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# GEOGRAPHY STUDENTS' PERCEPTION RELATED TO THE USE OF GIS OPEN SOURCE SOFTWARE IN GEOGRAPHIC HIGHER EDUCATION

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***ABSTRACT***

*Present-day geography is inconceivable in the absence of GIS software. The students and staff of the Faculty of Geography within the University of Bucharest use both proprietary GIS software and Open Source computer programmes. Consequently, this study aims at identifying to what extent each of them is used for various tasks and what is the students' perception of the GIS Open Source tools. For this purpose, we applied an online questionnaire (with 16 items) to which 154 students from various years of study (undergraduate and master students) and from various study programmes responded willingly. Even though the results cannot be generalised, they prove to be useful due to the information they provide. The main issues addressed by the questionnaire items were the following: the experience in working with computer and GIS software, the daily average working time, the types of software students use at home and during their classes, the illegal use of proprietary software, what software students would choose, etc. We insisted on the reasons why students choose or reject the GIS Open Source software.*

***Keywords:*** *GIS Open Source software, proprietary GIS software, QGIS, geography, education, university*

## INTRODUCTION

In the digital age, geographic research and education make extensive use of GIS software (freeware, Open Source and proprietary), inasmuch as its usefulness and contribution in the acquisition of geospatial skills is demonstrated by many studies (Dresen, 2006; Tsou & Smith, 2011; Moreno-Sanchez, 2012; Osaci-Costache, 2012a, 2012b, 2013; Azzari *et al*., 2013; Ertz *et al.*, 2014; Etherington, 2016). Besides, "only when free and open source software is fully integrated into geospatial education, we will be able to encourage a culture of openness and, thus, enable greater reproducibility in research and development applications" (Petras *et al*., 2015, pp. 942-943).

According to the published data, "only few university Geospatial Information Science curricula include open source approach, and most programs focus on use of proprietary software" (Mitasova *et al*., 2012, p. 42), while for research and industry the Free and Open Source Software (FOSS) become increasingly important. A study shows that the disproportionately high share of proprietary GIS software used in education is detrimental to the graduates' competiveness; in this respect, the United States have some positive experience "through the use of a new innovative geospatial curriculum built around open source software" (Davis, 2015, p. 3). There are in the world some universities relying on Open Source Software (OSS), as for instance the Polytechnic University in Valencia, which uses gvSIG, a model also employed in the Czech Republic (Nétek, 2012). In the United States, many universities use the QGIS software (Davis, 2015, p. 6), while North Carolina State University uses both proprietary software (ArcGIS) and Open Source solutions (GRASS GIS) (Petras *et al.*, 2015).

Proprietary or Open Source software should not be selected by taking into account only the friendly interface, because the software packages are only a tool for the geographer with sound knowledge, who "should be prepared to look beyond their software interface" (Bertazzon, 2013, p. 67). By doing this, he or she will prove himself or herself capable of applying critical thinking to his or her research (Goodchild & Janelle, 2010).

At the Faculty of Geography within the University of Bucharest, students employ GIS tools during their entire study period. In the first year of study, they use QGIS, GRASS GIS and SAGA GIS, and then they turn to proprietary software (especially ArcGIS, Surfer, and Global Mapper) and to other OSS (Ilwis, etc.). The students in Cartography come across the GIS software in the first semester, when they study "Methods and techniques of cartographic representation" (Osaci-Costache, 2012a, 2012b).

The main author of this study uses in her teaching and research activity the Free and Open Source Software (QGIS, GRASS, SAGA GIS,

gvSIG, etc.) since 2008. Besides, QGIS (http://www.qgis.org/en/site/) and GRASS (https://grass.osgeo.org/) are known to be the most popular and efficient Open Source GIS software used in education in other countries as well, as for instance in Italy (Azzari *et al*., 2013, p. 31).

The research started from the fact that a number of students who in the beginning use Open Source GIS tools, gradually turn to proprietary software, while others continue to prefer the Open Source solutions. The objects of this study are to find out the percentage of the students who use the two types of GIS software, to learn students' opinion about them, and to understand the reasons why they choose one or the other. In the economic and legislative context of Romania, it is advisable that people use GIS Open Source software. It is not the purpose of this study to analyse the proprietary and Open Source GIS software in terms of their performance or usefulness for various spatial analyses, as these aspects have already been discussed by many studies (e.g. Akbari & Ali Rajabi, 2013).

## MATERIALS AND METHOD

*The data-collecting tool*. We designed an original questionnaire (see Appendix 1). The 16 items it included belonged to three categories: one answer, multiple-choice answers, and open-ended answers. The questionnaire was created with Google Forms from Google Drive, a tool also used in previous studies (Osaci-Costache *et al*., 2014, 2015a, 2015b).

*Procedure*. The questionnaire was available to be filled in anonymously and voluntarily by all the students of the Faculty of Geography within the University of Bucharest. The students were sent the web address of the questionnaire by e-mail, but this was also posted on the Facebook page of the Faculty of Geography, as well as on the educational site "Cartografie-Topografie" (https://sites.google.com/a/geo.unibuc.ro/cartografie-topografie-site-didactic/). The answers were given online between January 30 and February 4, 2017.

*Participants*. In the end, we collected 154 answers (26% from 1st year students, 18.2% from 2nd year students, 14.3% from 3rd year students, 28.5% from 1st year master students and 13% from 2nd year master students). The present study relies on students' answers, which, although do not belong to all the students of the Faculty of Geography (so the data cannot be generalised), still satisfy our purpose, namely to identify students' opinions about using the GIS Open Source software. At the same time, we intended to find out the reasons that might lead to a more extensive or a more restrictive use of such tools in the academic environment in the years to come.

## RESULTS AND DISCUSSION

We deemed important to correlate the students' opinions with their experience in using the computer and the GIS software, which is why the first items were directed at this objective ("How long have you been using the computer?"; "How long have you been using GIS software?"). The answers proved the respondents were "digital natives" (Prensky, 2001), because 71.4% declared they had been using the computer for over 9 years, while 19.9% had been using it for 7-9 years, given that the age of the students was between 18 and 24 years. However, a small percentage (1.3%) of students in the 1st year of study stated that their experience with computers was less than 3 years (Figure 1).

As far as the use of GIS software was concerned, the situation was different: 28.6% of the students had an experience of less than one year, 51.9% had an experience of 1-3 years, while only 19.5% made use of GIS software for a period between 4 and 6 years (these were the master students; Figure 1). By analysing the answers in Google Forms, we were able to ascertain a very high share of the students who had an experience in GIS of 1-6 years (71.4%, i.e. 51.9% an experience of 1-3 years and 19.5% an experience of 4-6 years). At the same time, we observed that the experience increased with the passing of time, because all respondents came across the GIS software during the first year of study.

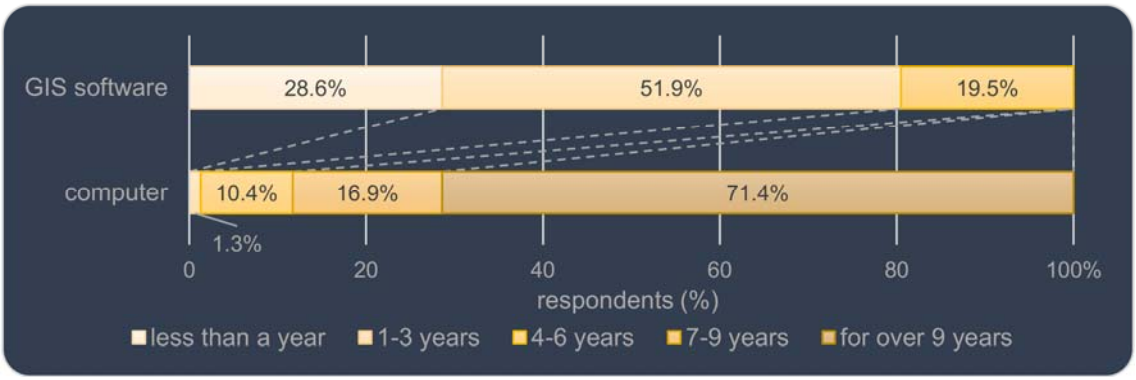


**Fig. 1.** Students' experience in using the computer and the GIS software

Another useful element for judging the relevance of the expressed opinions was the average daily time (in hours) spent in using GIS tools. Most students (41.6%) declared they used them 1-3 hours per day, 29.9% devoted themselves to these activities less than an hour per day, 13% used them for 4-6 hours per day, while 7.7% stated they called on these resources 7-9 hours per day (Figure 2). From other answers, we concluded that 50% of them were 1st year master students, 40% were 1st year

undergraduate students, and 10% were 2nd year undergraduate students. These people stated they used GIS software both for their homework and for their own research conducted with the purpose of attending various scientific conferences and workshops. However, we should note that 7.8% of the respondents declared they did not use GIS software at all (Figure 2). The analysis of the data collected in Google Forms led us to believe that these were the 1st year students from those study programmes where the use of GIS software begins later. We did not remove from the study the answers given by these respondents, because we also intended to learn the *a priori* opinions of the students who had not started to use the GIS software.

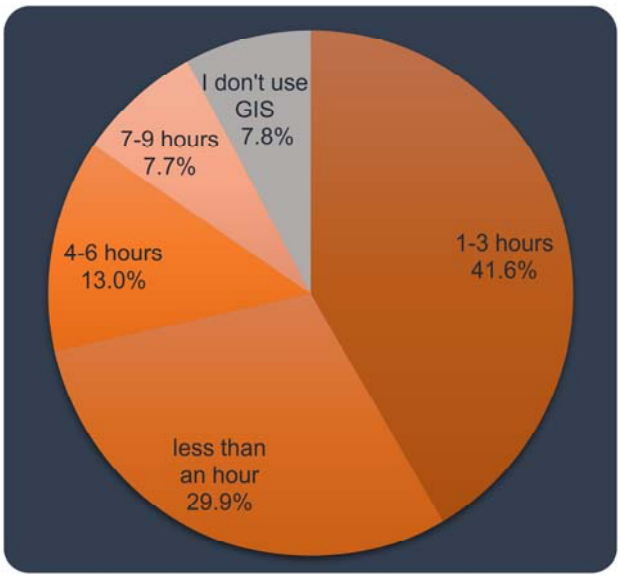


**Fig. 2.** Average daily time spent in using GIS tools

Most students used exclusively GIS Open Source software (50.6% at college and 46.8% at home), which was to be expected, because the members of the staff of the Faculty of Geography within the University of Bucharest used to promote such tools. Besides these students, there were others who used both types of software, but mostly OSS (24.7% at college and 22.1% at home). The total percentage of the respondents who used at college exclusively or mainly GIS Open Source software was 75.3% of the entire sample. However, if we take into account only the GIS users, the value amounts to 81.7%. The share of those who used only proprietary software was much smaller (7.8% at college and 10.4% at home). Also small was the percentage of those who made use of both types of software, but especially of proprietary ones (9.1%; Figure 3). Comparing the use in the institutional framework with the use at home, we were able to identify a small drop in using the Open Source software at home, which showed that during the teaching activities the students were somehow compelled to use OSS. This attitude is normal for the academics in the event they do not hold

a valid license for particular proprietary software. Besides, 77.9% answered (to another item) that during the teaching activities they were explained that the use of proprietary software in the absence of a valid license was illegal. At the same time, 7.8% of the respondents (i.e. the 1st year students who had not begun to use GIS software) stated they were not aware of this issue, while 14.3% failed to answer this question. Likewise, one can see that in the case of those who declared they did not use GIS software (some of them being 1st year students who had not begun to study GIS) the share of the students who used the software at home was higher by 3.9% in comparison with those who used it at college. This percentage pointed at those students who were reluctant while at home to engage in individual study or in doing their homework and projects (Figure 3.).

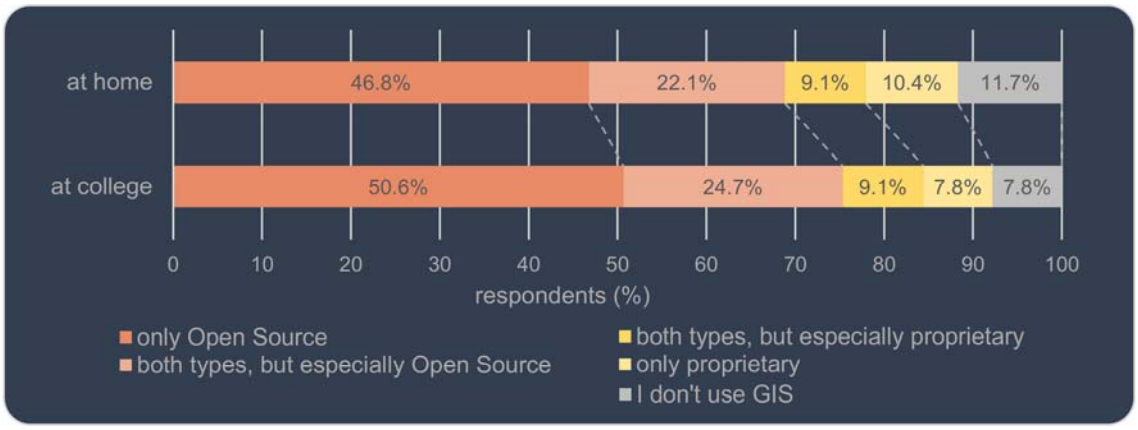


**Fig. 3.** Types of GIS software used by the students in the sample

The reasons why the students use GIS Open Source software are given in Figure 4. We analysed only the answers of those who declared they used OSS. The item we relied on in this respect was a multiple-choice one, as it included several possible reasons, together with a section allowing for an open-ended response. Almost half of the students opted for the answer, "it's the right thing to do if I don't hold a license for proprietary software" (44.2%), while 42.9% believed that GIS tools meet their professional needs.

A rather high share of the answers (37.7%; Figure 4), but not so high as it should have been, showed that the students were aware that the software was only a tool for preparing maps or for undertaking spatial analyses. Consequently, they understood that getting to know the software was not an end in itself, especially because the GIS software were relatively similar, while the geographer was not a technician instructed only to "press the button", but a theorist and a practitioner who, knowing the algorithm behind each button, was able to adapt to various interfaces. In other words, higher education must train "a generation of GIScientists, not simply GIS technicians" (Bertazzon, 2013, p. 67).

Besides, 26% of the answers valued the freedom of choice, attitude that is important especially for the development of FOSS, because the free development requires a lack of constraint. According to 23.4% of the answers, those who imposed the use of GIS Open Source software were the academics. If we make a comparison with the answers to the previous item, we see that most students used OSS even at home, although there, in the absence of the teacher, they had the liberty to choose (Figure 3). Moreover, the answers given to another multiple-choice question reveal that 42.9% of the respondents interacted at a given time with teachers who imposed them to use GIS Open Source software during the training activities. However, only 23.4% motivated in this way their preference for such solutions. Likewise, 43.8% came across teachers who allowed them to choose the computer programmes, while 17.1% declared the teachers compelled them to use proprietary GIS software.

At the same time, 13% of the students declared they liked GIS Open Source software tools, while 1.3% cited other reasons (open-ended response), such as the fact that SAGA GIS enabled them to run complex analyses (Figure 4).

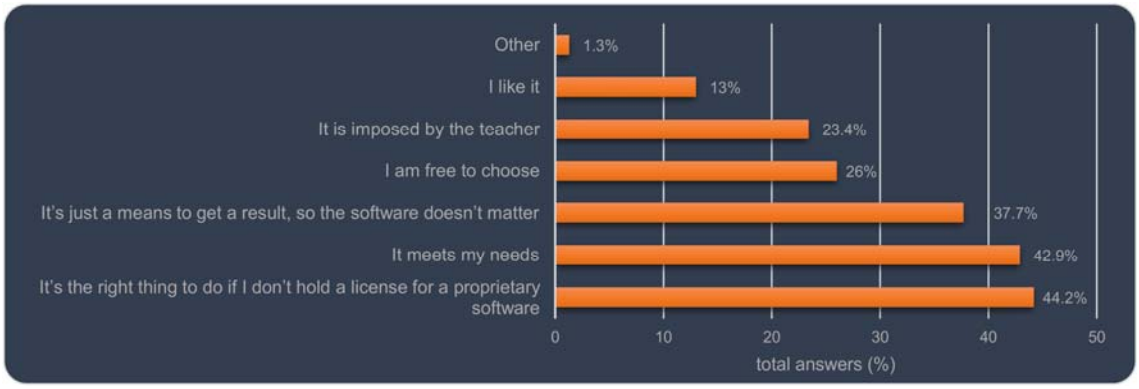


**Fig. 4.** Reasons why the students use GIS Open Source software

(The analysis was confined to the students that use GIS software; the item was a multiple choice one)

Confining the analysis to the respondents that used GIS software (we removed the students who had not begun to study GIS yet, i.e. 7.8% of the sample), we saw that only 14 students declared that they did not use GIS Open Source software (Figure 5). Some of the reasons why they claimed they did not use them, seemed at first sight to be objective. Thus, 16.9% stated (the item was a multiple-choice one) they preferred proprietary software because they heard or knew that the potential employers did not use OSS, which was true for Romania. Unlike other countries, where the local and central administrations, as well as many important institutions, such as environment agencies, statistical bureaus or various companies, use OSS, in Romania the situation is different. The discussions we have had

over the years with the students have revealed that they fear about failing to adapt to the use of proprietary software, because at college they employ GIS Open Source solutions. But the students should also understand that proprietary software are numerous and different and there is always a chance that the employing company should use a software that differs from those employed at college for training activities. Consequently, this is not an objective reason. The respondents invoked other reasons as well: I do not know such software tools (10.4%), I am already proficient in using proprietary GIS software and I do not want to turn to Open Source tools (7.8%), I hold a license for proprietary software (5.2%).

The subjective reasons were the following: I've used them and I've realised I don't like them (13%), I've used them and I believe they are not up to my level (5.2%; this share is represented by two 2nd year students, but it is hard to believe that a software like QGIS is not up to the expectations of a 2nd year student). The reluctance in using GIS Open Source software stems from misinformation combined with incomplete information and with the unwillingness to try something new. It is a serious fact that a number of respondents have learned from some academics that GIS Open Source software are not good, reliable or performant (6.5%). Even if there were such statements, the answers point out that only 5 students took the information as such and turned it into a justification for not using GIS Open Source software. Although this item had an open-ended section, no student provided further reasons.

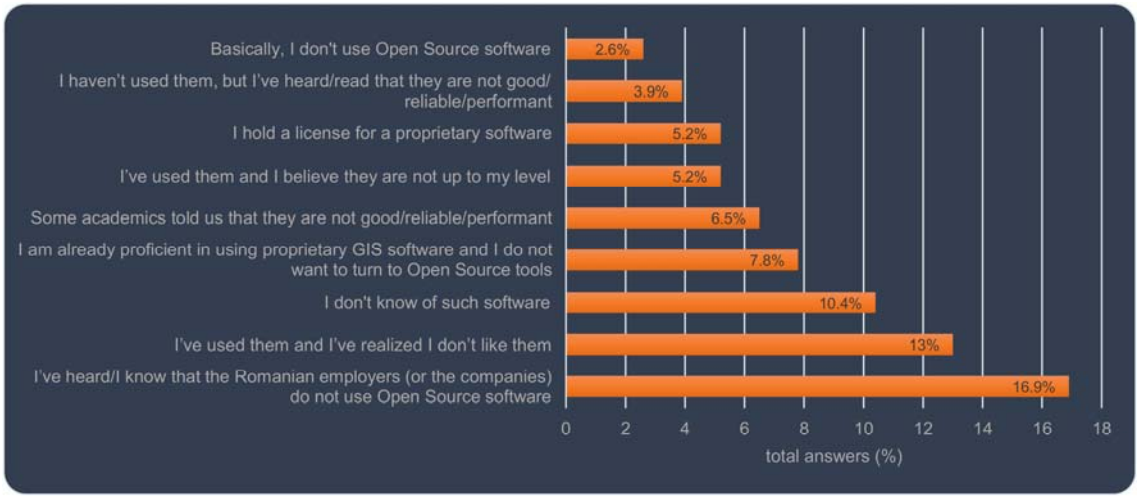


**Fig. 5.** Reasons why the students do not use GIS Open Source software (the analysis was confined to the students that use GIS software; the item was a multiple choice one)

The students who used GIS Open Source software were asked to say to what extent they considered important or less important the various reasons that determined their choice (multiple-choice answer). Their responses are given in Figure 6. One can ascertain that the reason that

mattered the most (49.2% of the options) was the liberty of using legally the software both at college and at home. The other options were the following: this software is free (43.1%), the interface is in several languages (also 43.1%) and it can be installed freely on several devices (also 43.1%). The fact that Open Source software uses standard formats was very important for 38.5% of the respondents, but if we put together the answers given by the students for whom this reason was very important, important or had an average importance, then the percentage amounts to 86.5%. The efficiency of this software is a criterion that matters very much and much for 56.9% of the students, while only 6.2% think that for them it is unimportant. If the documentation (user guides) and the tutorials that can be found on the internet matter very much for 41.5% of the respondents, the accessible interface ranks last, being very important only for 32.3%. This position is surprising if we take into account that the main obstacle in using the GIS Open Source software is the fear of the students that they will fail to adapt to the interface of proprietary software. The rather high percentage (13.8%) of those who declare that for them it is unimportant that this software is free is surprising. For most students, the possibility to communicate with those who develop the software is not an issue, 20% declaring that for them this fact is irrelevant (Figure 6).

A mention should be made of the students (3.9%) who, although they had not used GIS Open Source software previously, took the information that said this software was not good, reliable or performant (here the teacher must step in to argue the opposite). Likewise, 2.6% of the respondents "basically do not use Open Source software".

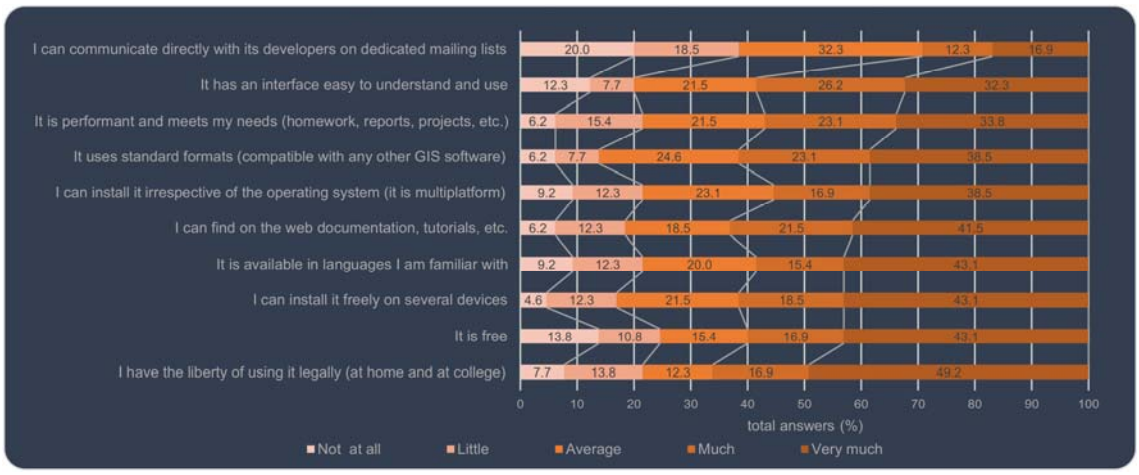


**Fig. 6.** Answers given to the question "In case you use GIS Open Source software, to what extent do the following reasons matter for you?"

(The respondents were able to choose from several answers)

The reasons that hinder the use of GIS Open Source software in university teaching activities emerge from the answers represented in Figure 7

(multiple-choice answers), which broadly correspond with the opinions expressed by the students during the past nine years of teaching activities. This question was answered both by the students who did not use the software because they had not begun a GIS course by that time and by those who chose to use proprietary GIS software. The first two reasons that mattered very much (each accounting for 11.1% of the options) were the following: these tools "do not meet my needs" and "I've heard that the Romanian companies do not use GIS Open Source Software". If the second reason is real (but easy to overcome), the first is strictly subjective and unrealistic if we take into account the standards reached by a number of GIS Open Source software (QGIS, gvSIG, GRASS, ILWIS). Moreover, many academics working in famous institutions employ these tools for their research activities.

Other objective reasons that matter very much are the following: the late documentation in relation with software development (8.3%; Figure 7) and the fact that students are not aware of the existence of such software (5.6% of the options, representing 1$^{st}$ year students who had not begun GIS courses by that time). If the students would use the LTR versions, then the documentation would correspond to GIS Open Source software. For instance, at this moment, QGIS corresponds to LTR 2.14.11. Essen, while the updated version is 2.18.3. Las Palmas. The last reason is also easy to fight if the academic staff will get involved in giving students adequate information regarding the performant GIS Open Source software.

The rapid evolution of the software and the difficulty in keeping up with them is an important and very important hindrance for 11.1% of the respondents (Figure 7). Although it seems to be a contradiction that progress comes to be viewed as an obstacle, these students think that the rapid evolution of the software is a real problem. In our teaching experience, there were many situations when some modules, plugins, etc. changed from semester to semester, which compelled us to explain the new working procedures. If for a researcher these updates are welcome, as they raise only minor problems of reorientation, for the students they are disconcerting. We have already stated that a solution would be the use of LTR versions for the practical activities, while, at home, the students have the liberty of passing or not to the new updates or versions (in QGIS, appear three new versions each year).

Unfortunately, the use of GIS Open Source software is also hindered by subjective reasons, such as "I do not like it" and "I've heard it is bad and I believe it" (Figure 7). It is unfortunate that some of the students take up the "myth" of bad quality OSS without testing if first and without trying to find out where these programmes are used, who uses them and with what results. There are many reasons why students are reluctant to test the software (a busy schedule, the lack of theoretical and practical knowledge, etc.), and this is why teachers have the responsibility of informing them.

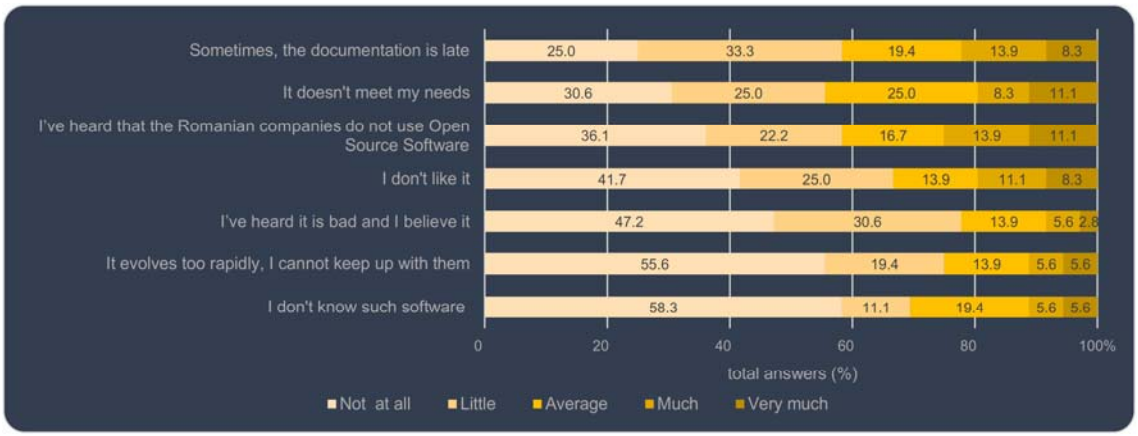


**Fig. 7.** Answers given to the question "If you do not use GIS Open Source software, to what extent do the following reasons matter for you?"

(The respondents were able to choose from several answers)

The open-ended answers given to the question, "What other reasons prevent you from using GIS Open Source software?" were few: bugs and unexpected errors (2 students); "I am already proficient in using proprietary GIS software and I do not want to turn to Open Source tools" (1 student); "teachers told me so" (1 student; hence we understand teachers recommended students not to use OSS); "I use them only for the projects where I am compelled to do so, because it seems useless to learn over four types of software simultaneously at the beginner level instead of getting trained in one or two thoroughly"). The geographers' formation at university level should aim not at turning the students into technicians who know what button to press when using a certain software, but at training specialists with good theoretical knowledge, able to adapt rapidly to any kind of software and to "produce" in their turn science and knowledge (Goodchild & Janelle, 2010; Bertazzon, 2013).

Besides, given the complexity of the GIS software, it is impossible that someone, after attending a course extending on 28 hours, were able to master a GIS tool thoroughly. For example, only the QGIS plugins amount at this very moment to 647; SAGA has 235 geoalgorithms integrated in QGIS, and GRASS has about 400 modules. The teaching activities have shown that the "bugs and unexpected errors" some students complained about occurred on laptops because of some problems pertaining to their operating systems (especially under Windows). Such errors occurred only seldom on the laptops of the faculty staff who used QGIS, GRASS, gvSIG, and SAGA.

The answers revealed that the students were using or had used previously both Open Source and proprietary software (between one and six software tools for each user; Figure 8). Some of them mentioned other computer programmes as well (OpenJump). Yet, they also provided open answers in which they included a number of software tools in wrong categories, which proved that a part of the respondents confused the Open

Source software tools with the proprietary ones and the GIS software with other computer programmes (graphics software, cartography software or Computer Aided Design – CAD). At the level of the investigated sample, the most used Open Source software was QGIS. This tool was mentioned by all respondents, but only 41.1% of them declared they used exclusively QGIS, while the rest were also familiar with several types of GIS Open Source software (Figure 8). The second position was occupied by GRASS GIS, with 47.1% of the answers, while Ilwis was ranked third (23.5%).

All the students who had already followed a course of GIS or Methods and techniques of cartographic representation stated that they used at least one GIS Open Source tool. But as far as proprietary computer programmes were concerned, 25% of the students said they had never used such software. The most used proprietary computer programme was ArcGIS (70.6% of the answers), followed by Surfer (30.9%) and MapInfo (4.4%; Figure 8). Some students used other proprietary GIS software tools (Global Mapper, GeoMedia, etc.).

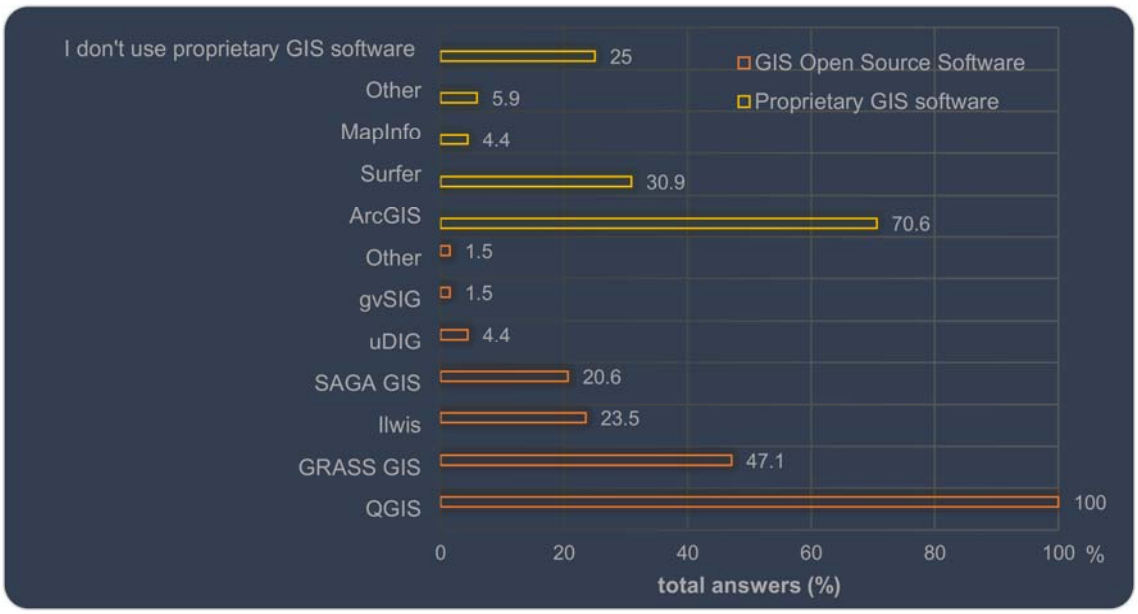


**Fig. 8.** GIS software tools used by students

(The respondents were able to choose from several answers)

It is interesting to note the students' behaviour if they could choose themselves the software they need: 51.9% would choose Open Source software and only 27.3% proprietary software, while 20.8% failed to answer this question (Figure 9). Although QGIS continued to occupy the first position (49.4%), ArcGIS recorded a significant percentage increase (44.2%). 3.9% students answered they would have used both (QGIS and ArcGIS), while 2.5% would have opted for computer programmes other than those specified in the questionnaire (Global Mapper or gvSIG; Figure 9). The questionnaire

included only the most widely used GIS software tools, a proprietary software package (ArcGIS), and an Open Source one (QGIS).

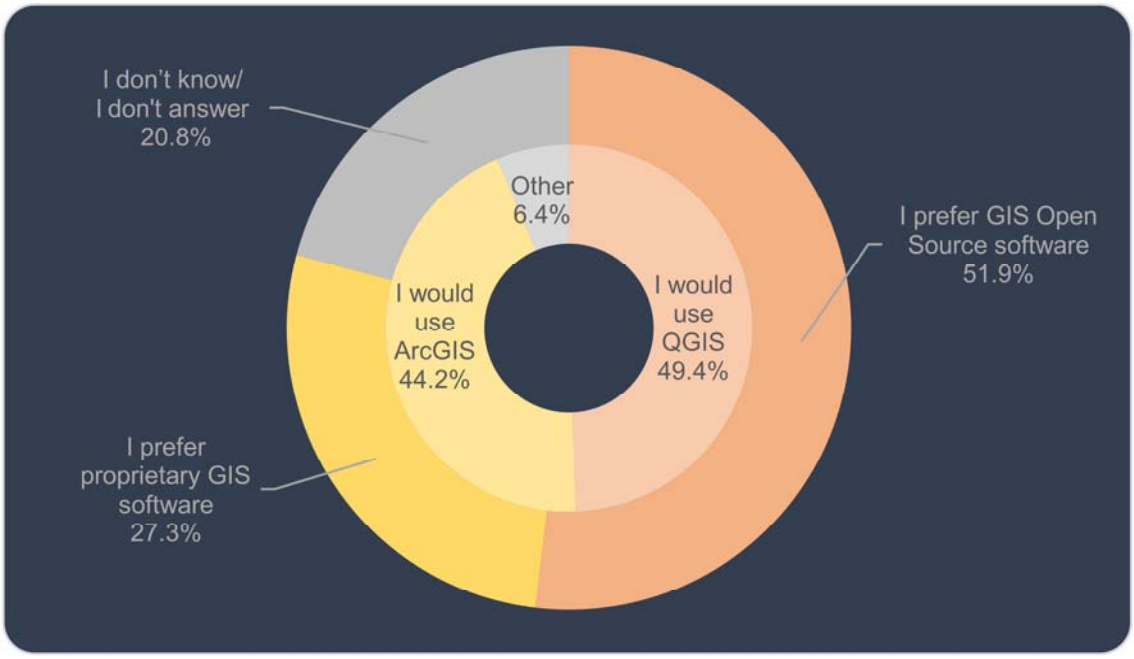


**Fig. 9.** Students' preferences related to GIS Open Source and proprietary software, if they had the liberty of choosing themselves

## CONCLUSIONS

Most students (71.4%) who participated in this survey have used the computer for over 9 years, but all of them, observing the structure of the curriculum, start to use GIS software in the 1st year of study (the students in Cartography, in the first semester and the others, in the second semester). As a result, their experience in using these types of software increases each study year, but without exceeding a working experience of 4-6 years.

The reasons why the students choose GIS Open Source software (including at home) are both objective (the legal use of proprietary software; the usefulness of GIS Open Source tools for the students' requirements; the fact that these tools are employed for specific results; the zero costs; the liberty of using them legally on several devices at home and at college) and subjective (the liberty of choosing and the pleasure of working with such tools). All the respondents used or had used previously the QGIS software package and many of them were also familiar with ArcGIS. A large share of students was also in favour of the Open Source solutions.

There are several reasons why some of the students are reluctant to use GIS Open Source, but the main issue here is that they fear they will not be able to cope subsequently with proprietary software (although even proprietary computer programmes differ from each other, which makes their concern to be unjustified).

The rapid development of GIS Open Source tools compels the students to adapt, but in some cases, the user guides lag behind. In order to solve this problem, the teachers should recommend the LTR versions of the programmes.

The use of GIS Open Source software (and mainly QGIS) at the Faculty of Geography within the University of Bucharest is a positive experience at least for three reasons: (1) the software is free, so this is an advantage both for the students and for the university; (2) the software can be used legally by students and staff both at college and at home; (3) the software is efficient and meets the students' needs.

## References

Akbari, M., & Ali Rajabi, M. (2013). Evaluation of Desktop Free/Open Source GIS Software Based on Functional and Non-functional Capabilities. *Technical Gazette, 20*(5), 755-764.

Azzari, M., Zamperlin, P., & Landi, F. (2013). GIS in Geography Teaching. *Journal of Research and Didactics in Geography (J-READING). 2*(2), 27-42, DOI: 10.4458/2379-03.

Bertazzon, S. (2013). Rethinking GIS Teaching to Bridge the Gap between Technical Skills and Geographic Knowledge. *Journal of Research and Didactics in Geography (J-Reading), 1*(2), 67-72, DOI: 10.4458/0900-07.

Davis, P. (2015). Educating 21st Century Geospatial Technology Industry Workers with Open Source Software. *OSGEO Journal Volume 14*(1), 3-8, retrieved January 25 2017, from https://journal.osgeo.org/index.php/journal/article/view/222/188Đol. 14.

Dresen, E. (2006). The Potential Use of Open Source GI Software in Education Research Semester – Project, *FIT*, retrieved January 25 2017, from https://www.noexperiencenecessarybook.com/o95Gw/open-source-gis.html.

Ertz, O., Rey, S.J., & Joost, S. (2014). The Open Source Dynamics in Geospatial Research and Education. *Journal of Spatial Information Science, 8*, 67–71, DOI:10.5311/JOSIS.2014.8.182.

Etherington, T.R. (2016). Using Open-Ended Geographic Information System Assessments to Allow Students to Construct Relevant Geographies Given the Internationalisation of Tertiary Education in New Zealand. *New Zealand* Geographer, 72, 151–158, DOI: 10.1111/nzg.12109.

Goodchild, M.F., & Janelle, D.G. (2010). Toward Critical Spatial Thinking in the Social Sciences and Humanities. *Geojournal, 75*(1), 3-13, DOI: 10.1007/s10708-010-9340-3.

Mitasova, H., Landa, M., & Shukunobe, M. (2012). Building Open Source Geospatial Education at Research Universities: Where We Are and What Is Holding Us Back. *Proceedings of the 2012 Open Source Geospatial Research & Education Symposium, Yverdon-les-Bains, Switzerland, 24–26 October 2012*, 42-49, retrieved January 10 2017 from http://2012.ogrs-community.org/2012_keynotes/abstract_Mitasova.pdf.

Moreno-Sanchez, R. (2012). Free and Open Source Software for Geospatial Applications: A Mature Alternative in the Geospatial Technologies Arena. *Transactions in GIS, 16*, 81–88.

Nétek, R. (2012). Potential Influence of E-Learning and Open Source Solutions for Education at Palacký University in Olomouc Inspired by Polytechnic University in Valencia. *Geoinformatics FCE CTU 8*, 79-90, DOI: https://doi.org/10.14311/gi.8.6.

Osaci-Costache, G. (2012a). Folosirea programului Quantum GIS în cadrul cursului „Metode și tehnici de reprezentare cartografică”/Using the Quantum GIS Programme during the Cartographic Representation Methods and Techniques Course. In Dulamă M.E., Ilovan O.-R. & Bucilă F. (Eds.), *Tendințe actuale în predarea și învățarea geografiei* (pp. 113-118). Cluj-Napoca: Presa Universitară Clujeană.

Osaci-Costache, G. (2012b). La formazione delle competenze professionali nella specializzazione in Cartografia attraverso l’uso delle fonti cartografiche web e dei programmi gratuiti, liberi e Open Source/ Professional Skills Training on Mapping Specialization Using Web Mapping Sources and Freeware, Free and Open Source Programmes. *Bollettino dell’Associazione Italiana di Cartografia, Anno XLVIII, 144-145-146*, 125-135.

Osaci-Costache, G. (2013). Programe gratuite, libere şi Open Source folosite la Cartografie/Freeware, Free and Open Source Programmes in Cartography. In Dulamă M.E., Ilovan O.-R. V Conţiu H.V., Osaci-Costache G. (Eds.), *Tendinţe actuale în predarea şi învăţarea geografiei. Contemporary trends in teaching and learning geography*, 12 (pp. 93-100). Cluj-Napoca: Editura Presa Universitară Clujeană.

Osaci-Costache, G., Cocoş, O. & Cocoş, A. (2014). Online Cartographic Materials for Geographical Higher Education: Opportunity or Threat? *Proceedings of the 9th International Conference on Virtual Learning ICVL 2014, Bucharest, 24-25 Oct. 2014*, 218-224, București: Editura Universității, retrieved February 5 2017, from http://www.scribd.com/doc/243333879/Proceedings-of-ICVL-2014-ISSN-1844-8933#scribd.

Osaci-Costache, G., Cocoş, O., & Cocoş, A. (2015a). Virtual Environment – A Cartographic Documentation Tool for the Students in Geography. *Proceedings of the 10th International Conference on Virtual Learning ICVL 2015, Timişoara, Romania, 31 Oct. 2015*, 107-113, București: Editura Universității, retrieved January 20 2017, from http://www.scribd.com/doc/286449807/Proceedings-of-ICVL-2015-ISSN-1844-8933-ISI-Proceedings.

Osaci-Costache, G., Ilovan, O.-R., Meseşan, F., & Dulamă, M.E. (2015b). Google Earth Helping Virtual Learning in the Geographical University Education System in Romania. *Proceedings of the 10th International Conference on Virtual Learning ICVL 2015, Timişoara, Romania, 31 Oct. 2015*, 114-120, București: Editura Universității, retrieved January 5 2017, from http://www.scribd.com/doc/286449807/Proceedings-of-ICVL-2015-ISSN-1844-8933-ISI-Proceedings.

Petras, V., Petrasova, A., Harmon, B., Meentemeyer, R.K., & Mitasova, H. (2015). Integrating Free and Open Source Solutions into Geospatial Science Education. *ISPRS Int. J. Geo-Inf. 4*, 942-956, DOI: 10.3390/ijgi4020942.

Prenksy, M. (2001). Digital Natives, Digital Immigrants. Part 1, *On the Horizon*, *9*(5), 1-6, retrieved from http://dx.doi.org/10.1108/10748120110424816.

Tsou, M.H., & Smith, J. (2011). Free and Open Source Software for GIS education. *National Geospatial Technology Center of Excellence - Funded in part by the National Science Foundation, GeoTech Center*, retrieved January 5 2017, from https://pdfs.semanticscholar.org/4a3c/91fcbed134dbe2225ce8b0a459f6fc60be08.pdf.

**Appendix 1**

## Geography students' perception related to the use of GIS Open Source software in geographic higher education

*****Compulsory item

**I am a male / female ***

*Please tick only one option.*

- o 1st year student
- o 2nd year student
- o 3rd year student
- o 1st year master student
- o 2nd year master student

**How long have you been using the computer? ***

*Please tick only one answer*.

- o less than a year
- o 1-3 years
- o 4-6 years
- o 7-9 years
- o for over 9 years

**How long have you been using GIS software? ***

*Please tick only one answer.*

- o less than a year
- o 1-3 years
- o 4-6 years
- o 7-9 years
- o for over 9 years

**What type of GIS software do you use? ***

*Please choose only one answer for each item.*

| | only Open Source | only proprietary | both types, but especially Open Source | both types, but especially proprietary | I don't use |
|---|---|---|---|---|---|
| at college | ☐ | ☐ | ☐ | ☐ | ☐ |
| at home | ☐ | ☐ | ☐ | ☐ | ☐ |

**How many hours per day (on an average) do you use GIS software? ***

*Please choose only one answer.*

- o less than an hour
- o 1-3 hours
- o 4-6 hours
- o 7-9 hours
- o for over 9 hours
- o I don't use GIS

**Regarding the use of GIS software in class ***

*Several possible answers.*

- o some academics compel us to use Open Source software
- o some academics compel us to use proprietary software
- o some academics give us freedom in choosing the software (Open Source or proprietary)
- o I don't know, I haven't used yet

**We were told that using a proprietary software without holding a valid license is illegal ***

*Please choose only one answer.*

- o yes
- o no
- o I don't know / I refuse to answer

**I use GIS Open Source software because ***

*Several possible answers.*

- o it's the right thing to do if I don't hold a license for a proprietary software
- o it is imposed by the teacher
- o I am free to choose
- o it's just a means to get a result, so the software doesn't matter
- o I like it
- o it meets my requirements
- o I don't use
- o Other:
  .....

**I do not use GIS Open Source software because ***

*Several possible answers.*

- o I don't know of such software
- o I haven't used it, but I've heard/read that it is not good/reliable/performant
- o some academics told us that it is not good/reliable/performant
- o I've heard/I know that the Romanian employers (or the companies) do not use Open Source software
- o I've used it and I believe it is not up to my level
- o I've used it and I've realized I don't like it
- o basically, I don't use Open Source software
- o I hold a license for proprietary software
- o I am already proficient in using proprietary GIS software and I do not want to turn to Open Source tools
- o it is not my case, because I already use such software
- o Other: .....

**In case you use GIS Open Source software, to what extent do the following reasons matter for you (several possible answers)**

*Please choose only one answer for each item.*

| | Not at all | Little | Average | Much | Very much |
|---|---|---|---|---|---|
| It is free | ☐ | ☐ | ☐ | ☐ | ☐ |
| I have the liberty of using it legally (at home and at college) | ☐ | ☐ | ☐ | ☐ | ☐ |
| I can install it freely on several devices | ☐ | ☐ | ☐ | ☐ | ☐ |
| I can install it irrespective of the operating system (it is multiplatform) | ☐ | ☐ | ☐ | ☐ | ☐ |
| It has an interface easy to understand and use | ☐ | ☐ | ☐ | ☐ | ☐ |
| I can communicate directly with its developers on dedicated mailing lists | ☐ | ☐ | ☐ | ☐ | ☐ |
| I can find on the web documentation, tutorials, etc. | ☐ | ☐ | ☐ | ☐ | ☐ |
| It is available in languages I am familiar with | ☐ | ☐ | ☐ | ☐ | ☐ |
| It is performant and meets my needs (homework, reports, projects, etc.) | ☐ | ☐ | ☐ | ☐ | ☐ |

| | Not at all | Little | Average | Much | Very much |
|---|---|---|---|---|---|
| It uses standard formats (compatible with any other GIS software) | ☐ | ☐ | ☐ | ☐ | ☐ |

**If you do not use GIS Open Source software, to what extent do the following reasons matter for you (several possible answers)**

*Please choose only one answer for each item.*

| | Not at all | Little | Average | Much | Very much |
|---|---|---|---|---|---|
| I don't know such software | ☐ | ☐ | ☐ | ☐ | ☐ |
| I've heard it is bad and I believe it | ☐ | ☐ | ☐ | ☐ | ☐ |
| I don't like it | ☐ | ☐ | ☐ | ☐ | ☐ |
| It doesn't meet my needs | ☐ | ☐ | ☐ | ☐ | ☐ |
| I've heard that the Romanian companies do not use GIS Open Source Software | ☐ | ☐ | ☐ | ☐ | ☐ |
| Sometimes, the documentation It is late | ☐ | ☐ | ☐ | ☐ | ☐ |
| It evolves too rapidly, I cannot keep up with it | ☐ | ☐ | ☐ | ☐ | ☐ |

**What other reasons prevent you from using GIS Open Source software? (Please skip question if you use it)**

*Free answer.*

**What GIS Open Source software do you / did you use? ***

*Several possible answers.*

- o QGIS (Quantum GIS)
- o gvSIG
- o GRASS GIS
- o SAGA GIS
- o uDIG
- o Ilwis
- o I don't /I didn't use GIS Open Source software
- o Other: .....

**What proprietary GIS software do you use / have you used? ***

*Several possible answers.*

- o ArcGIS
- o MapInfo
- o Surfer
- o I don't/I didn't use proprietary GIS software
- o Other: .....

**Of the two types of GIS software ***

*Please choose only one answer.*

- o I prefer GIS Open Source
- o I prefer proprietary GIS
- o I don't know/I refuse to answer

**If I had to choose, I would use ***

*Please choose only one answer.*

- o QIS
- o ArcGIS
- o Other: .....