University of New York – School of Public Health offers a graduate course on *GIS in Public Health* since 2010, which is mainly dealing with VGI data collection (Goranson, this volume). Students spend some time learning the technology for data collection (GeoChat), select a research question and collect data in the field using VGI. After pre-processing the data for further analysis in ArcGIS. In a separate Public Health course the students set up their own Ushahidi[8] deployments around a research question and solicited participation from the public.

Since 2010 the Université Paris-Est Marne-la-Vallée (Marne-la-Vallée, France) offers a weekly course on *Production de données géographiques collaboratives* (*Production of collaborative geographic data*) for Master's students in Information Systems and Web applications and in Geographic Information. It is an introductory course explaining this new approach of collecting geographic data. The students revise related work and summarize the main advantages and weakness of this type of data. The process of contribution to OSM is discussed and tested. In a final VGI development project some of the students choose to use OSM data and the API, others choose sources like Google Maps or Géoportail to implement crowdsourcing applications.

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[6] See `http://wiki.osm.org/wiki/Education\#The_OpenStreetMap_Curriculum`.

[7] See `http://wiki.osm.org/wiki/OpenStreetMap_and_Home_Education`.

[8] See `http://www.ushahidi.com/`

In summary, it has been shown that the current role of VGI in education, following a review of literature, websites and courses is still a minor one. Very few references referring to VGI in K-12 and university education are available, even in GI Science education. Most of the courses, lectures and projects on VGI are focussed on OpenStreetMap, not taking into account the variety of available applications.

In the next chapter, we will outline our personal experience in teaching classes related to VGI at the Institute for Geoinformatics, University of Münster.

3 VGI in the ifgi Curriculum

The Institute for Geoinformatics at University of Münster[9] (ifgi) is one of Europe's biggest research and education centers in the field of GIScience. The course program covers both BSc and MSc programs in Geoinformatics. Additionally, there is an international MSc in Geospatial Technologies, and a graduate school offering an international PhD program on semantic integration of geospatial information.[10] Ifgi offers numerous GI related courses for students in other programs, such as computer science, landscape ecology, geography or didactics of geography.

Moreover, ifgi started a high school education and cooperation initiative called GI@School in 2006. GI@School has developed from a student-driven initiative into an integrated part of the curriculum and project work at ifgi with the purpose to transfer fundamental and hands-on knowledge in geoinformatics to K-12 education. It has established a functioning network of schools, teachers, and students where the exchange with public authorities, industry partners, and partnerships with local schools plays an important role. In addition, the GI@School project develops teaching and learning modules on geoinformatics for schools. These modules can be integrated into class units of different lenghts (90 minutes up to full project days or weeks) being held in schools or at ifgi. VGI is one of the key topics in GI@School's work.

The experience with VGI in ifgi's educational work at K-12, undergraduate and graduate level, as well as from works presented in the related work section allow to define a certain classification of the ways how VGI can be used in learning and teaching. The simplest and mostly first contact with VGI (also shown in the survey) is when students are working with VGI collected by others (1). This can be browsing on the OpenStreetMap website, analysing geotags from Flickr or even importing vector data from OpenStreetMap into an GIS environment for further analysis. A different use case is when students are producing VGI (2) as in data collection and submission for OpenStreetMap or geotagging of Flickr pictures. Finally, students are developing VGI-related applications (3), where available VGI is part of the application (as base map, as POIs) or where the application is made for VGI collection:

[9] See `http://ifgi.uni-muenster.de/`.
[10] See `http://irtg-sigi.uni-muenster.de/`.

1. Working with VGI collected by others:
    a. Using products based on this VGI (e.g. Map from OpenStreetMap)
    b. Using this VGI to create other products (e.g. in a GIS)
2. Producing VGI:
    a. Collecting data in the field and submitting them to OSM
    b. Enrichment of existing non-spatial information (e.g. geotagging)
3. Deveolping applications
    a. based on VGI (as in 1)
    b. for VGI collection (as in 2)

We will refer to this classification in further sections, where we present examples of VGI-related activities at ifgi.

3.1 VGI in K-12 education

VGI plays a major role in the approach GI@School takes for K-12 education. Some of the practical modules of GI@School, being held in high schools, cover the underlying principles and practical use of GPS technology. As first actions to implement VGI modules after introducing GPS, we started with OpenStreetMap mapping parties and mapped the school ground and surroundings with the students (2a). They were divided into groups taking over one part of the area to be mapped. They ware annotating their mapped points and tracks with paper and pencil. Back in class, we used the Java OpenStreetMap Editor[11] to annotate and upload the data to OpenStreetMap. Seeing the mapped features appear on the OpenStreetMap website after some minutes was very motivating for the students, as they immidiately received feedback about their successful contribution to the project. Over the last three years, we have organized 12 mapping parties in German high schools and 8 on an international level (India, Rwanda, Brazil) and have reached around 800 high school students.

Since 2009, we have organized some project weeks with the focus on web-based VGI-projects. One outstanding result is the platform TiMiC[12] (*TiMiC is Mobility in Cities*). It was implemented in 2009 by a group of high school students, working at ifgi once a week for 2–3 hours over the course of 4 Months. This VGI based system allows users to submit traffic events, such as accidents or road works, via SMS to the system, which then appear on a Google Map interface (3b). The students participated in a national competition and won the first prize for IT-related projects.

In the GeospatialLearning@PrimarySchool project[13] children of ages 6–12 work with the XO laptop developed by the One Laptop Per Child (OLPC) initiative and a connected GPS-receiver to map geographic features such as trees, water, and vegetation. Due to XO laptop's capability to create ad-hoc networks, the children can collaboratively work on the data collection. While tagging outdoors, they see each other on a digital map (from OpenStreetMap) and see their tagging activities, so they collaboratively create a map of the surrounding area (1a, 2a). The collected data can be exported to KML and integrated into other systems (1b).

[11] See `http://josm.openstreetmap.de`.
[12] See `http://www.timic.de`.
[13] See `http://52north.org/GeospatialLearning`.

3.2 VGI in undergraduate programs

In undergraduate classes, VGI has been one central topic over the last two years in the Introduction to GIS class taught every semester at ifgi. This is a compulsory class for all first semester geoinformatics bachelor students, as well as third semester geography and landscape ecology bachelor students. Due to the broad range of student backgrounds and the spectrum of topics around GIS covered in this class, the coverage of VGI is limited to OpenStreetMap. The students learn about the organization of the OpenStreetMap community and how the data is collected (1a, 2a). The more technical aspects cover the structure of the OpenStreetMap files and the versioning approach taken in OpenStreetMap. We have made the experience that this part is challenging for most students, as most of them do not have any experience with the eXtensible Markup Language (XML).

The introduction to GIS class is a combined lecture and lab, where the students have to solve practical tasks every week and do hands-on work in groups of two. The task for the VGI lecture is to register to OpenStreetMap and add several features using one of the web-based editors. By solving these tasks, the students see how editing works, and what different types of features can be created. Specifically, they learn how the tagging process works, including checking the OpenStreetMap wiki for the current consensus on the tags to use for the features they add (2b). Recording and uploading GPS tracks is not part of the class; instead, the students learn how to import the OpenStreetMap data into ArcGIS and how to combine the data with other data (1b). This way, the students also learn about both the advantages and disadvantages of using VGI in their project, namely that OpenStreetMap offers data that are hardly available from any other easily accessible source, but that the accuracy and completeness may vary from one area to another (and even from one feature to another). From most students, we get positive feedback about the VGI lecture. Especially the fact that their own added data is almost immediately shown on the main OpenStreetMap website is very motivating for the students.

3.3 VGI in graduate studies

In graduate classes, VGI has become an important part of the curriculum for the MSc students in geoinformatics and the Erasmus Mundus students for the MSc in geospatial technologies at ifgi. While these classes are in principle open to other programs, students from other programs hardly ever participate in classes related to VGI, probably due to the technical nature of these course offerings. Most graduate classes related to VGI are organized as study projects, which have the goal to develop a software project over the course of the semester in small teams of three to five students. One of the recent study projects was also centered on OpenStreetMap. No specific task was given, though, so that the first task during the semester was to form groups of three and come up with an innovative project that is realistic to implement by the team within the given time frame.

The four projects implemented by the teams showed an impressive range of ideas. Team one developed a web application for smart phones that allows users to tag points of interest on the go (3b). Team two implemented a service that allows users to print maps out of OpenStreetMap for hiking or biking trips (3a), including the calculated route (Fritze et al., 2011). The service automatically generates a multipage PDF file from a given GPS track (i.e., the planned route), and optimizes the print layout around the track. Team three came up with the idea for an indoor counterpart for OpenStreetMap called OpenFloorMap (Lasnia et al., 2011). Their implementation consists of an Android app to measure rooms using smart phone sensors, and a web application that allows users to integrate their room measurements into an existing building model (3b). This project is still developed further[14] and will also be the subject of an upcoming graduate class. Finally, team four adapted the idea developed for LinkedGeoData (Auer et al., 2011), which provides the OpenStreetMap data as a semantically annotated Linked Data set. One shortcoming of LinkedGeoData at the time of the study project[15] was that it was never up to date, as the dataset was only rebuilt infrequently from an OpenStreetMap dump. The team therefore built a live wrapper that provides a semantically annotated view of the current state of the OpenStreetMap dataset (3b), including querying and annotation capabilities (Trame et al., 2011).

The approach to let the students develop their own project ideas instead of giving them a prepared task led to a set of innovative and diverse projects that the students really identified with. The general level of motivation was very high. As the references above show, three out of the four projects have led to a conference publication. The students therefore did not only engage with their software project, but also learned how the submission and reviewing process of a conference works, which was a new experience for most of them. On the development side, the students acquired consummate skills in generating, handling, and processing VGI.

3.4 Application development and testing

A recent study project on geospatial learning has produced two VGI related prototypes that focus on the use in schools. In the “Participatory App”, school children can mark points of interest related to one topic (chosen collaboratively or by the teacher) on a map, based on OpenStreetMap. This can happen on a desktop PC in class, where they tag places they know about, or with a mobile device with GPS (3b). Scenarios under consideration are marking dangerous traffic situations on their way to school, or places where they find trash in public or parks. These data, collected by several classes or schools, is a valuable input to the city council, pointing them to littered parks, for example. This can be an incentive for the children to participate, as their work can change their living conditions.

A second group presented a tool for educational geotagging (3b) in school. Here, the teacher has to prepare appropriate feature descriptions which will be automatically integrated into the system. The students developed an XML-file for tree classification. Geotagging happens in the field with a mobile device. The children approach a tree and click a button in the system, which marks their position on a map. A wizard, generated from the tree XML-file, leads the user through the classification process, by asking questions (“Is it a broad-leafed tree or a conifer? ”), showing pictures of leaf-types. By answering a series of such questions, they get to the exact tree classification and also learn about the classification process. Usability tests were

[14] See `http://openfloormap.de/`.

[15] LinkedGeoData (`http://linkedgeodata.org`) also provides a life wrapper now.

conducted with elementary and high school children for both applications, where user interface problems could be solved. The test participants have shown a big motivation in the data collection process. An ongoing project on "Educational Map Apps" will present more VGI prototypes of this kind for smartphones or tablets.

In this chapter we have outlined ifgi's education activities referring to VGI from K-12 to graduate studies. We have introduced a classification for the integration of VGI in education and have classified ifgi's activities into courses and projects where: (1) students work with VGI collected by others, (2) students produce VGI and (3) students develop VGI-related applications. We have shown that a broad implementation of VGI activities is possible and can be integrated into curricula on all levels. We have presented synergies in VGI application development in gradute studies for the use in undergraduate and K-12 education.

4 Survey and Evaluation

The goal of the web-based survey presented in this section was to find out more about the impacts of the use of VGI in education. The participants were high school and university students who have already worked with VGI in some form, either through the GI@School program (K-12) or in undergraduate and graduate classes. We were particularly interested in the influence of educational use of VGI on their knowledge about and current use of VGI.

4.1 Survey design

The questionnaire consisted of 15 multiple choice questions and was divided into five parts. Questions 1–5 and 15 focussed on personal information, such as age, gender, educational background (high school or university), the favorite/main subjects (for high school students) or the field of study (for university students) and the private use of social networks with the possibility to share location information (such as "check-ins"). Questions 6 and 7 asked if the participants know different VGI applications and how and in which context they got to know them. Taking into account that the term VGI is not very common, especially in high school and undergraduate classes, we asked these and further questions in form of a matrix, presenting 7 common VGI applications. We decided on photo geotagging platforms (giving the examples of Flickr, Picasa and Panoramio), OpenStreetMap, WikiMapia, GeoCommons, Google MyMaps, Google BuildingMaker/SketchUp and CrisisMappers. Questions 8–10 and 12 focused on motivation, incentives and impact in the use and contribution of VGI, question 11 asked about the usability of the mentioned VGI applications and questions 13 and 14 about the students' opinion on the use and contribution of VGI in education.

4.2 Participants

At K-12 level the questionnaire was sent out to 10 german schools that participated in ifgi's GI@School program and worked with VGI (mostly in the form of OSM mapping parties), two additional german schools were contacted via the OSM education projects website. On undergraduate and graduate level, students attending VGI related classes at ifgi were contacted. These were students in the Geoinformatics (BSc, MSc), Geospatial Technologies (MSc), Landscape Ecology (BSc, MSc), Geography (BSc, MSc, MEd) and Computer Science (BSc, MSc) programs. The survey link was also sent to international colleagues teaching VGI related courses.

In total 202 students participated in the study, of which 26.5% were female. 33% of the participants were in high school, the remaining 67% students in university. Most participants from high school mentioned mathematics or geography as their main or favorite subjects, while languages and computer science were not very common (see Figure 1). Over 50% of the participants at university level are enrolled in courses closely related to GI Science (Geoinformatics and Geospatial Technologies) (see Figure 2).

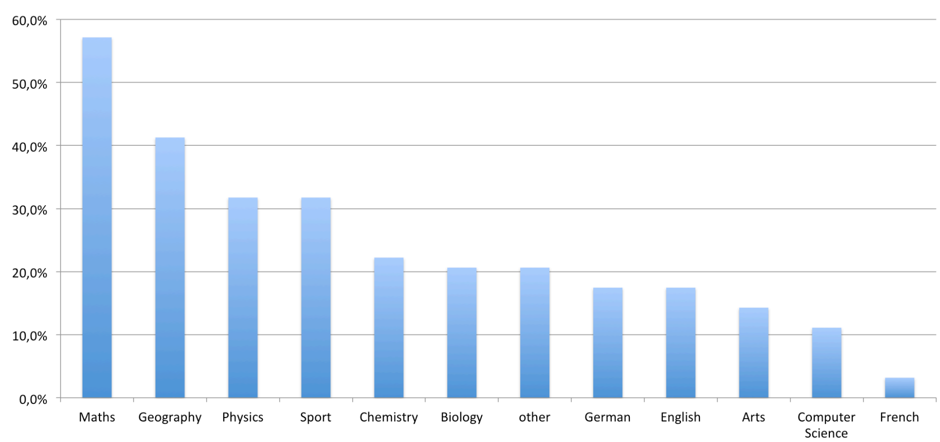

Figure 1: Favorite and main subjects of K-12 students (N=63).

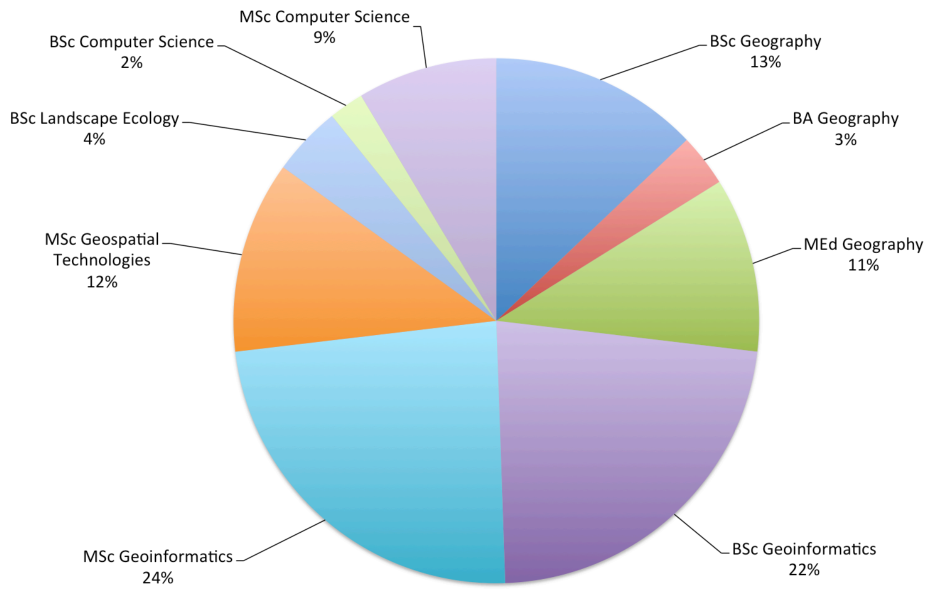

Figure 2: Study programs of university students (N=106).

4.3 Evaluation

OpenStreetMap is the most known VGI application to the survey participants, only 4% of the participants did not know this project. Due to strong use of OpenStreetMap in ifgi's education activities, this seems to be obvious: 70% of the participants had their first contact to OSM in High School or University. In comparison, Wikimapia, GeoCommons and CrisisMappers are not very known to the participants: 65%, 68% and 85%, respectively, did not know these platforms (see Figure 3). These three seem to be particularly new for the high school students: 77% (Wikimapia), 96% (GeoCommons) and 100% (CrisisMappers) had not come across these platforms before. It is noticeable that photo geotagging platforms and Google MyMaps were discovered in their spare time by close to 50% of the participants and by less than 20% in the education context.

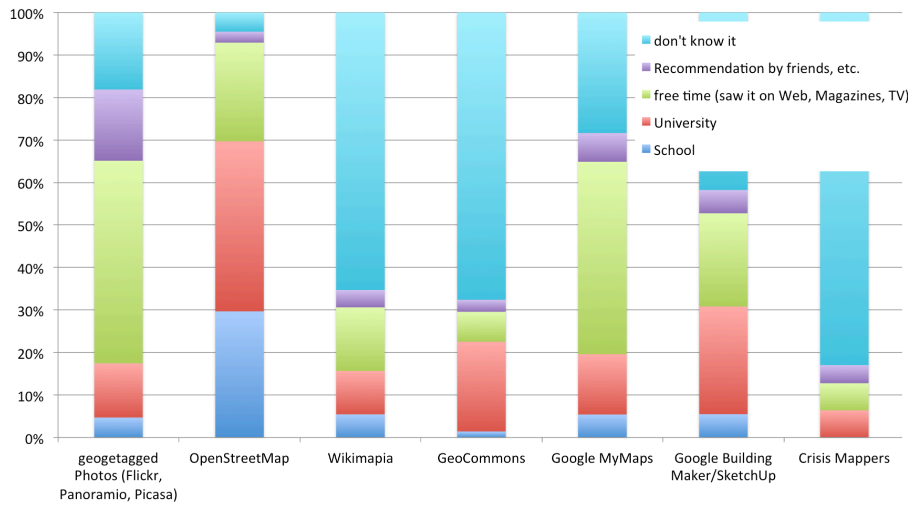

Figure 3: "Which of these projects/applications do you know and how did you find out about them? " (N=156)

As OpenStreetMap seems to be the mainly used VGI application in education, we take a closer look into the educational use. In high school, OpenStreetMap is being used mainly in projects and regular lessons (2a) by the participants. At university level, projects and introductory classes are also the main use cases, but thesis work and other contexts seem to be relevant as well (see Figure 4). This may be due to the fact that the use of OpenStreetMap data (1a) and software development based on OpenStreetMap (3a, 3b) are being fostered at ifgi. Nonetheless, a large part of the participants used (1a) or contributed (2a) to OpenStreetMap in a private context.

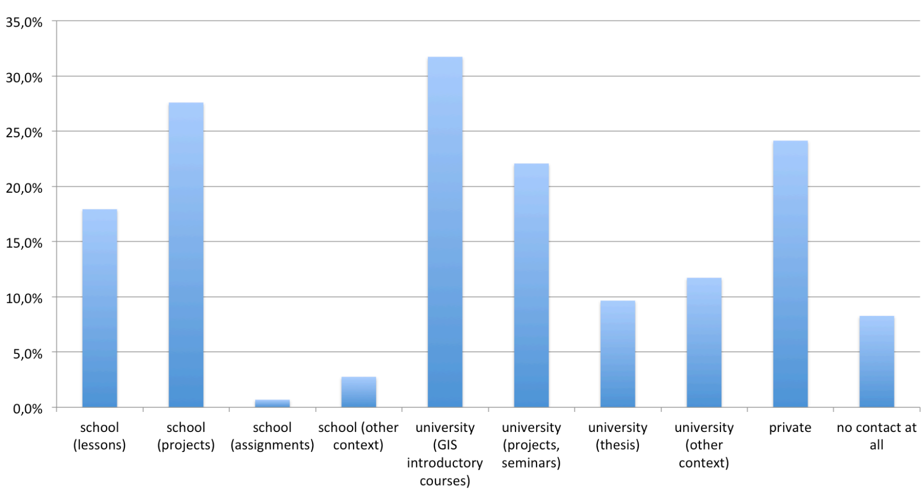

Figure 4: Context of interaction with OpenStreetMap (N=145).

The main motivation for using and contributing to OpenStreetMap is education, as already found out in question 7. But other highly rated motivations are the general interest in the project (30%) and the belief in the social impact of OSM (17%).

WikiMapia, GeoCommons and CrisisMappers were not known to most of the participants. Most participants had "just tried out" geotagging photos and Google MyMaps. Besides OpenStreetMap, Google SketchUp and the BuildingMaker were used by 33% of the participants in an educational context (see Table 2).

Table 2: Education as a motivation for VGI use and contribution.

Answer options	Education (abs.)	Education (rel.)	Responses
GeoTagged Photos	20	15.0%	133
OpenStreetMap	76	38,8%	196
Wikimapia	11	13,6%	81
GeoCommons	15	20,5%	73
Google MyMaps	23	20,0%	115
Google Building Maker/SketchUp	31	31,3%	99
Crisis Mappers	3	5,2%	58

A closer look at the participants' behavior after working with VGI in school or university reveals that a high number of participants have never used the platforms again. In particular, CrisisMappers (85,7%), Wikimapia (71,4%) and GeoCommons (74,5%) hardly ever used again.

In comparison, OpenStreetMap reaches only low numbers. 24,1% of the participants have never used OSM again after the contact in an educational context. OSM is to be seen as the most positive example, as 20,3% of the participants still use it regularly, 16,5% once in a while and 27,8% use it sometimes. Photo geotagging platforms (50%) and Google MyMaps (40%) are still used by nearly half of the participants more than once after educational contact (see Figure 5).

Seeing the educational background is interesting in the case of OSM. There are big differences between the high school and the university students on the further use. While 75,6% of the university students worked more than once with OSM after contact in education, only 46,3% of the high school students did so (see Figure 6).

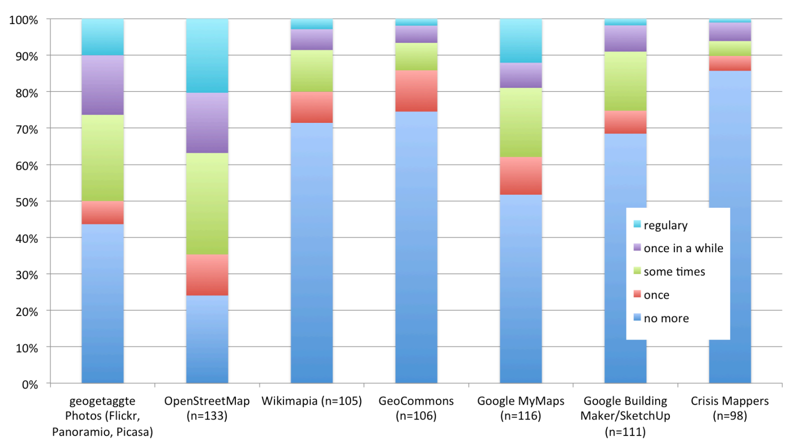

Figure 5: Frequency of project activity after educational use.

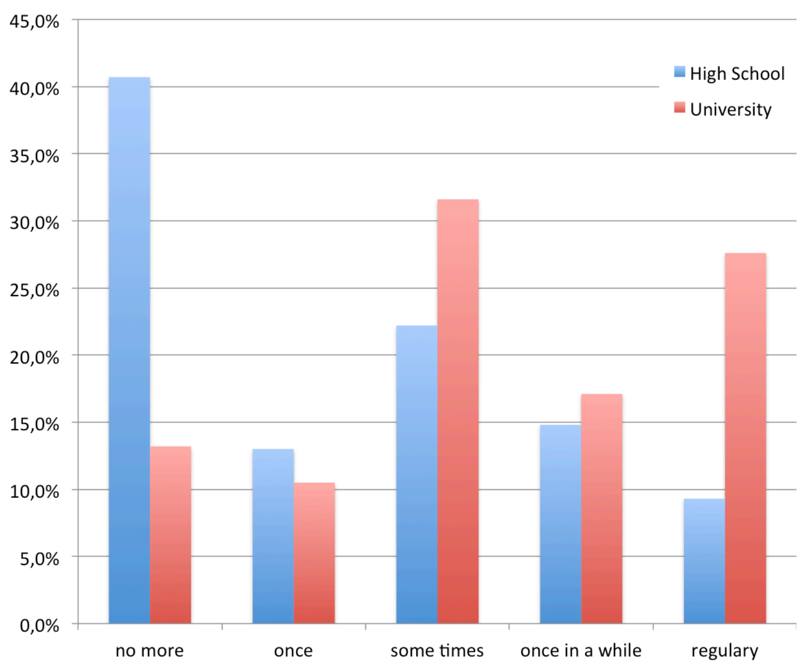

Figure 6: Frequency of OpenStreetMap activity after educational use, compared to level of education (N=130).

Figure 7 shows the reasons for stopping to use or contribute to the VGI platforms. It only takes the participants into account that stopped after educational use. Participants who never used the platform or still use it were ignored in this analysis. OSM and Google Sketchup/BuildingMaker are being considered as too time consuming by around 20% of the participants. OpenStreetMap seems to be the most complicated platform to contribute to; this reason was given by 19,2% of the participants. Privacy issues are a relevant reason for photo geotagging platforms and Google MyMaps, but the most striking reason is the missing revenue for the participants, chosen by 40–50% for all platforms.

This leads to the question which incentives would get the students at high school or university level to participate in and contribute to VGI projects in general. Better usability is the highest rated incentive (62,8%), followed by friends being active in the same project (47,3%). More acceptance and acknowledgement in society do not seem to be very important for the participants (28,9%). Financial compensation is interesting for the participants at this point as well (43%), but a closer look reveals some major differences in gender (see Figure 7). Financial compensation seems to be particularly important for male participants (51,8%), but not for female (23,7%). Female participants stress the importance of usability (73,7% vs. 57,8%).

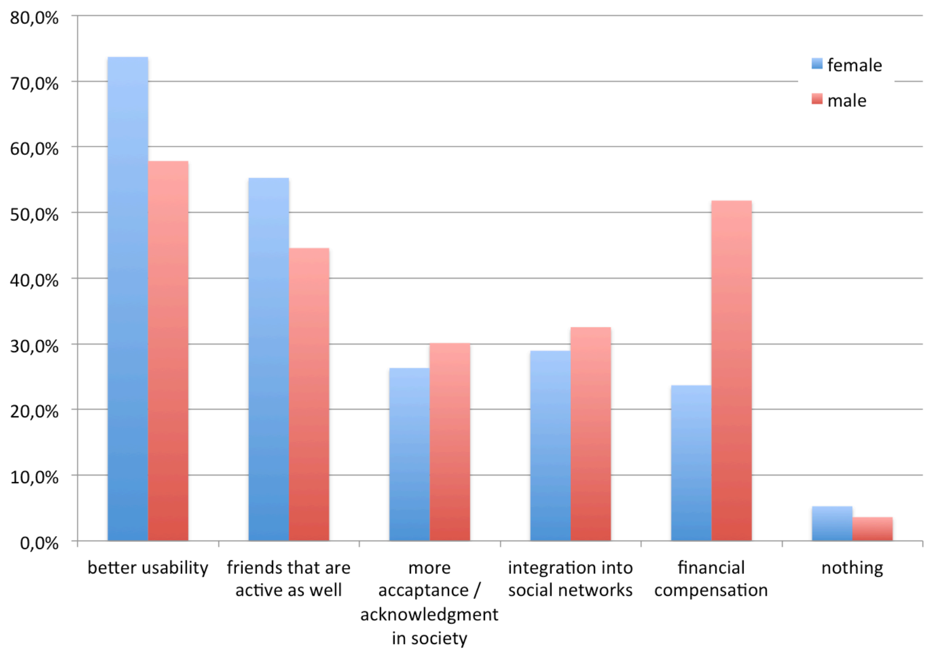

Figure 7: "Which incentives would make you participate in the projects/applications mentioned before? " (N=121).

A closer look at the perceived complexity of the aforementioned VGI platforms shows that few participants find the platforms very complicated to use. CrisisMappers is only considered to be "okay" to "very complicated" (on a 5-step scale, ranging from "very simple" to "very complicated"), but was only known by 12 participants. Google SketchUp/BuildingMaker has quite similar values. Only 17,7% of the participants considered it being simple or very simple. In contrast, the photo geotagging platforms and Google MyMaps are considered simple or very simple by 73,6%, respectively 63,2% of the participants. OpenStreetMap, known and used by most of the participants (120), was rated complicated or very complicated by only 18,3% (see Figure 8).

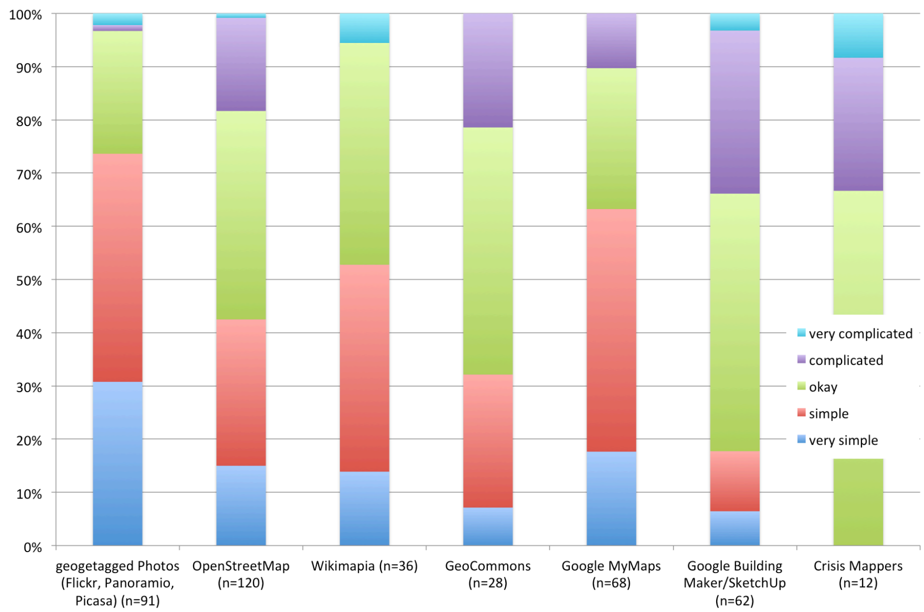

Figure 8: Usability ratings for use and contribution.

The last questions referred to the use of VGI in education in general as a quantitative and qualitative measure. 52% of the participants think that VGI data and applications are being used too little or far too little in education, while 41,5% think its coverage in education is just right. It has to be taken into account that the participants were ercruited from groups that were exposed to VGI at a relative high level (GI@School students, ifgi students). This is not very common, especially in K-12 education, but also in undergraduate and graduate studies, as shown in the related work section. 70,2% of the participants think that the use of and learning with VGI in education makes sense or makes a lot of sense, which confirms the efforts of including these projects in education. In both questions the results were very similar for high school students and university students and for male and female students.

In summary, the results of the survey indicate that there is still significant room for improvement for the long-term effects of VGI in education. The majority of students does not engage in any of the bigger VGI communities after their contact with VGI in class. This picture contradicts our own impressions sketched in Section 3 – VGI is always a motivating topic in class. In the end, there seems to be a significant difference between acitivities that are fun in class, and activities that are fun in one's spare time.

The questions on usability and motivations give an indication how long-term engangement could be increased, namely by (1) making the tools less complicated and hence more accessible for less tech-savvy users; and (2) increasing the user base. While usability is a technology issue that is constantly improving, the user base will eventually get broader over time as VGI becomes more of a mainstream topic. Easier to use interfaces should also flatten the learning curve and should make the VGI communities more accessible for non-tech users.

5 Conclusions

Looking at the emergent impact of VGI in society and science (Haklay, 2010), it is surprising that the topics and methods concerned with VGI are integrated into curricula only slowly and only to a limited extent, as shown in the related work section. The Institute for Geoinformatics has put a focus on VGI related education and partly developed a flow, where students in graduate programs develop VGI applications, undergraduate students are exposed to VGI data analysis and K-12 students work on data collection (see Section 3). The K-12 students act as usability testers of newly developed applications by ifgi students and contribute to scientific projects as data collectors or be part of participative planning processes (see Section 3.4). An integral approach to university-school cooperation to bring VGI to educational use, as presented here, seems to be a good solution, as curriculum development is a rather slow and inflexible process. VGI applications are often not known to teachers or even students in GIScience related programs, as the survey has shown. To formalize the multiple ways VGI can be used in learning and teaching, a classification of use-cases was presented: (1) students working with VGI collected by others, (2) students producing VGI and (3) students developing VGI-related applications. These three classes can be subdivided in different contexts as shown in Section 3.

The conducted survey (section 4) revealed that OpenStreetMap is the most known VGI application among the participants. Since ifgi's VGI related education efforts are often based on OSM, this seems to be obvious. However, OSM is also one of the applications that offers more than just data collection. Due to the easy access to the raw data (under Creative Commons Attribution-ShareAlike 2.0 license) it can be used in various ways: as geodata source, for data quality analysis, as base map in other applications, or for studies in cartography (Rieffel, 2012). This makes OSM an extremely flexible tool in education, also shown in the variety of educational contexts it already is being used in (see Figure 4).

VGI has already found its way to a major part of the students. Photo geotagging applications and Google MyMaps are being used in their spare time by nearly 50% of the survey participants. This shows a general acceptance of participation in and contribution of geographic information. However, the further use of and contribution to VGI related applications after the contact in school or university is still quite low. It seems to be difficult to keep the students on track contributing, especially in the K-12 context (Figure 6). The missing revenue (Figure 7) shows that teachers should emphasize the impact and importance of VGI and especially OpenStreetMap in society. Options to reach this goal could be focusing on applications in developing countries and for humanitarian activities[16]. Another aspect, especially in education, is the use of participatory VGI applications, where VGI can be used as an instrument in planning processes. This is a strong motivation in the educational context. The students know that all their work around VGI (from collection and submission to use) makes sense and will be used for a good purpose they will benefit from. A closer look at the incentives (Figures 8–10) implies that VGI platforms still need to improve their usability. The activity of friends or an integration into social networks are important and feasible as well, in contrast to financial compensation. Seeing the participants strong activity in social networks (see Figure 9), one could assume that some kind of

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[16] See `http://hot.openstreetmap.org/`

a mixed form of VGI and social network could keep the students in track of contributing.

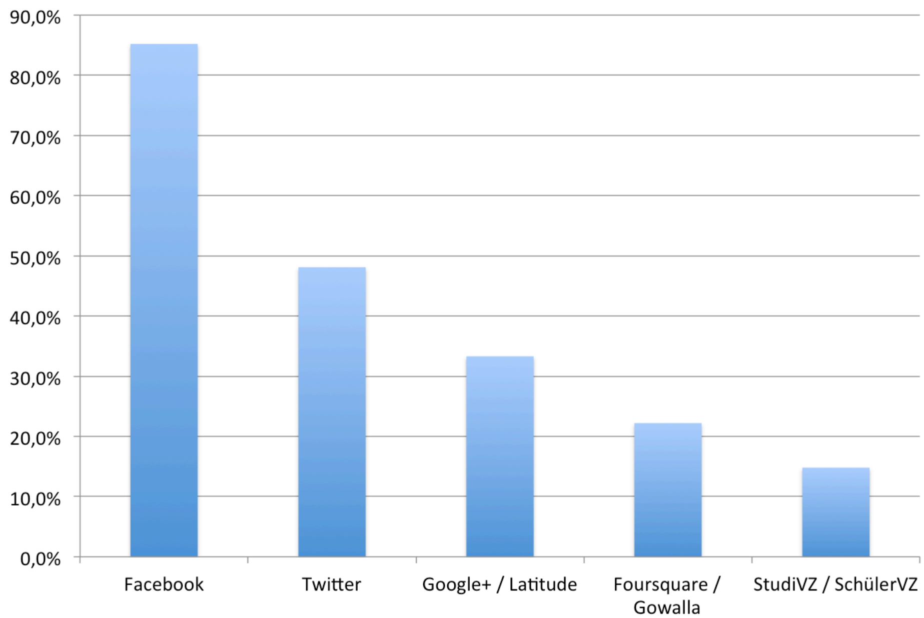

Figure 9: Social network use among the participants (N=117).

From the educator's perspective we can say that working with and contributing to VGI projects is a very motivating part in class. One can find several modern learning paradigms in this activity:

The constructionism theory, based on Piaget's constructivism theory of childhood learning (Piaget, 1926), in which children learn by doing and making in a public, guided, collaborative process including feedback from peers, not just from teachers. They explore and discover instead of consuming prepared knowledge (Papert, 1991) Papert states that this happens "especially felicitously in a context where the learner is consciously engaged in constructing a public entity". It is meant to see learning as "building knowledge structures".

In our case the meaningful product is VGI, it is created through a collaborative process and there is feedback of a whole community. As constructionism may be a rather extreme approach to learning, situated learning may fit better the educational reality. Here learning is a product of an activity, context, and culture, wherein realistic tasks shall be carried out collaboratively (Brown, 1989).

Situated learning with VGI also brings the educational and the computational worlds together and leads to modern computational approaches, such as situated computing. Situated computing can be understood as a paradigm for mobile computer users based on their physical context and activities carried out as a part of their daily life (Hirakawa, 2001). The growing use of mobile devices in education, even on K-12 level, is also a foundation for future VGI applications in education, where the whole process of data collection, data processing and use of VGI can be carried out in the field.

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