education sciences

Article

Attitudes of Teachers and Students towards the Possibilities of GIS Implementation in Secondary Schools in Croatia

Silvija Šiljeg [1], Antonio Milanović [2] and Ivan Marić [1,*]

[1] Department of Geography, University of Zadar, 23000 Zadar, Croatia
[2] Zadar Public Library, 23000 Zadar, Croatia
* Correspondence: imaric1@unizd.hr; Tel.: +385-958219909

Abstract: The geographic information system (GIS) is, at the global level, recognized as one of the best ICTs for implementation in the subject of geography. The application of GIS in the Republic of Croatia (RH) lags behind developed countries. The main objective of this research was to examine the attitudes of secondary school students and geography teachers regarding the introduction of GIS in the educational system process. In the period from 3 October 2021 to 27 January 2022, a survey questionnaire was conducted in 30 secondary schools in the RH on a sample of 611 students and 96 teachers. The results have showed that both teachers and students have a positive attitude toward the introduction of GIS for the purpose of teaching geography. More than 80% of teachers believe that GIS is not sufficiently represented in the high school and geography curricula which is recognized as one of the most important factors which limit GIS implementation. A majority (77%) of teachers are not using GIS on any teaching level, which is not surprising since both surveyed teachers and students have poor knowledge of GIS, although teachers rated their knowledge a little higher. Teachers perceive students' interest in GIS exactly as students express it; predominantly indifferent. The most important factors limiting the implementation of GIS are recognized as: a lack of necessary GIS software and licenses; not knowing how to use GIS; and an insufficient number of teaching units dedicated to GIS in the geography curricula. An equal percentage of both teachers and students believe that there are prerequisites for GIS implementation in their schools. One of the basic prerequisites for GIS implementation is that education authorities need to "see" GIS as an important part of geography and include it more in school curricula. In almost all countries where GIS has been implemented in schools, difficulties in its implementation have been documented.

Keywords: GIS; secondary schools; geography; teacher and student attitudes

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Citation: Šiljeg, S.; Milanović, A.; Marić, I. Attitudes of Teachers and Students towards the Possibilities of GIS Implementation in Secondary Schools in Croatia. *Educ. Sci.* **2022**, *12*, 846. https://doi.org/10.3390/educsci12120846

Received: 20 September 2022
Accepted: 16 November 2022
Published: 22 November 2022

1. Introduction and Background

The curricula for teaching subjects need to be updated and improved in order to meet socio-political and economic changes and progress in the academic world [1,2]. In modern European curricula, geography has an applicative educational role because it develops the skill of intelligent problem prediction, by shaping the vision and helping to introduce different solution strategies [3]. In the last two decades, due to the emergence and development of new technologies (the speed and availability of the internet, hardware, software, geospatial sensors), the secondary school and elementary school education processes have been experiencing enormous changes [4–6]. The paradigm in education is slowly changing from the learning of factual information to the application of knowledge and technology in solving practical tasks. Therefore, technology is increasingly recognized as a "valuable tool", which enables the implementation of various methods in order to understand and respond to 21st-century challenges [7]. For example, the GENIP (GENIP is a consortium of geographical associations committed to improving geographic education) consortium in the USA encouraged the use of "problem-solving" geospatial technologies (GST) [8] as additional learning and teaching tools in education [7]. The GST by itself is not a "problem-solving" tool. It can, in different ways, be implemented in school subjects or teaching units in order to overcome certain problems (e.g., spatial orientation, how maps are made, topography, etc.). In the context of geography, GIS software (Geographic Information Systems) stands out as geospatial technology, offering teachers the ability to use a wide range of tools [4,5,9–11]. Namely, GIS is listed among the 25 most important technological innovations that influenced the development of humanity in the 20th century [12]. It has been recognized as the best technology that can be implemented in the teaching of the subject of geography [2,13]. However, the definition of GIS is the subject of numerous scientific papers [7,14–18]. In this paper, GIS is defined as an instructional tool that facilitates students' engagement in inquiry and their understanding of geography and improves their skills in geographical analysis and reasoning. Understanding GIS primarily depends on the expertise of the user; that is, on the purpose of its application. GIS is recognized as a technological tool that serves to acquire and develop knowledge or as an independent goal of scientific research [14]. However, regardless of the definition and views of GIS, it was already pointed out at the end of the 20th century that GIS systems will undoubtedly play a central role in the development of knowledge in the future [11,14,18]. Some research suggests that the application of GIS in schools supports increased intrinsic motivation and higher-level thinking processes [19,20]. However, the simple introduction of GIS in secondary schools does not necessarily have an immediate direct effect on increasing student motivation. The prerequisite for this is that teachers and students must know how to use GIS, otherwise it can have the opposite effect [11]. GIS is important for geography because it connects practical geographical skills and knowledge (foundation) in order to achieve reflexive competence (the application of skills and knowledge to practical challenges and issues). More precisely, the following geographical competencies can be promoted through the use of GIS: problem-solving and geospatial thinking, the investigation of geographical relationships, patterns, and trends, and decision-making.

The inclusion of GIS in the teaching of the subject of geography simultaneously represents one of its greatest opportunities and greatest challenges [12,21,22]. Namely, the integration of GIS into the teaching of geography is complicated by many factors highlighted in numerous studies [2,10,12,18,23] and often requires a great deal of personal involvement from the teacher [24]. This is because most teachers have not had a formal education in GIS. Therefore, it is necessary to acquire new knowledge and skills for which they often do not have enough time. Furthermore, they are obliged to follow the official geography curricula, which makes it difficult to introduce new elements into classes. GIS has been used intensively for a long time at the university level in various scientific fields [25]. For example, the number of university programs that offered GIS in the USA and Canada in the early 1980s was 10. However, by the end of the 1990s, that number exceeded 2000 [12]. Simultaneously with the application of GIS in institutions of higher education, a significant integration of GIS in secondary education has started in the USA and Europe [6]. Its potential application in secondary education began in the 1990s [13,18,22,26]. Many studies show that GIS is recognized as a useful educational tool in creating an inquiry-based learning environment [4,18,27,28]. Today, GIS occupies a place in high school geography curricula, and sometimes in other subjects like mathematics, biology, environmental science, etc., in China [6,29], the USA and Canada [12,21], Malaysia [13,30], the Netherlands [21], Switzerland [24], Hong Kong [2], Taiwan [29,31], the Republic of Korea [32], South Africa [10,29,33], Egypt [28], Nigeria [28], the Democratic Republic of the Congo [28], Rwanda [34], Uganda [28], India [29], Turkey [29], the UK [29], and other countries [21,29,35,36]. In 1998, GIS was introduced in Singaporean secondary schools as a tool for teaching geography [22].

GIS entered the educational systems of Europe in the early 2000s. For example, in 2003, serious thought began to be given to introducing GIS into secondary education in Finland [25]. In 2008, the Society of Swiss Geography Teachers launched an initiative in 44 Swiss schools [24] for the introduction of GIS in teaching to begin. Norway started using

GIS in the education system in 2006 [37]. Germany began serious education reforms in 2000 after very poor PISA results, and after some time they introduced GIS into teaching [38]. In Poland, GIS is used in secondary schools in the processing and presentation of geographic data, the interpretation of various thematic maps, the creation of simple maps, and the analysis and presentation of spatial data [39]. In the research of Manić et al. [40], it was determined that the majority of the 126 students of secondary vocational schools in Serbia know about the concept of GIS and that one-third have the theoretical knowledge and practical skills for its application. Furthermore, in 2003, the South African Department of Education (DoE) stated in the National Curriculum Statement (NCS) for Geography that GIS is a "skill to be acquired". Subsequently, GIS was gradually introduced into the curricula from 2006 to 2008 [33]. Nevertheless, the vast majority of all these countries, despite the early recognition of the usefulness of GIS and the readiness for change and innovations, experienced great difficulties during the implementation of GIS in secondary schools [12]. Many teachers worldwide still struggle to find the best way to implement GIS in practical lessons [28]. Namely, in the early 2000s, Chalmers [41] while analyzing the issues and prospects associated with GIS in New Zealand's schools, stated his pessimistic view about the widespread use of GIS in schools because the main problem will be a lack of teacher time rather than software difficulties.

For example, Siegmund et al. [42] point out that a large proportion of teachers in Germany do not have sufficient computer skills to implement GIS in practice. The problem of having the equipment (hardware and software) but missing the necessary knowledge to implement GIS is common for many developed and less-developed countries [28,43]. Furthermore, in 2005, Turkey included GIS in the geography curricula. However, its implementation in practice became extremely difficult due to the lack of technological equipment and staff expertise [44]. In South Africa, due to all the difficulties of implementing GIS [28], the form of an analog "paper" GIS package adapted to teaching in resource-poor schools was considered. Given that it does not require the purchase of IT equipment or sending teachers on expensive courses, and provides students with conceptual knowledge of GIS, it is an ideal solution [33]. In the Netherlands, the implementation of GIS in schools began in the early 2000s and was marked by great difficulties (unavailability of data and software, a lack of funding, and a lack of teachers) [21].

1.1. Education System in Republic of Croatia (RH)

According to the official site of the Ministry of Science and Education, the education system of the RH consists of (a) early and preschool education; (b) primary school education; (c) secondary school education, and (d) higher education [45]. Early and preschool education in the RH includes the upbringing, education, and care of children of preschool age, from six months to starting school. Primary education in the RH is compulsory and free of charge for all children between the ages of six and fifteen, and for students with multiple developmental disabilities up to the age of 21. For persons older than 15 years who have not completed the legally required primary school, there is the possibility of inclusion in the primary education program for adults. Secondary school education enables everyone, under equal conditions and according to their abilities, to acquire the knowledge and skills for work and continuing education after completing primary school education. The detailed breakdown of secondary schools in the RH is listed in Section 2. Higher education in Croatia is primarily regulated by the Law on Scientific Activity and Higher Education which provides a framework for the implementation of the Bologna Process and the modernization of the organizational scheme in science and higher education [46].

Article 115 of the Act on Education in Primary and Secondary Schools states that teachers have the right and obligation to undergo permanent professional training and improvement through programs approved by the Ministry of Science and Education [47]. This refers to individual and organized training in home science, methodology, pedagogy, the field of information and communication technologies, and any other relevant field necessary for effective and high-quality performance in educational activities in school institutions. The teacher training system should be a continuous process that includes a period of study and a period of professional development in lifelong education. It can be individual and collective, in and out of school (counseling, seminars, activities, study trips, etc.) [48]. Namely, teachers of all subjects, including geography, under the conditions prescribed by the document Rule of the advancement of teachers and professional associates in primary and secondary schools and student dormitories can advance to the following positions: (1) mentor; (2) advisor; (3) higher advisor [49]. The evaluation of professional-pedagogical work, among other things, is scored according to criteria divided into categories, one of which is lectures, workshops, and education. In the context of teaching geography, this can refer to the attendance of various workshops and GIS courses aimed at raising digital competences [50].

1.2. GIS in the Republic of Croatia (RH)

In the Republic of Croatia (RH), there is a widespread prejudice that a student is good at geography only if he knows the capitals of all countries by heart. Therefore, it is reasonable to assume that the image of geography as a subject in school and as a science is quite distorted. This can have negative effects on the potential enrollment of students in geography, and the later employment opportunities for young geographers [51]. In the RH, the implementation of GIS in the subject of geography is limited to isolated examples of good practice and teachers' own initiative [48]. This type of teaching approach generally increases the difference in the quality of teaching at the regional level of the country. Namely, although the problem of insufficient practical and experimental work by students in regular classes is highlighted every day [48], the existing workload of students and teachers with the current teaching content is used as a justification for not introducing additional content (e.g., GIS, sensors, student projects) into the curricula.

In the curricula for the subject of geography in the RH, adopted on 22 January 2019, under the jurisdiction of the Ministry of Science and Education, 70 h per year are provided for the first, second, and third grades of secondary schools, while 64 h per year are provided for the 4th grade [52]. In this curriculum, textbooks, atlases, workbooks, and other analog and digital learning materials that can contribute to easier learning are mentioned as materials for acquiring knowledge. In the entire curriculum, which is 145 pages long, GIS is mentioned only three times, in the following order:

(a) Connections with other subjects and cross-curricular topics;
(b) Materials and sources;
(c) Environment.

It is stated that " . . . a modern classroom for the subject of geography should be equipped with a sufficient number of computers connected to the Internet and with software programs that enable the implementation of GIS . . . " [52]. However, despite the formal acknowledgment of these statements, it is obvious that the current infrastructural equipment in most schools in the RH, the content of the curriculum, and the staff who are untrained in GIS, almost make it impossible to realize these statements.

In recent years, changes in the educational system of the RH have been the subject of numerous public discussions. Namely, the implementation of the first phase of the "School for Life" curricular reform brought certain changes not only in the content but also in the teaching performance. Teachers were given the opportunity to introduce students to geography in an interesting way with the help of new technologies. For example, from September 2018 to September 2022, the project "e-Schools: Development of a system of digitally mature schools (Phase II)" has been under way, with the aim of increasing the digital maturity of schools, contributing to the digital transformation of teaching and business processes in the education system, and preparing students for life and work in the 21st century [53]. In the context of these new circumstances, it is necessary to examine the attitudes of students and teachers toward the possibilities and potential difficulties of GIS implementation in the secondary schools of the RH. Currently, there is not a sufficient number of studies dealing with this topic in the RH. More precisely, except for Džankić [54], who deals with the application of GIS in teaching geography in primary and secondary schools, there were no papers found on Google Scholar dealing with this topic. However, this paper is locked for download on the digital repository of the University of Zagreb. Similar research in the RH was carried out by Tandarić and Tekić [50] who analyze the perception of geography as a science and school subject, Seljan [55] who analyzes the status of geography as a subject within the education system of the RH, Marin and Magaš [56] who analyze a methodical and didactic aspect of geography teaching, Marušić [57] who analyzes the perception of school subjects on several selected dimensions, and Kurilj [50] who analyzes the digital competence of geography teachers. The views of students and teachers are in this case important because they (1) can enable more precise identification of the limiting factors for GIS implementation and, (2) can be indicators of their future behavior toward GIS implementation.

The main objective of this research was to analyze the attitudes of secondary school students and teachers toward the possible implementation of GIS in the subject of geography. Furthermore, the main factors which are slowing down the implementation of GIS will be identified. Two sub-objectives emerged from the main goal of the work:

(a) To examine the readiness, interest, preconditions, and previous knowledge of teachers and students for the implementation of GIS in teaching,
(b) To identify the main factors which make it difficult to implement GIS in teaching.

From the set objectives, one hypothesis emerged. According to the opinion of the teachers, the main limiting factors for GIS implementation are organizational, among which the appearance of GIS in the plans, programs, and curricula stands out [58,59].

1.3. Study Area

The survey questionnaire was sent to all acquired e-mail addresses (n = 260) of secondary schools where geography is taught, which was the basic criteria for school selection. The results presented in the paper are the result of the response of teachers and students that voluntarily participated in the research. Regarding the types of schools that participated, there were no biases (gymnasiums, other secondary schools, professional schools, private schools); all types of schools where geography is taught participated. The spatial coverage of the research included 30 secondary schools in the RH.

2. Materials and Methods

The research methodology consisted of several steps. The first step included the acquisition of the e-mail addresses of secondary schools' where geography is taught. Secondary schools in the RH are defined as three-, four- or five-year schools that students attend after completing eight years of elementary school. Secondary schools are divided into gymnasiums, professional schools, and art schools. Gymnasiums can be general, linguistic, classical, natural science–mathematical, and science schools. In them, education lasts four years. Professional schools are divided into four-year schools (technical, economic, agricultural, etc.), three-year (industrial, craft, etc.) schools, and one five-year school (medical). Art schools educate students in the fields of music, dance, fine arts, and design, and their education lasts four years. In addition to these, there are military and religious secondary schools. After completing secondary school, the student can continue his education at universities. Over 260 e-mail addresses of secondary schools where geography is taught were collected. However, it should be noted that this is not the total number of secondary schools in the RH where geography is taught.

The second step included the creation of a questionnaire based on the relevant literature [11,18,25,28], whereby the variables applicable to both investigated groups were selected. All questions were formed in a way that they are understandable to teachers and students. The survey questionnaire was constructed in three parts. It included (a) basic data about the respondent; (b) the teachers'/students' views on the possibilities of GIS implementation in teaching; (c) and factors limiting the implementation of GIS. The total questionnaire consisted of 25 questions (46 variables) of which 21 were closed and 4 were open-ended. For closed type, respondents could choose the degree of agreement/disagreement on the 5-point Likert scale, while for open-ended questions, they could enter guidelines for facilitating the process of GIS implementation. Depending on the question asked, the respondents (students and teachers) chose answers on a 5-point Likert scale according to the following scaling:

- (1) poor; (2) satisfactory; (3) good; (4) very good; (5) excellent.
- (1) totally irrelevant; (2) irrelevant; (3) neither irrelevant nor important; (4) important, (5) totally important
- (1) extremely low; (2) low, (3) neither low nor high; (4) high, (5) extremely high

With the aim of comparing the attitudes of teachers and students, an analysis was carried out by comparing the percentage (%) of their response on a 5-point Likert scale and by comparing the derived statistical metrics: the median (mid-value of any given data set), arithmetic mean (a central tendency that represents the average of any given collection of data), mode (the most frequently occurring answer), and standard deviation (SD) were calculated. A similar approach was conducted in Artvinil [11], where the general level of secondary school students' attitudes towards GIS in teaching geography was evaluated using the Likert scale. Namely, the obtained data were analyzed by means, standard deviations (SD), *t*-tests, and Pearson correlation coefficients. The arithmetic means and SDs were calculated for evaluating the general level of students' attitudes.

In the survey questionnaire, the emphasis was placed on examining the factors that are limiting the implementation of GIS. The limitation factors were grouped into two groups: technical and organizational. The technical factors included eight factors: unfamiliarity with working with software, a lack of software and licenses, the speed and availability of the Internet, the lack and disorganization of geospatial data, networking problems, a lack of knowledge of working in databases, a technological lack of school equipment, a lack of IT equipment. The organizational factors included ten factors: a lack of education and training in GIS, a lack of literature and manuals on GIS, a lack of time for additional education, a lack of awareness of the importance and possibilities of GIS, financial reasons, a lack of space/IT classrooms, the inexperience of staff, an insufficient number of teaching units dedicated to GIS in the curriculum, the motivation of teachers, the motivation of students, which were separately evaluated overall by respondents.

The third step was related to the geocoding of the addresses of the schools whose respondents answered the questionnaire and the creation of the SPSS database. The fourth step was related to testing the reliability of the questionnaire (Cronbach's Alpha (Cronbach's alpha coefficient measures the reliability of variables, and indicates whether multiple variables can be used to form a single score)) and conducting the Chi-square test, i.e., testing with regard to the observed variables, where the results of the Chi-square test are presented in absolute frequencies and percentages. In order to better examine the relationships between the observed variables, in the fifth step, the Pearson correlation coefficient was calculated.

In the last step, the interpretation of the results was carried out. In order to examine attitudes towards GIS implementation, the research was conducted among secondary school students who take geography for at least one hour a week and among teachers who teach geography at secondary schools for at least one hour a week. The sample included 611 students (N = 611) and 96 teachers (N = 96). The research was conducted in the period from 3 October 2021 to 27 January 2022. The Google Forms program was chosen as the platform for the distribution of the questionnaire. The survey questionnaire was posted on the specific group on Facebook and sent to all of the acquired official e-mail addresses of schools where geography is taught, with the aim of increasing the response rate. The social network refers to a private group on Facebook under the name Geografi i pedagoška dokumentacija (Geographers and pedagogical documentation), which primarily brings together geography teachers. The goal of the group is to share all teaching materials, experience, and ideas for teaching geography at all levels of the Croatian education system.

The type of sample was intentional because only those students who took, or are taking geography and only those teachers who teach geography in secondary schools could access the questionnaire. The addresses of schools attended by students and where teachers work were geocoded using Google Earth and imported into GIS, resulting in a cartographic visualization of the sample.

Since the examination of attitudes toward the possibilities of GIS implementation in teaching is a latent variable that is not directly measurable [60], it was operationalized through the assessment of several statements on a rating scale. By calculating Cronbach's alpha, an attempt was made to determine the degree of reliability of the applied measuring scales; that is, whether they were confirmed as valid instruments for measuring the respondents' attitudes. The Chi-square test was applied to determine if some of the obtained (observed) frequencies deviate from the expected frequencies, while the Pearson correlation coefficient was applied to determine if there is a relationship between the selected variables.

3. Results and Discussion

3.1. Sample Characteristics

The survey was conducted in the period from 3 October 2021 to 27 January 2022, in 30 secondary schools. The sample was purposive and included 611 high school students who took (or are taking) geography and 96 teachers who taught (or teach) geography. Since one survey questionnaire in the group of teachers was not completely filled out, it was excluded from the overall analysis, so the final sample consisted of n = 706 respondents, of which 13.5% of respondents were from the group of teachers, and 86.5% from the group of students (Table 1).

Table 1. Number and percentage of respondents by role and gender.

		N	%
Group	Teachers	95	13.5
	Students	611	86.6
	Total	706	100.0

It should be emphasized that the exact data on the number of teachers who teach geography was not available at the national/regional level during the period in which the research was conducted (e.g., an individual teacher can teach at several schools, in several counties). This is mentioned by Kurilj [50]. Considering that a teacher can teach in several types of schools, for example in a gymnasium, technical, industrial, trade schools, and secondary education institutions for adults, the official number of teachers does not give the number of natural persons employed in secondary schools.

According to the data of the State Bureau of Statistics, in the RH at the beginning of the 2021/2022 school year, 25,492 teachers worked in secondary schools [61]. However, this includes teachers of all subjects. Kurilj [50] mentioned an approximate number of 1500 geography teachers in primary and secondary schools. According to this number, given that only secondary school teachers participated in this research, it can be concluded that more than 5% of the total number of secondary school geography teachers in the RH participated in the research.

Moreover, official data on students learning geography in secondary school does not exist, according to the authors' knowledge. According to the data of the State Bureau of Statistics, in the RH at the end of the 2020/2021 school year, 438 secondary schools were in operation. However, this includes all secondary schools, including those that have geography in their curricula, and those that do not. What is more, there were a total of 146,143 high school students in the RH. However, this includes all students, those who take geography, and those who do not.

3.2. Reliability of the Constructed Questionnaire

In order to determine the reliability of the constructed questionnaire as a measuring instrument, the section on the limitation factors for the introduction of GIS in the teaching of geography, which consists of 10 questions, was tested with Cronbach's Alpha coefficient. It determined that its value is quite high, i.e., 0.891 (Table 2), which represents a very high-reliability value for the specified factor.

Table 2. Reliability of the questionnaire.

Cronbach's Alpha	Number of Questions
0.891	10

The following text lists the separate results for Cronbach Alpha for the variables listed. If you look at the data given by Cronbach's Alpha when a single question is deleted, you can see that the reliability does not increase significantly if any question is omitted from the analysis. This indicates the high consistency of the question within the observed factor and the possibility to form a total score for the mentioned variables (based on the weight factor if the question is deleted):

(a) limitation for the introduction of GIS in the teaching of geography: lack of literature and manuals on GIS (0.879);
(b) limitation for the introduction of GIS in the teaching of geography: lack of awareness of the importance and possibilities of GIS (0.877);
(c) limitation for the introduction of GIS in the teaching of geography: lack of space (informatics classroom) (0.881);
(d) limitation for the introduction of GIS in the teaching of geography: inexperience of staff/teachers (0.883);
(e) limitation for the introduction of GIS in the teaching of geography: insufficient number of teaching units dedicated to GIS in the curriculum (0.875);
(f) limitation for the introduction of GIS in the teaching of geography: teacher's motivation (0.883);
(g) limitation for the introduction of GIS in the teaching of geography: student motivation (0.883);
(h) limitation for the introduction of GIS in the teaching of geography: ignorance of working in software (0.876);
(i) limitation for the introduction of GIS in the teaching of geography: internet speed and availability (0.886);
(j) limitation for the introduction of GIS in the teaching of geography: lack of IT equipment (0.883).

Since the sample was not paired with the Mann–Whitney U test, a comparison was made with regards to the observed groups, and a significant difference was observed in the total limitation for the introduction of GIS in the teaching of geography factor, with the value of the factor being higher among teachers (Mann–Whitney U test, $p < 0.001$) (Table 3), which indicates the fact that when the overall limitations are taken into account, then teachers had a better knowledge of the system and were also more aware of these limitations for the introduction of GIS in the teaching of geography.

Table 3. Comparison with regard to the observed groups.

		Group	p
		Median *	
Limiting factors in the introduction of GIS in the geography teaching	Teachers	3.40 (3.00–3.80)	MW = 17,866.000 $p < 0.001$
	Students	3.00 (2.40–3.30)	

* Interquartile range.

3.3. Teachers' and Students' Attitudes

3.3.1. Importance of the Introduction of GIS in Teaching

This question can be regarded as very important since the teachers' and students' attitudes toward ICT are one of the main factors which affect whether technology can be successfully implemented in classrooms [34,62].

For the question on the importance of the introduction of GIS in teaching for the sake of higher quality teaching (Figure 1), more than 70 % of teachers recognized the importance of GIS for geography teaching, while in the group of students this percentage is lower. This follows results obtained by Demirci [63], where 76% of the surveyed teachers (*n* = 79) in Turkey regarded GIS as an important and effective teaching tool for geography lessons. Moreover, half of the teachers (51%) in that research agreed or strongly agreed that the use of GIS is necessary for geography lessons. A certain parallel can be drawn with the research of Korevaar and van der Schee [64], where it is stated that 40% of the surveyed geography teachers (n = 74) in the Netherlands believed that GIS should be compulsory in geography teaching. In comparison with our results, somewhat higher results were obtained by Akinyemi [34] where (97%) of surveyed teachers (n = 100) in Rwanda strongly agreed and agreed that the use of GIS in teaching is essential.

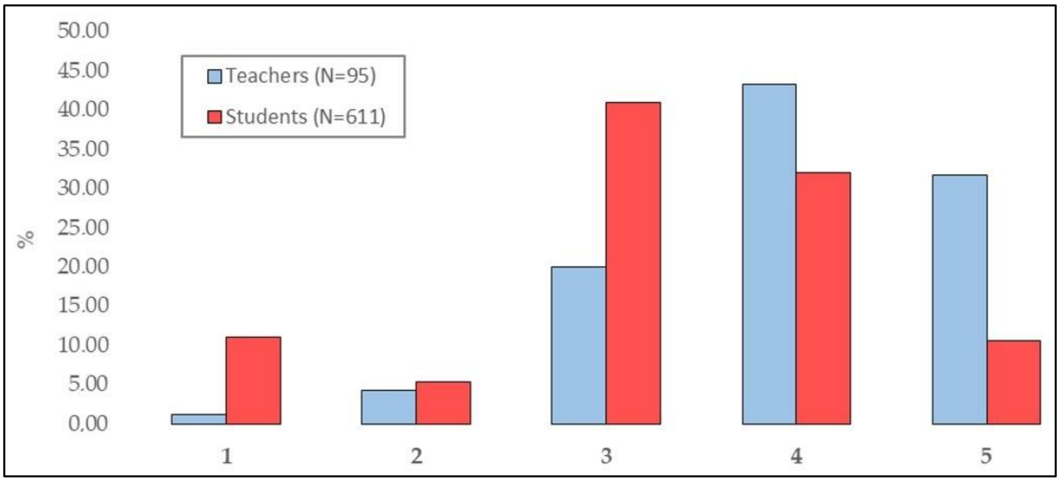

Figure 1. The percentage (%) of teachers and students who answered the question The importance of the introduction of GIS into the geography teaching process for the sake of higher quality teaching (1—totally irrelevant; 2—irrelevant; 3—neither irrelevant nor important, 4—important; 5—totally important).

Results from our research have shown that around 40 % of students think that it is important to introduce GIS into geography teaching. However, 15% of students think that it is totally irrelevant or irrelevant to introduce GIS into geography teaching.

Although, some researchers, like Donert and de Miguel Gonzalez [65], state that there is a lack of willingness of teachers to change their ways and implement GIS and new technologies, in this case only 5% of them regard GIS as something that is not important or necessary to be integrated into the teaching of geography. In the aforementioned research of Demirci [63], the same percentage (5%) of the teachers disagreed with the statement that GIS is an effective teaching tool for geography lessons while 28% of them disagreed or strongly disagreed with the statement that the use of GIS is necessary for geography lessons. In our research, we came to the result that as many as 20% of teachers have a completely neutral opinion about the importance of introducing GIS into geography lessons.

When the mentioned question was evaluated on the basis of total points on the Likert scale, the arithmetic mean, median, and mode for teachers' attitudes were 4 (important), and the standard deviation (SD) was determined as 0.887. For the students, this value was somewhat lower; the median and mode were determined as 3 (neither irrelevant nor important) and the arithmetic mean was 3.25, while the SD was 1.086. According to these findings, both teachers and students have a positive attitude toward the introduction of GIS in teaching. However, teachers perceive the introduction of GIS in teaching geography to be more important than students. Furthermore, teachers have less dispersion, that is, diversity in their attitudes compared to students (Table 4).

Table 4. Comparison of teachers' and students' attitudes on the importance of the introduction of GIS into teaching.

	Teachers	Students
SD	0.887	1.086
MEDIAN	4	3
MODE	4	3
AVERAGE	4.00	3.25

3.3.2. Appearance of GIS in High School Curricula

When observing the answers to questions about the appearance of GIS in high school curricula in general or in the geography curriculum by grades (from 1 to 4), the majority of teachers rate the appearance as poor and satisfactory, compared to students who are probably less familiar with the curricula (especially of other classes than the one they are attending). For example, more than 80% of teachers believe that GIS does not appear enough in high school curricula. The results are almost identical for the geography curriculum by grades (from 1 to 4). This is not surprising given that the non-inclusion or omission of GIS from the geography curriculum of secondary schools is recognized as one of the most important factors limiting and challenging the implementation of GIS in the educational process [66].

When the question about the appearance of GIS in high school curricula is evaluated on the basis of total points on the Likert scale, the median and mode for teachers' attitudes were measured as 1 (poor), the mean was 1.568, while the SD was 0.834. For the students, values were somewhat higher; the median and mode were measured as 3 (good) and the arithmetic mean was 2.505, while the SD was 1.218. According to these findings, teachers believe that GIS is poorly represented in high school curricula. Students perceive there to be a greater presence of GIS in high school curricula, and they have a larger dispersion, that is, diversity in their attitudes compared to teachers (Table 5).

Table 5. Comparison of teachers' and students' attitudes on appearance of GIS in high school curricula.

	Teachers	Students
SD	0.834	1.218
MEDIAN	1	3
MODE	1	3
MEAN	1.568	2.505

When the question about the appearance of GIS in geography curricula was evaluated on the basis of total points on the Likert scale, the median and mode for teachers' attitudes were determined as 1 (poor), and the arithmetic mean was 1.632, while the SD was 0.912. For the students, values were somewhat higher; the median was 3, the mode was the same as for the teachers, and the arithmetic mean was 2.429. According to these findings, teachers believe that GIS is poorly represented in geography curricula. Students perceive there to be a greater presence of GIS, and they have a larger dispersion, that is, diversity in attitudes compared to teachers (Table 6).

Table 6. Comparison of teachers' and students' attitudes on appearance of GIS in geography curricula.

	Teachers	Students
SD	0.912	1.258
MEDIAN	1	3
MODE	1	1
MEAN	1.632	2.429

This problem is sometimes transferred to higher levels of education related to geography [28]. Namely, as mentioned in Section 1, GIS is largely taught in many universities worldwide, not only in geography-related subjects. Therefore, in some cases, tertiary students who encounter GIS for the first time at universities have great problems mastering the course and can develop an aversion toward GIS. This can be confirmed through the personal experience of the authors and other research [28]. If GIS were somewhat more represented in the geography curriculum of high schools, such problems could potentially be avoided. Unfortunately, this kind of policy creates a "closed circle" because when tertiary students in universities create an aversion to GIS, it ultimately can result in fewer expert GIS staff who possess the necessary technical knowledge, which will again complicate the process of GIS implementation in schools [28].

3.3.3. Use of GIS in the Teaching of Geography

As expected, almost 77% of teachers are not using GIS on any level of teaching for the purposes of processing and adopting educational content. This result, obtained in 2022, corresponds to the results of similar research conducted twenty years ago. In the context of possible GIS implementation in secondary schools, this can be considered worrying. For example, Ho and Ding [67] around twenty years ago, reached the conclusion that 71% of teachers used GIS at any level of teaching. Our values are similar to those in the early 2000s when around 12% of surveyed teachers in 69 Finnish secondary schools said they were using GIS softwares [25]. Moreover, in a study by Höhnle et al. [68] around 70% of teachers in Germany had never used desktop GIS, while around 45% of them had never used web-based GIS. In comparison with countries close to the Republic of Croatia, a worse result was recorded in Bosnia and Herzegovina by Avdić et al. [69] where over 80% of surveyed teachers did not use GIS for the purpose of teaching.

However, our results are somewhat better than those in the studies of Demirci [12], where only 16% of the surveyed teachers used GIS at some basic level, Singh et al. [30], where only 14.3% of surveyed teachers in Malaysia used GIS, and Degirmenci [70], where 13.3% of surveyed teachers in Turkey stated that they used GIS in teaching. These values correspond to the end of the 20th and the beginning of the 21st century, when it was stated that the level of GIS use in European secondary schools did not exceed around 20% in France, Sweden, Finland, and the UK [44,71]. At the beginning of the 21st century, around 12% of the 243 participating schools in the UK were using GIS at the time [72]. In The Netherlands' 12% of surveyed teacher respondents stated that they were using GIS in their courses [64]. Similar values were achieved for Singaporean schools [22]. The results from Kerski [73] revealed that of the 1900 classrooms in high schools in the US which had access to GIS, <15% reported using GIS. Of course, in other, less-developed countries, GIS was omitted from curricula and used only in individual educational institutions thanks to enthusiastic teachers [71]. However, GIS use in schools has spread in that area. In Bevainis [74] 73.3% of surveyed geography teachers in Japan have stated that they use GIS in geography teaching. In Norway, 71% of surveyed teachers have used GIS in their teaching [37].

From the results of the previous question, where it was determined that GIS is almost not included in the geography curricula (Table 5) and the fact that GIS is only mentioned three times in the 145-page long geography curricula, it can be speculated that about 20% of teachers who apply GIS in their teaching do so in a way that they are in some way reorganizing their curriculum causing a shift toward problem-based learning, similar to in Bednarz's study [75].

3.3.4. Knowledge of GIS Application

At the beginning of the questionnaire, all respondents (students and teachers) rated their knowledge of GIS on a Likert scale from 1 to 5, and the results showed that the majority of students rated their knowledge as don't know or basic, while the situation is somewhat better for the group of teachers, where 35.4% of them stated that they don't know GIS, and 32.3% stated that they know the basics (Figure 2). This is somewhat better than Oppong and Ofori-Amoah [66], who found that 71% were unfamiliar with the use of GIS [12]. In comparison with a country close to the Republic of Croatia, a worse result was recorded in Bosnia and Herzegovina, where in the research of Avdić et al. [69], of 81 teachers surveyed, over 55% stated that they did not know theoretical or practical GIS. However, only 9.5% and 1.1% of teachers stated that they know GIS to a very good or excellent level. It is surprising that a similar, even slightly higher percentage was reported by students, 3.3% for excellent, and for 8.7% very good. This may be the result of ignorance or underestimation of the complexity of GIS by students or the fact that younger generations use different ICT more and have encountered some version of a GIS program, the knowledge of which they projected onto this question. This conclusion is the result of the answers to the open-ended questions.

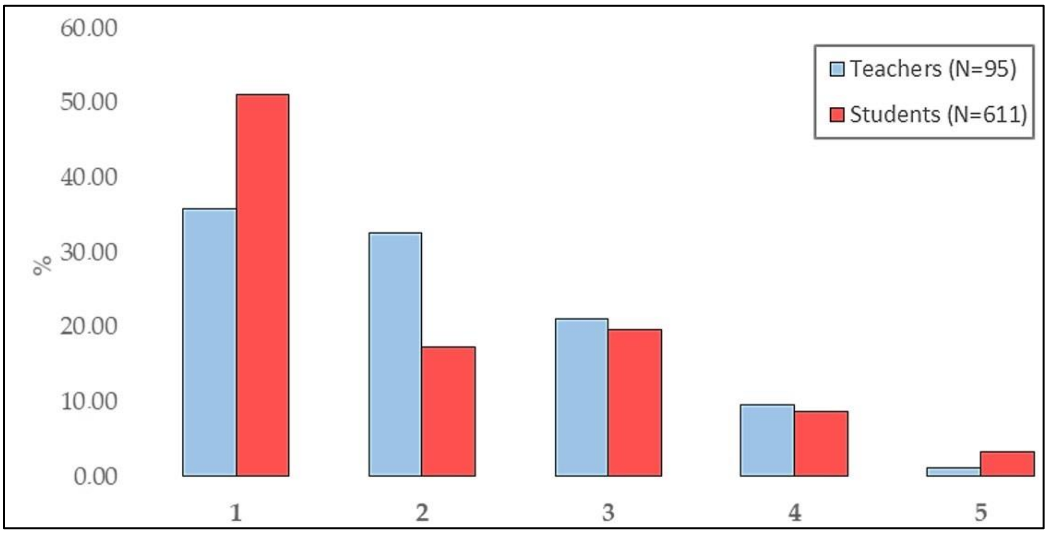

Figure 2. The percentage (%) of teachers and students who answered the question Rate your knowledge of GIS on a scale from 1 to 5 (1—don't know; 2—basic; 3—good; 4—very good; 5—excellent).

When the question of knowledge of GIS was evaluated on the basis of total points on the Likert scale, the median for teachers' attitudes was determined as 2 (basic) and the mode was 1 (don't know), while the arithmetic mean was 2.074. The SD was 1.023. For the students, the values were somewhat lower. The median was 1 (don't know), the mode was the same as for teachers, and the arithmetic mean was 1.957 (Table 7). According to these findings, both teachers and students have poor knowledge of GIS, although, as expected, teachers rate their knowledge of GIS slightly higher. The variability in the answers is almost equal for students and teachers.

Table 7. Comparison of teachers' and students' attitudes on knowledge of GIS.

	Teachers	Students
SD	1.023	1.161
MEDIAN	2	1
MODE	1	1
MEAN	2.074	1.957

In summary, these results indicate that all participants involved in teaching are aware of their limitations regarding their knowledge of GIS content. The numbers are not surprising because, in many schools where the implementation of GIS is in the initial stages [28,76], GIS is taught more as theory ("learning about GIS") than in practical teaching ("learning with GIS"). Additional efforts need to be made to increase teachers' GIS knowledge because research [11,77,78] has shown that the level of motivation in class can be increased if students and teachers know how to use GIS. Therefore, not knowing how to use it can negatively affect teachers' and students' motivation [11].

3.3.5. Degree of Importance of the Application of GIS in the Teaching of Different Elements

In this set of questions, teachers were asked to rate the degree of importance of the application of GIS in the teaching of different elements which included: (a) the processing and presentation of geographic data; (b) the interpretation and creation of geographical maps; (c) the analysis and presentation of spatial data. Although the majority of teachers (>70%) do not apply GIS to geography teaching and do not know how to use GIS in a very good or excellent manner, the majority of teachers have positive opinions about the importance of applying GIS in these areas. There are no statistically significant differences in rating the importance of GIS for the selected elements (Figure 3). These results are similar to Demirci's study [12], where 76% of teachers thought that GIS was an important tool for geography lessons. Therefore, although most teachers do not use it in class and do not have much knowledge of it, they believe it is important in geography teaching. This may suggest that teachers are willing to use new educational methods in their teaching.

However, the teachers rated the degree of importance of the application GIS in (a) *the processing and presentation of geographic data* somewhat lower than in (b) *the interpretation and creation of geographic maps* and (c) *the analysis and presentation of spatial data* (Figure 3).

Statistically significant differences between the groups (students and teachers) were observed on the subject, where 81.1% of teachers believe that GIS knowledge is totally important and important for the processing and presentation of geographic data, while 52.6% of students think the same. In the context of this study, GIS knowledge can be defined as the successful integration of GIS into geography lessons [63]. Therefore, students showed no statistically significant difference in rating the importance of GIS for the three selected elements, but, unlike professors, rate the degree of importance of the application of GIS in the teaching of different elements lower. When asked to evaluate the "Degree of the importance of introducing GIS into the teaching process for better geography teaching", the students answered on average lower values than the professors, which points to the fact that the quality teaching of geography does not depend as much on the introduction of GIS as the professors think. For the question "The degree of importance of the application of GIS for the three elements in the teaching process, (a) the processing and presentation of geographic data, (b) the interpretation and creation of geographic maps, and (c) the analysis and display of spatial data", in the answers of students there is no statistically significant difference. Based on the answers to these two questions, it can be concluded that the students believe that the teaching of geography can be of high quality without GIS, but if it is applied, then it is important in all elements of teaching.

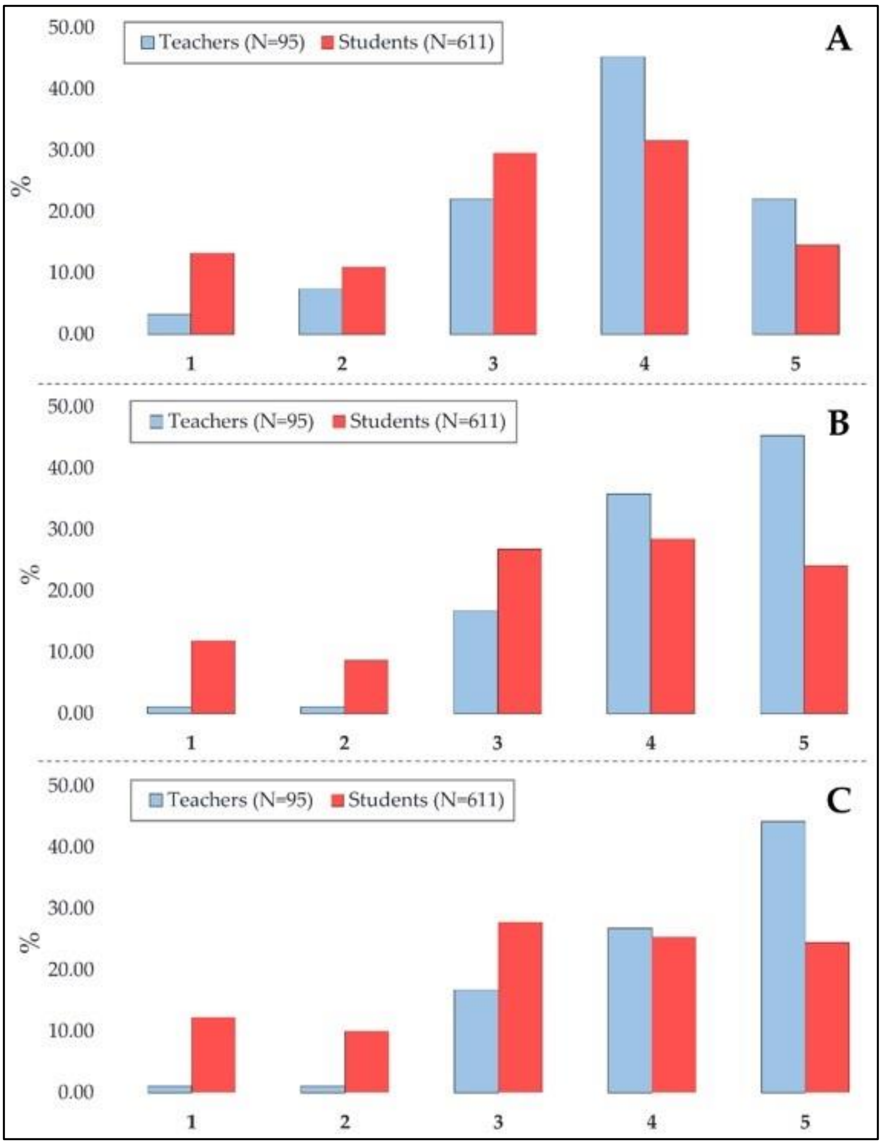

Figure 3. The percentage (%) of teachers and students who answered the questions: Rate the degree of importance of the application of GIS in the teaching of geography for these elements: (**A**) the processing and presentation of geographic data; (**B**) the interpretation and creation of geographic maps; (**C**) the analysis and presentation of spatial data (1—totally irrelevant; 2—irrelevant; 3—neither irrelevant nor important; 4—important; 5—totally important).

On average, almost 70% of teachers rated the importance of implementing GIS for the defined set elements as important or extremely important, while among students, this percentage was around 45% (Figure 3). On average, almost 50% of students think that the degree of importance of the application of GIS in the stated elements is completely unimportant, unimportant, or neither important nor unimportant. These values are similar to those in Yap et al. [22], where more than 50% of surveyed students in Singapore considered GIS knowledge in visualization and spatial analysis data to be completely unimportant, unimportant, or neither important nor unimportant. The fact that almost a majority of the students do not recognize the possibilities offered by the application of GIS is very worrying.

When the question rate the degree of importance of the application of GIS in the teaching of geography for the selected elements: (A) the processing and presentation of geographic data; (B) the interpretation and creation of geographic maps; (C) the analysis and presentation of spatial data was evaluated on the basis of total points on the Likert scale, for all three mentioned elements (A–C), the median and mode for teachers' attitudes were measured as 4 (important) or 5 (very important). The value of the SD for all three elements was also similar. However, when observing the arithmetic mean parameter, the highest value was measured for (B) the interpretation and creation of geographic maps. Students gave somewhat lower estimates for the degree of importance of the application of GIS in the selected elements of learning; the median and mode for the selected elements were 3 (neither irrelevant nor important) or 4 (important). The value of the SD for all three elements was also similar, but somewhat higher than that of teachers. The arithmetic mean measured for students was also lower for each element than it was for teachers. Students also have the highest value of mean measured for element (B) (Table 8). According to these findings, both teachers and students believe that the application of GIS in the selected elements of teaching is important. However, for teachers, the degree of importance of GIS is estimated to be higher compared to students' opinions.

Table 8. Comparison of teachers' and students' attitudes on the degree of importance of the application of GIS in the teaching of geography for the selected elements: (A) the processing and presentation of geographic data; (B) the interpretation and creation of geographic maps; (C) the analysis and presentation of spatial data.

	Teachers			**Students**		
	A	**B**	**C**	**A**	**B**	**C**
SD	0.986	0.844	0.840	1.219	1.273	1.292
MEDIAN	4	4	4	3	4	3
MODE	4	5	5	4	4	3
MEAN	3.76	4.23	4.22	3.23	3.44	3.40

3.3.6. Limiting Factors of GIS Implementation

A similar percentage of most teachers and students (62.1% for teachers, and 64.5% for students) believe that in their school there are some prerequisites for GIS implementation. However, students and teachers were given the option to identify the main groups of limiting factors in GIS implementation. The limiting factors are grouped into two clusters (a) organizational and (b) technical. The organizational group contains the following factors:

- a lack of awareness of the importance and possibilities of GIS, staff expertise,
- a lack of finances,
- a lack of time for education,
- a lack of literature, and
- a lack of education.

The technical group contains the following factors:

- a lack of data,
- a lack of knowledge of software,
- problems with networking,
- the internet,
- a technical lack of school equipment.

An almost equal percentage of both teachers and students estimated (around 65%) that the main limiting factors of GIS implementation are organizational factors.

It is not surprising that organizational limiting factors prevail over technical ones in hindering GIS implementation since similar problems are mostly identified in the Mzuza and Van Der Westhuizen study [28], where organizational factors were seen to be responsible for the absence of GIS in secondary school curricula, and the lack of knowledge and technical expertise were also recognized as important limiting factors. Egiebor and Foster [7] recognized similar factors; the lack of teachers' expertise and time for GIS implementation, and the absence of GIS-related curricula.

In the RH, at the beginning of the school year, students are presented with the annual plan and program of the subject, and the curricula for individual classes are made publicly available and it is possible to view them. Since high school students voluntarily filled out the questionnaires (under teacher supervision), the author's assumption is that they were familiar with the content of the plan and program. Kim et al. [32], in analyzing GIS education for teachers in the Republic of Korea, clearly pointed out that the change in geography curricula must be considered a fundamental element in the implementation of GIS in the educational system. Namely, if GIS is not explicitly introduced in the curricula, it is unreasonable to expect teachers to implement a GIS-oriented education. In addition to the necessary changes in the curriculum, Kerski [73] notes the perceived effectiveness of GIS as one of the limiting factors, which implies that many do not recognize the usefulness of GIS and that this sort of thinking transfers to the national level.

The technical limiting factors of GIS implementation are more characteristic of African and other developing countries [43,79]. Furthermore, one of the reasons why the technical group of factors is recognized as less of an obstacle to the implementation of GIS than the logistical one is the fact that in recent years there has been significant development in ICT and geospatial technologies, and the internet has become faster and more accessible, and the price of IT equipment (software and hardware) has fallen. Furthermore, there are more and more OpenSource or freely available GIS programs and GIS databases. In addition, it is now possible to use web GIS services on smartphones and tablets, which has reduced the occurrence of software and technical problems for geography teachers. In the questionnaire, teachers were asked to rate 18 potential factors limiting GIS implementation in schools on a scale from 1 (unimportant) to 5 (extremely important) (Table 9). In Table 8, the rows containing the percentages of the surveyed teachers who considered a specific limiting factor as important or extremely important in preventing the implementation of GIS in schools are colored red. The rows containing the percentages of surveyed teachers who considered a specific limiting factor as extremely unimportant and unimportant in preventing the implementation of GIS in schools are colored blue.

Table 9. Teacher's ratings of the limiting factors of GIS implementation.

Importance Degree	a (%)	b (%)	c (%)	d (%)	e (%)	f (%)	g (%)	h (%)	i (%)	j (%)	k (%)	l (%)	m (%)	n (%)	o (%)	p (%)	q (%)	r (%)
1	10.5	4.2	3.2	5.3	7.4	11.6	5.3	**2.1**	8.4	**12.6**	**3.2**	**4.2**	**20.0**	2.1	10.5	3.2	**11.6**	15.8
2	6.3	13.7	13.7	8.4	17.9	18.9	7.4	**8.4**	13.7	**14.7**	**4.2**	**7.4**	**14.7**	15.8	22.1	9.5	**28.4**	21.1
3	21.1	27.4	30.5	35.8	42.1	27.4	34.7	**25.3**	43.2	**44.2**	**28.4**	**21.1**	**36.8**	34.7	34.7	27.4	**25.3**	24.2
4	30.5	35.8	29.5	32.6	12.6	14.7	25.3	**31.6**	20.0	**17.9**	**31.6**	**28.4**	**13.7**	28.4	17.9	30.5	**17.9**	15.8
5	31.6	18.9	23.2	17.9	20.0	27.4	27.4	**32.6**	14.7	**10.5**	**32.6**	**38.9**	**14.7**	18.9	14.7	29.5	**16.8**	23.2
MEDIAN	4	4	4	4	3	3	4	**4**	3	**3**	**4**	**4**	**3**	3	3	4	**3**	3
MEAN	3.663	3.516	3.558	3.495	3.200	3.274	3.621	**3.842**	3.189	**2.989**	**3.863**	**3.905**	**2.884**	3.463	3.042	3.737	**3.000**	3.095
MODE	5	4	3	3	3	5	3	**5**	3	**3**	**5**	**5**	**3**	3	3	4	**2**	3
SD	1.277	1.080	1.089	1.051	1.172	1.356	1.122	1.045	1.114	1.125	1.027	1.131	1.295	1.040	1.193	1.084	1.272	1.392

a—lack of education and training in GIS, b—lack of literature and manuals on GIS, c—lack of time for additional education, d—lack of awareness of the importance and possibilities of GIS, e—financial reasons, f—lack of space (computer classroom), g—lack of staff expertise, h—an insufficient number of teaching units dedicated to GIS in the curriculum, i—teacher motivation, j—student motivation, k—not knowing how to work in GIS software, l—lack of necessary software and licenses, m—internet speed and availability, n—the lack of geospatial data, o—networking problems, p—lack of knowledge of working in databases, q—technological equipment of the school, r—lack of IT equipment (computers, tablets).

When the question rate the limiting factors of GIS implementation was evaluated on the basis of total points on the Likert scale, from the calculated metrics, the three most important factors that limit the implementation of GIS in schools (red bold text—Table 8) were recognized as: (l)—the lack of necessary software and licenses; (k)—not knowing how to use GIS software; (h)—an insufficient number of teaching units dedicated to GIS in the curriculum. For the three listed limiting factors, the most commonly observed value in the set of data (the mode) was 5 (extremely important). In addition to these, factor (a) the lack of education and training in GIS also has the mode value of 5, but its arithmetic mean is slightly lower than for the three previously mentioned parameters (Table 9).

The first limiting factor identified (l—the lack of necessary software and licenses) can be easily addressed since there are many free, open-source GIS programs available that do not require the purchase of licenses. This advantage was recognized by several teachers and proposed as a guideline to facilitate the process of implementing GIS in classes. It is also possible to download various databases from services like Diva GIS and Geofabrik for free, which can be used in teaching. The second identified limiting factor (k—not knowing how to use GIS software) can only be solved by educating the teaching staff. Namely, in the part of the survey where teachers were asked to state at least one guideline to facilitate the process of implementing GIS in teaching 38% of teachers stated that it is necessary to organize additional education, workshops, and training for them. Below are some examples of responses:

- "Mandatory free and paid courses for all Geography teachers in Croatia."
- "A simple approach when holding initial seminars on GIS."
- "The development of professional competences related to GIS among teachers during their studies, and especially after through various forms of professional development"
- "More education for teachers, because today the tool is available to everyone and everyone uses it"
- "To organize FREE education, of course as a compulsory subject for all majors in the study of geography."

The third most important factor limiting the application of GIS in schools according to teachers is (h) an insufficient number of teaching units dedicated to GIS in the curriculum. This is not surprising considering that in other countries it has been recognized as one of the most important factors. Almost 20% of teachers, when asked to state at least one guideline to facilitate the process of implementing GIS in teaching, indicated a change in the curriculum. Below are some examples of responses:

- "Additional changes to the curriculum. For example, it would be preferable to implement GIS in the 4th gymnasium at the expense of contents that are not the core of our profession."
- "Introduce it into the curriculum, give schools GIS software and geo data (shapefiles) which, unfortunately, have to be paid for."
- "According to the new curriculum, GIS is not covered in any teaching unit in the high school, and there is not even a cartography unit, so students do not have the opportunity to learn about GIS. Introduce the topics of cartography and GIS into classes."
- "Throwing out other teaching content that must be processed in order to devote more space to GIS. Introduce GIS as a compulsory topic in the geography curriculum, devote part of the geography curriculum to practical teaching and working with GIS, and offer optional geography and GIS modules."
- "Introduction of GIS into the curriculum for all classes."

One of the teachers stated that the implementation of GIS into teaching is a utopian and pointless attempt due to the huge amount and the novelty of the content and the application of new curricula, the time required to prepare lessons according to the new curriculum, the lack of a timetable, limited space, and the lack of knowledge of working in GIS programs. He believes that GIS is not applicable in teaching except for individual approaches and working with a group of up to 5–6 students.

From the calculated metrics, three factors that were recognized as the least important in limiting GIS implementation (blue bold text in Table 9) were (q)—the technological equipment of the school, (j)—student motivation, (m)—internet speed and availability. For the three listed limiting factors, the most commonly observed value in the set of data was 3 (neither important nor unimportant). Although several factors had a mode value of 3, these three were identified by comparing their arithmetic mean and median values (Table 9). These factors are to be expected, considering that schools in the RH are becoming more and more equipped, the number of students is decreasing, and children are increasingly oriented toward digital content. For example, the education reform in the RH started in

2016, and since 2017, digital transformation has been included. The Croatian academic and research network CARNET, in cooperation with the Institute for Youth Development and Innovation, acquired 45,000 microcomputers for school students [80].

3.3.7. Improving GIS Knowledge

On the question what form of learning/improving GIS would be most acceptable for you, the students answered that the best format would be in regular classes in the classroom (62.2%) or in additional classes in the classroom (16.5%), while the teachers answered workshops (40.6%), courses (21.9%), and online webinars (17.7%). These are similar results to those found in Wang and Chen's study [31], where the vast majority of surveyed regular and substitute teachers in Taiwan stated that the most important contributor to their GIS knowledge is workshops. Our results are not surprising considering the activities of the associations of the Croatian Geographical Society of Zagreb and Zadar in the RH (Figure 4), which, every year, organizes winter and summer seminars and workshops for geographers (Figure 4) where you can listen to useful lectures and participate in GIS workshops [50].

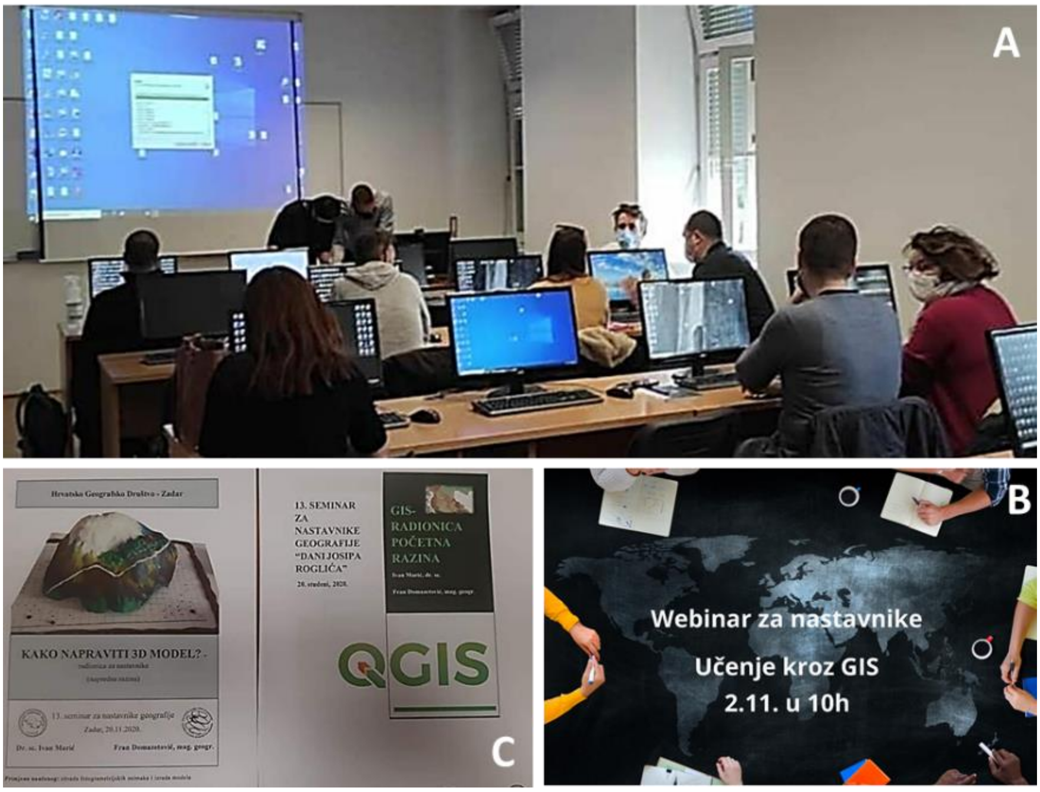

Figure 4. (**A**) Workshop for geography teachers organized by Croatian Geographical Society-Zadar; (**B**) GIS webinar organized by GDI; and (**C**) a GIS script created for geography teachers.

Based on the above answers, it can be concluded that students prefer learning new teaching content through direct interaction with the teacher (face to face), while teachers give preference to practical work in their free time outside of regular classes. This is not surprising since, in Croatia, there is a practice where teachers are educated in groups through workshops or courses that are organized during working hours, not in their free time. These answers provide guidelines for the future organization of education.

On the question have you ever improved your GIS knowledge, most teachers answered positively with 51.6%. In some ways, this percentage is encouraging. However, the fact that, even though most of them have received some form of GIS training, only 23% use GIS in class is worrying. This is one of the key steps and prerequisites for the successful implementation of GIS in the educational system. In Norway, 82% of surveyed teachers (*N* = 81) stated that they have taken some training in the use of GIS [37].

Higher education must take a role in organizing these workshops [29,81] and the pricing of workshops must be lower or free. This is recognized in the study of Kim et al. [32], where the following measures are highlighted: (a) the development of various educational resources to help teachers to use and implement GIS, and (b) to enable an array of pre- and in-service GIS education events. This is increasingly being carried out at workshops and (summer and winter) seminars for teachers organized by various geographical associations in the RH. At these workshops and seminars, teachers are provided with spatial data for the GIS workflow, installation documents for specific open-source GIS programs, and instructions for work with clear learning outcomes. This is a good practice considering that some studies have shown [82] that the majority of teachers who participated in some form of GIS training use the same material they received there in their geography teaching. However, such initiatives are not systematic and do not have a national character, remaining isolated examples of good practice.

3.3.8. Students' Interest in GIS

Only 14% of teachers rated students' interest in GIS as high or very high. On the other hand, students valued their own interests a little more, about 15% of students consider that they have a high interest in GIS and an equal percentage consider that they have a very high interest. It is worrying that almost 50% of teachers consider students to be indifferent to GIS, while as many as 37% of them consider that they show low or very low interest in GIS. The concern is due to both the opinion of the teachers and the observed lack of interest from the students.

The largest percentage of students, about 29%, stated that they are indifferent to GIS, that is, their interest is neither low nor high. This is similar to research by Klein [83], which indicates that students, on a scale from 1 to 5, had a mean interest value of 3.07.

When the mentioned question was evaluated on the basis of total points on the Likert scale, according to the median and mode parameters, the teachers assessed the students' interest as neither low nor high, and the arithmetic mean was measured as 2.621. Furthermore, students perceived their interest in GIS to be at the same level for the stated parameters. According to these findings, teachers perceive students' interest in GIS exactly as students express it, predominantly indifferent (Table 10).

Table 10. Comparison of teachers' and students' attitudes on students' interest in GIS.

	Teachers	Students
SD	0.958	1.187
MEDIAN	3	3
MODE	3	3
MEAN	2.621	2.807

It is necessary to work on raising students' interest in GIS because a well-documented interest in GIS helps to enhance student interest in geography [84]. Sometimes the reason for the weak interest of students, if GIS is just starting to be applied in school, can be the lack of a ready-to-use product. For example, the interface design may be too complicated to work with, or certain tools or spatial data may be missing. In such situations, teachers recognized the weaker interest of students [84].

Research has shown if the conditions of geography teaching change, with a reform in the curricula prescribing more research work, teachers and students may become more interested in GIS [21].

Testing with respect to the observed variable was performed using the Hi-square test, and the data are presented in the form of absolute frequencies and percentages (Table 11). If you look at the significance level of the questions, the importance of introducing GIS into the teaching for better geography teaching; the appearance of GIS in secondary school curricula;

the appearance of GIS in the geography curriculum by grade level in high school for 1st grade; the appearance of GIS in the geography curriculum by grade level in high school for 2nd grade; the appearance of GIS in the geography curriculum by grade level in high school for 3rd grade; the appearance of GIS in the geography curriculum by grade level in high school for 4th grade; on a scale from 1 to 5, rate your knowledge of GIS; rate the degree of importance of the application of GIS in the teaching of geography for the following elements: processing and presentation of geographic data; rate the degree of importance of the application of GIS in the teaching of geography for the following elements: the interpretation and creation of geographical maps; rate the degree of importance of the application of GIS in the teaching of geography for the following elements: the analysis and presentation of spatial data; have you ever improved your GIS knowledge through courses, workshops, seminars, etc.; on a scale from 1 to 5, rate your students' interest in content related to GIS, it can be observed that the value of the Hi-square is $p < 0.05$, which means that a statistically significant difference was observed with regard to the observed groups (teachers and students).

Table 11. Comparison of answers with regard to the observed groups.

		Groups				p *
		Teachers		Students		
		N	%	*N*	%	
The importance of the introduction of GIS into geography teaching for the sake of higher quality teaching	totally irrelevant	1	1.1%	68	11.1%	0.000
	irrelevant	4	4.2%	33	5.4%	
	neither irrelevant nor important	19	20.0%	250	40.9%	
	important	41	43.2%	195	31.9%	
	totally important	30	31.6%	65	10.6%	
	Total	95	100.0%	611	100.0%	
Appearance of GIS in high school curricula	poor	60	63.2%	173	28.3%	0.000
	satisfactory	18	18.9%	117	19.1%	
	good	15	15.8%	204	33.4%	
	very good	2	2.1%	74	12.1%	
	excellent	0	0.0%	43	7.0%	
	Total	95	100.0%	611	100.0%	
Appearance of GIS in the geography curriculum in high school for 1st grade	poor	53	55.8%	207	33.9%	0.000
	satisfactory	26	27.4%	128	20.9%	
	good	15	15.8%	169	27.7%	
	very good	1	1.1%	78	12.8%	
	excellent	0	0.0%	29	4.7%	
	Total	95	100.0%	611	100.0%	
Appearance of GIS in the geography curriculum in high school for 2nd grade	poor	55	57.9%	195	31.9%	0.000
	satisfactory	21	22.1%	134	21.9%	
	good	16	16.8%	167	27.3%	
	very good	3	3.2%	81	13.3%	
	excellent	0	0.0%	34	5.6%	
	Total	95	100.0%	611	100.0%	
Appearance of GIS in the geography curriculum in high school for 3rd grade	poor	35	36.8%	195	31.9%	0.000
	satisfactory	34	35.8%	102	16.7%	
	good	20	21.1%	194	31.8%	
	very good	6	6.3%	86	14.1%	
	excellent	0	0.0%	34	5.6%	
	Total	95	100.0%	611	100.0%	

Table 11. *Cont.*

		Groups				
		Teachers		Students		*p* *
		N	%	*N*	%	
Appearance of GIS in the geography curriculum in high school for 4th grade	poor	45	47.4%	210	34.4%	0.000
	satisfactory	28	29.5%	94	15.4%	
	good	18	18.9%	181	29.6%	
	very good	4	4.2%	90	14.7%	
	excellent	0	0.0%	36	5.9%	
	Total	95	100.0%	611	100.0%	
Do you use GIS in teaching for the purposes of processing and adopting educational content? Does your teacher apply GIS in the processing of teaching content?	Yes	22	23.2%	145	23.7%	0.903
	No	73	76.8%	466	76.3%	
	Total	95	100.0%	611	100.0%	
Rate your knowledge of GIS on a scale from 1 to 5	don't know	34	35.8%	312	51.1%	0.004
	basic	31	32.6%	106	17.3%	
	good	20	21.1%	120	19.6%	
	very good	9	9.5%	53	8.7%	
	excellent	1	1.1%	20	3.3%	
	Total	95	100.0%	611	100.0%	
Rate the degree of importance of the application of GIS in the teaching of geography for these elements: processing and presentation of geographic data	totally irrelevant	3	3.2%	81	13.3%	0.002
	irrelevant	7	7.4%	67	11.0%	
	neither irrelevant nor important	21	22.1%	181	29.6%	
	important	43	45.3%	193	31.6%	
	totally important	21	22.1%	89	14.6%	
	Total	95	100.0%	611	100.0%	
Rate the degree of importance of the application of GIS in the teaching of geography for these elements: interpretation and creation of geographical maps	totally irrelevant	1	1.1%	73	11.9%	0.000
	irrelevant	1	1.1%	53	8.7%	
	neither irrelevant nor important	16	16.8%	164	26.8%	
	important	34	35.8%	174	28.5%	
	totally important	43	45.3%	147	24.1%	
	Total	95	100.0%	611	100.0%	
Rate the degree of importance of the application of GIS in the teaching of geography for these elements: analysis and presentation of spatial data	totally irrelevant	1	1.1%	75	12.3%	0.000
	irrelevant	1	1.1%	61	10.0%	
	neither irrelevant nor important	16	16.8%	170	27.8%	
	important	35	36.8%	155	25.4%	
	totally important	42	44.2%	150	24.5%	
	Total	95	100.0%	611	100.0%	
Are there prerequisites for the integration of GIS in your school?	Yes	59	62.1%	394	64.5%	0.653
	No	36	37.9%	217	35.5%	
	Total	95	100.0%	611	100.0%	
Have you ever improved your GIS knowledge through courses, workshops, seminars, etc.?	Yes	49	51.6%	59	9.7%	0.000
	No	46	48.4%	552	90.3%	
	Total	95	100.0%	611	100.0%	
In your opinion what are the main limitations to the introduction of GIS in teaching?	organizational factors	62	65.3%	415	67.9%	0.607
	technical factors	33	34.7%	196	32.1%	
	Total	95	100.0%	611	100.0%	

Table 11. *Cont.*

		Groups				p *
		Teachers		Students		
		N	%	*N*	%	
On a scale from 1 to 5, rate your students' interest in content related to GIS On a scale from 1 to 5, rate your interest in content related to GIS	extremely low	15	15.8%	151	24.7%	0.000
	low	21	22.1%	97	15.9%	
	neither low nor high	46	48.4%	180	29.5%	
	high	11	11.6%	91	14.9%	
	extremely high	2	2.1%	92	15.1%	
	Total	95	100.0%	611	100.0%	

* Hi square test.

3.4. Correlation Analysis

A statistically significant difference was not observed in the questions,

(a) do you apply GIS in teaching/for the purposes of processing and adopting teaching content; (b) if your school does not use GIS in teaching, are there any preconditions for its integration?; (c) In your opinion, are the main limitations to the introduction of GIS into teaching organizational/technical factors?

The respondent's answers to the above questions indicate the objective approach of teachers and students to the research topic, where most respondents are aware that there are prerequisites for integrating GIS into teaching (part of which is a shift in the educational system), and that the main limitations are organizational factors, which include staff expertise, a lack of finances, a lack of time for education, a lack of literature, a lack of education, etc.

In order to better examine the relationships between the observed variables in the SPSS program, the Pearson's correlation coefficient was calculated. The value of this test is in the interval $-1 \leq r \leq +1$, and if $r > 0.80$ it is a strong positive correlation, if $0.5 < r \leq 0.80$, it is a medium-strong positive correlation, and if $0 < r \leq 0.5$, it is a weak positive correlation. The higher the value of the Pearson correlation coefficient, the stronger (more significant) the correlation between the variables.

From Table 12, it can be seen that a positive correlation was recorded between all the observed variables, and the highest positive correlations were recorded between the indicators to evaluate the degree of importance of the application of GIS in the teaching of geography for the mentioned elements:

(a) rate the degree of importance of the application of GIS in the teaching of geography for the specified elements: interpretation and creation of geographical maps and analysis and display of spatial data ($r = 0.863$; $p < 0.01$);
(b) rate the degree of importance of the application of GIS in the teaching of geography for the specified elements: processing and presentation of geographic data and analysis and display of spatial data ($r = 0.785$; $p < 0.01$);
(c) rate the degree of importance of the application of GIS in the teaching of geography for the specified elements: processing and presentation of geographic data and interpretation and creation of geographical maps ($r = 0.775$; $p < 0.01$).

Table 12. Pearson correlation coefficient (1).

		1	2	3	4	5	6	7
1. Rate the importance of introducing GIS into teaching for better geography teaching	r	1	0.064	0.242 **	0.199 **	0.203 **	0.078	0.173 **
	p		0.111	0.000	0.000	0.000	0.053	0.000
	N	611	611	611	611	611	611	611
2. Rate your knowledge of GIS on a scale from 1 to 5	r	0.064	1	0.280 **	0.263 **	0.260 **	0.124 **	0.159 **
	p	0.111		0.000	0.000	0.000	0.002	0.000
	N	611	611	611	611	611	611	611
3. Rate the degree of importance of the application of GIS in the teaching of geography for the following elements: processing and presentation of geographic data	r	0.242 **	0.280 **	1	0.775 **	0.785 **	0.277 **	0.499 **
	p	0.000	0.000		0.000	0.000	0.000	0.000
	N	611	611	611	611	611	611	611
4. Rate the degree of importance of the application of GIS in the teaching of geography for the following elements: interpretation and creation of geographical maps	r	0.199 **	0.263 **	0.775 **	1	0.863 **	0.257 **	0.488 **
	p	0.000	0.000	0.000		0.000	0.000	0.000
	N	611	611	611	611	611	611	611
5. Rate the degree of importance of the application of GIS in the teaching of geography for the following elements: interpretation and creation of geographical maps	r	0.203 **	0.260 **	0.785 **	0.863 **	1	0.248 **	0.477 **
	p	0.000	0.000	0.000	0.000		0.000	0.000
	N	611	611	611	611	611	611	611
6. On a scale from 1 to 5, rate your students' interest in content related to GIS	r	0.078	0.124 **	0.277 **	0.257 **	0.248 **	1	0.633 **
	p	0.053	0.002	0.000	0.000	0.000		0.000
	N	611	611	611	611	611	611	611
7. Limitation for the introduction of GIS in the teaching of geography	r	0.173 **	0.159 **	0.499 **	0.488 **	0.477 **	0.633 **	1
	p	0.000	0.000	0.000	0.000	0.000	0.000	
	N	611	611	611	611	611	611	611

** Correlation is significant at the 0.01 level.

Based on the results of this statistical analysis, it can be concluded that the application of GIS is important in all elements of the subject of geography, regardless of which subjects are taught or learned. An improved knowledge of GIS is achievable and should be implemented in teaching units, whether on the creation of geographic maps, geospatial analysis, visualization, the presentation of geographic data, or topics from physical or social geography. In addition, the correlation between the mentioned variables leads to the conclusion that in both examined groups, it was determined that by increasing the importance of the application of GIS in one element of geography teaching, the importance also increases for other elements. A positive medium-intensity correlation was also recorded between the variables on a scale from 1 to 5, rate your students' interest in content related to GIS and the limitation for the introduction of GIS in geography lessons ($r = 0.633$; $p < 0.01$). This points to the conclusion that although there are limitations, students show some interest in the content connected to GIS, which is positive feedback for the group of teachers.

From Table 13, it can be seen that a positive correlation was recorded between all the observed variables, and the highest positive correlations were recorded between the indicators:

(a) interpretation and creation of geographic maps and rate the degree of importance of the application of GIS in the teaching of geography for the mentioned elements: analysis and display of spatial data ($r = 0.843$; $p < 0.01$);
(b) rate the degree of importance of the application of GIS in the teaching of geography for the specified elements: processing and presentation of geographic data and analysis and display of spatial data ($r = 0.746$; $p < 0.01$);

(c) rate the degree of importance of the application of GIS in the teaching of geography for the specified elements: processing and presentation of geographic data and interpretation and creation of geographical maps ($r = 0.682$; $p < 0.01$);
(d) the importance of introducing GIS into teaching for better teaching of geography and evaluate the degree of importance of the application of GIS in geography teaching for the following elements: processing and presentation of geographic data ($r = 0.620$; $p < 0.01$),

Table 13. Pearson correlation coefficient (2).

		1	**2**	**3**	**4**	**5**	**6**	**7**
1. The degree of importance of introducing GIS into teaching for better teaching of geography	r	1	0.234 *	0.620 **	0.327 **	0.499 **	0.450 **	0.142
	p		0.022	0.000	0.001	0.000	0.000	0.169
	N	95	95	95	95	95	95	95
2. Rate your knowledge of GIS on a scale from 1 to 5	r	0.234 *	1	0.176	0.116	0.080	0.278 **	−0.103
	p	0.022		0.088	0.265	0.442	0.006	0.323
	N	95	95	95	95	95	95	95
3. Rate the degree of importance of the application of GIS in the teaching of geography for: the processing and presentation of geographic data	r	0.620 **	0.176	1	0.682 **	0.746**	0.330 **	0.011
	p	0.000	0.088		0.000	0.000	0.001	0.919
	N	95	95	95	95	95	95	95
4. Rate the degree of importance of the application of GIS in the teaching of geography for: the interpretation and creation of geographical maps	r	0.327 **	0.116	0.682 **	1	0.843 **	0.399 **	0.028
	p	0.001	0.265	0.000		0.000	0.000	0.789
	N	95	95	95	95	95	95	95
5. Rate the degree of importance of the application of GIS in the teaching of geography for: the analysis and display of spatial data	r	0.499 **	0.080	0.746 **	0.843 **	1	0.396 **	0.100
	p	0.000	0.442	0.000	0.000		0.000	0.336
	N	95	95	95	95	95	95	95
6. On a scale from 1 to 5, rate your students' interest in content related to GIS	r	0.450 **	0.278 **	0.330 **	0.399 **	0.396 **	1	−0.030
	p	0.000	0.006	0.001	0.000	0.000		0.774
	N	95	95	95	95	95	95	95
7. Limitations for the introduction of GIS in the teaching of geography	r	0.142	−0.103	0.011	0.028	0.100	−0.030	1
	p	0.169	0.323	0.919	0.789	0.336	0.774	
	N	95	95	95	95	95	95	95

* Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).

These are correlations of medium intensity.

Based on these results, it can be concluded that the quality teaching of geography significantly depends on the level of the application of GIS, that is, that the processing, analysis, visualization, and presentation of geographic data in the teaching is more comprehensive, accessible and understandable if it is carried out with the application of GIS.

4. Conclusions

Through the conducted research, the following most important conclusions can be highlighted. According to the results, both teachers and students have a positive attitude toward GIS implementation in the teaching of geography. However, teachers perceive the importance of introducing GIS to be higher than students. As expected, most of the surveyed teachers (77%) are not using GIS on any level of teaching for the purposes of processing and adopting educational content in the subject of geography. This is to be expected, since both teachers and students have poor knowledge of GIS, although teachers rate their knowledge slightly better. Furthermore, it is positive that the teachers showed the initiative to improve their knowledge of GIS. Specifically, 51.6% of them answered positively to the question of whether they improved their GIS knowledge. A higher percentage of teachers recognized the importance of GIS application in teaching and are more aware of the benefits of it in mastering specific elements of geography subjects than students. This is understandable considering that students do not spend enough time learning about and with GIS, and therefore they cannot even know its advantages. According to these findings, teachers perceive students' interest in GIS exactly as students express it, predominantly indifferent. Namely, only 14% of teachers rated students' interest in GIS as high or very high.

As mentioned, although this data is worrying and according to the literature, ranks the RH behind other countries that started implementing GIS in the early 2000s, it is necessary to emphasize that it is very hard to implement GIS into the curricula immediately after learning about it or receiving it. Therefore, one of the basic prerequisites for the implementation of GIS in schools is that various education authorities need to recognize GIS as an important part of geography and include it more in school curricula. Then the teachers and, even more so, the students will undergo a paradigm shift in their attitudes toward GIS. It is necessary to point out that it takes a lot of time to train teachers (workshops, etc.) to teach GIS and to solve the technical limitations in schools. In almost all countries where GIS has been implemented in schools, difficulties in its implementation have been noted. At a similar percentage, most teachers and students believe that in their school there are some prerequisites for GIS implementation. Teachers identified the following limiting factors as the most important in complicating the implementation of GIS: the lack of necessary software and licenses; not knowing how to work in GIS; an insufficient number of teaching units dedicated to GIS in the curricula. Namely, the results show that teachers believe that GIS is poorly represented in geography curricula. Students perceive the appearance of GIS to be somewhat higher.

We believe that the application of GIS in a larger number of teaching units and an increased level of integration into the school curriculum would motivate teachers and students even more and increase interest in geography. Moreover, if open-source GIS and Cloud GIS, with GIS lesson (scripts) plans and data, are provided to all secondary schools, the implementation of GIS in education could be significantly accelerated.

Author Contributions: Conceptualization, S.Š. and I.M.; methodology, S.Š. and A.M.; software, S.Š.; validation, S.Š. and A.M.; formal analysis, S.Š.; investigation, A.M.; writing—original draft preparation, A.M. and I.M.; writing—review and editing, A.M. and I.M.; visualization, I.M.; supervision, S.Š. and I.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research is founded through Croatian Science Foundation project UIP-2017-05-2694.

Institutional Review Board Statement: The Ethics Committee of the University of Zadar has concluded that the paper is written in accordance with the Ethical Codex of the University.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Acknowledgments: This work has been supported in part by Croatian Science Foundation under the project UIP-2017-05-2694.

Conflicts of Interest: The authors declare no conflict of interest.

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