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Review

RAZVOJ PRIMJENE GIS-A NA GEOGRAFSKOM ODSJEKU PMF-A SVEUČILIŠTA U ZAGREBU

DEVELOPMENT OF GIS AT THE DEPARTMENT OF GEOGRAPHY, FACULTY OF SCIENCE, UNIVERSITY OF ZAGREB

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Izvod

Danas je gotovo nemoguće zamisliti stjecanja novih znanja i istraživanja u geografiji te uspješno i efikasno upravljanje prostornim resursima bez GIS-a. Mnogobrojni radovi u svjetskoj literaturi ukazuju na značenje koje se u zadnjih tridesetak godina pridaje temi GIS-a u znanstvenom istraživanju i visokoškolskoj nastavi geografije. U članku se, u okviru temeljnih teorijskih postavki vezanih uz ulogu i značenje GIS-a i drugih novih informacijskih tehnologija u visokoškolskom obrazovanju geografa u svijetu, definira dosegnuti trenutni nastavni i znanstveno-istraživački okvir primjene GIS&T na Geografskom odsjeku PMF-a Sveučilišta u Zagrebu. U pogledu razvoja GIS-a na Geografskom odsjeku izdvojena su dva temeljna razvojna aspekta: institucionalizacija GIS obrazovanja na Geografskom odsjeku PMF-a (povećanje broja predmeta koji su vezani uz GIS u obrazovanju geografa i ustroj smjera Geografski informacijski sustavi u okviru diplomskog sveučilišnog studija geografije na Geografskom odsjeku PMF-a) i jačanje primjene GIS-a u znanstveno-istraživačkom radu. U skladu s navedenim prepoznata su karakteristična razdoblja razvoja nastavne i znanstvene komponente GIS-a na Geografskom odsjeku PMF-a.

Ključne riječi: GIS, razvoj, Geografski odsjek, PMF, obrazovanje geografa, tercijarno obrazovanje, Sveučilište u Zagrebu

Abstract

It is virtually impossible today to imagine acquiring new geography knowledge, conducting research or successfully and efficiently managing spatial resources without the use of GIS. Many global publications have outlined the importance imparted to GIS in both scientific research and teaching of geography at the university level over the past 30 years. This paper defines the current GIS&T teaching and scientific research framework at the Department of Geography, Faculty of Science, University of Zagreb, within the basic theoretical postulates related to the role and importance of GIS and other new information technologies in higher education of geographers worldwide. With regard to as the development of GIS at the department, two basic developmental aspects have been addressed: institutionalisation of GIS education at the Department of Geography, Faculty of Science (increase in the number of GIS-related courses in the education of geographers, and the structure of the Geographic Information Systems study programme within the graduate studies of geography at the Department of Geography, Faculty of Science) and strengthening the use of GIS in scientific research. The characteristic development periods of GIS teaching and scientific components at the Department of Geography, Faculty of Science have also been defined.

Key words: GIS, development, Department of Geography, Faculty of Science, education of geographers, tertiary education, University of Zagreb

GIS U TEORIJSKO-METODOLOŠKOM SUSTAVU GEOGRAFIJE

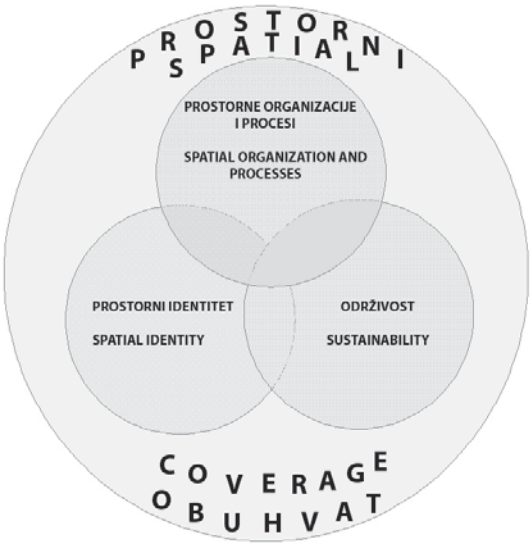
Polazeći od identifikacije geografije kao znanosti koja svojim tehnikama i metodama rada, pristupom, razmatranjem, definiranjem i predviđanjem može postaviti i objasniti prostorne zakonitosti, organizaciju i logiku prostora (Šterc, 2015) odnosno polazeći od četiri temeljna geografska koncepta (sl. 1) na kojima se temelji poučavanje i istraživanje u geografiji (prostorni identitet, prostorne organizacije i procesi, održivost te prostorni obuhvat koji ima integrativni karakter i sadržan je u prethodna tri) (Nacionalni kurikulum nastavnog predmeta geografija, prijedlog, 2016) otvara se pitanje uloge i značenje Geografskih informacijskih sustava u sklopu teorijsko-metodološkog sklopa geografije.

Geografski informacijski sustavi omogućuju primjenu metoda prostorne analize koje mogu pomoći u objašnjava-

GIS IN THE THEORETICAL AND METHODOLOGICAL SYSTEM OF GEOGRAPHY

Considering identification of geography as a science whose techniques and methods, approach, considerations, definitions and predictions may establish and explain spatial laws, organisation and logic (Šterc, 2015) and considering the four basic geographic concepts (Fig. 1) that provide the foundations for geography teaching and research (spatial identity, spatial organisation and processes, sustainability, and spatial coverage, which has an integrative character and is contained in the previous three concepts) (Draft National Geography Curriculum, 2016) the question arises as to the role and significance of GIS in the theory and methodology of geography.

Geographic information systems enable us to use spatial analysis methods that may help explain basic



Sl. 1: Koncepti u geografiji (izvor: Nacionalni kurikulum nastavnog predmeta geografija, prijedlog, 2016)
Fig. 1: Geographic concepts (source: Draft Geography National Curriculum, 2016)

nju temeljnih pitanja geografskih istraživanja vezanih uz regije (prostorni identitet), razumijevanja obrazaca prostornog rasporeda, odnosa i procesa te modeliranja njihovog budućeg razvoja. Pri tome temeljne metodološke postavke geografskih informacijskih sustava ne samo da su izravno povezane već se može reći da su sastavni dio metodološkog sklopa geografije odnosno dijela metoda koje u geografiji imenujemo kao geografske ili prostorne metode analize: primarno vezane uz geografski pristup i geografski predmet interesa. Primarno to su: terenska metoda (anketiranje, intervjuiranje, promatranje, mjerenje, brojenje…), metoda tematskog kartiranja, cijeli metodološki sustav GIS-a i prostorno modeliranje i predviđanje (Šterc, 2015). Geografske (prostorne) metode su svojstvene primarno geografskom pristupu i geografskom predmetu interesa jer su one neodvojivi dio geografskog identiteta. (Šterc, 2015). Te su metode temeljene na osnovnim počelima i problemima svakog geografskog istraživanja i temeljnim obilježjima geografskih podataka: Toblerovom prvom zakonu geografije[1] koji je formaliziran kroz koncept prostorne korelacije (spatial autocorrelation), uzorkovanju prostornih objekata i pojava, problemu promjene pojave s udaljenošću (npr. između prostornih uzoraka), problemu njezinog mjerenja a povezano s udaljenošću, problemu mjerila odnosno razine geografske detaljnosti, problemu geovizualizacije, problemu fraktalne dimenzije prostornih entiteta i dr. Svi ovi problemi utemeljeni su u istraživačkoj potrebi da se stvarni svijet uopći, ge-

[1] Bliži objekti u prostoru povezaniji su od udaljenijih odnosno imaju sličnija obilježja od udaljenijih "Everything is related to everything else, but near things are more related than distant things."

questions in geographic research related to regions (spatial identity), and understand spatial arrangement, relationship and process patterns and thus model their future development. In this process, the basic methodological postulates of geographic information systems are not only directly connected, but also form an integral part of the methodological framework of geography, i.e. the geographic or spatial analysis methods. They are primarily related to geographic approach and geographic interests and include the following: field method (surveys, interviews, observations, measurements, counts…), thematic mapping method, the entire GIS methodological system and spatial modelling and predictions (Šterc, 2015). Geographical (spatial) methods are inherent primarily to the geographic approach and interests because they are an inseparable part of the geographic identity (Šterc, 2015). These methods are based on the fundamental postulates and problems of any geographic research and on the basic features of geographic data: Tobler's First Law of Geography[1] that is formalized through the concept of spatial autocorrelation, sampling of spatial objects and entities, and the issues of changes over distance (e.g. among spatial samples), measurement related to distance, scale, i.e. the level of geographic detail, geovisualization, fractal dimensions of spatial entities, etc. All these problems are rooted in the need of researchers to generalize the

[1] "Everything is related to everything else, but near things are more related than distant things."

neralizira te da se apstrahiraju najbitniji elementi prostora u sklopu predmetnog geografskog istraživanja. U tom procesu geografi pokušavaju dokučiti gdje, kako i zašto se prostorne strukture, pojave i procesi pojavljuju u prostoru ovisno o prirodnoj osnovi, različitim oblicima organizacijskih struktura stvorenih da pridonose i održavaju materijalno bogatstvo društva te karakteru i „prirodi“ mjesta (place) kreiranih unutar tih struktura (Johnson, 2005).

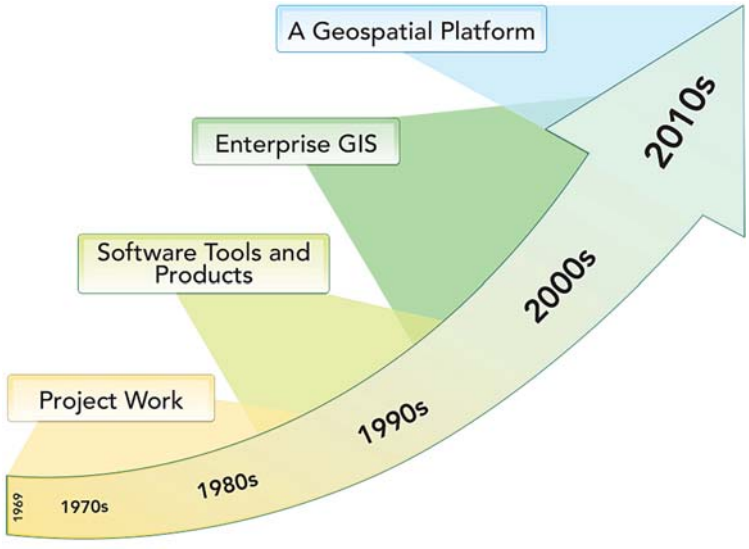
Geografi su kroz različite znanstvene paradigme (empirijsko-pozitivističke, hermeneutičke, kriticističke) pokušavali prezentirati rezultate svojih istraživanja u cijelom nizu pristupa. U skladu s razvojem različitih paradigmi i pristupa unutar geografije GIS se prvotno najčešće povezivao s istraživanjima koja su se temeljila na postavkama empirizma i pozitivizma (što je rezultat percepcije jake povezanosti s tehničkim instrumentarijem odnosno aspektom u istraživanjima) dok se u novije vrijeme znatno povećao broj istraživanja u kojima se GIS primjenjuje unutar socijalno aspektiranih teorija u geografiji (Johnson, 2005).

Može se reći da je GIS od usko specijalističkog načina korištenja danas ušao u razdoblje masovne primjene pri čemu je omogućeno nestručnjacima putem korisnički pristupačnog softvera rješavanje prostorno uvjetovanih problema (sl. 2). Sve se više GIS funkcionalnost nastoji, koristeći web i cloud tehnologiju, koncipirati kao poslovni model – model softvera kao usluge (SaaS – Softver as a Service). O tome svjedoči i primjer tvrtke ESRI koja softver ArcGIS-a pretvara u oblik geoprostorne platforme (geospatial platform) koja objedinjuje web i cloud tehnologiju: ArcGIS kao platforma omogućava slobodne geoprostorne funkcije svakom korisniku i omogućava pristup bilo kojoj aplikaciji ili uređaju bilogdje i bilokada (Dangermond, 2012).

real world and to abstract the most important elements of space within the specific geographic study. In this process, geographers aim to establish where, how and why spatial structures, phenomena and processes occur depending on their natural basis, on various forms of organisational structures created to contribute to and maintain the wealth of society, and on the character and nature of places created within these structures (Johnson, 2005).

Geographers have tried to present the results of their research through various scientific paradigms (empirical/positivist, hermeneutic, criticist). In line with the development of various paradigms and approaches within geography, initially GIS was most often connected with research based on empirical and positivist postulates (the result of the perception of strong connections with technical instruments, i.e. technical aspects of research), In recent years, the number of research programmes where GIS is applied within social theories in geography has significantly increased (Johnson, 2005).

As GIS shifted from narrow specialist use to mass use, non-experts were enabled to resolve spatial problems with user-friendly software (Fig. 2). There are increasing numbers of GIS functionalities using web and cloud technologies, in the form of a business model – Software as a Service model (SaaS model). This can be illustrated by the example of the company ESRI, which converts ArcGIS software into a geospatial platform that combines web and cloud technologies: ArcGIS as a platform allows each user to use geospatial functions and enables access to any application or device anywhere and anytime (Dangermond, 2012).



Sl. 2: Evolucija ArcGIS-a u platformu ESRI (izvor: Esri News, 2012-2013)

Fig. 2: The evolution of ArcGIS as a platform (source: ESRI News, 2012.2013)

Prema tome, u suvremenom razvoju GIS-a kroz paradigmu „uslužno orijentirane arhitekture/service-oriented architecture (SOA) mogu se očekivati dva izazova: pojednostavljivanje korištenja i učenja funkcija unutar GIS-a – samih naredbi (pojednostavljivanje funkcionalnosti GIS-a) i izazov stvaranja standardizirane terminologije tih usluga jer SOA se pojavljuje kao nova paradigma u računalstvu u kojoj se zahtijeva međusobno povezivanje on-line usluga, više nego operacija na desktopu (Goodchild, 2011).

Nije potrebno posebno naglašavati značenje GIS-a kao opće vrijednost koja omogućava stjecanje temeljnih kompetencija potrebnih danas u društvu temeljenom na informacijskim i komunikacijskim tehnologijama (80% informacijskih potreba lokalnih vlasti i kreatora politike vezano je uz lokaciju u prostoru) (Biggs i Garson, 1992; Franklin i Hane, 1992) te značenje GIS-a u kreiranju novih znanja o prostoru, posebice putem stvaranja, iz postojećih, kvalitativno nove prostorne informacije što afirmira njegovu ulogu u procesu učenja, upravljanju i efikasnom korištenju prostora kao ograničenog resursa od lokalne do globalne razine. Može se reći da su geografski informacijski sustavi postali „Conditio sine qua non“ uspješnog upravljanja prostorom. Tako tržišna istraživanja i istraživanja unutar industrije naglašavaju da stjecanje GIS kompetencija postaje nužno za rad u cjelokupnom gospodarstvenom i poslovnom okruženju (Sinton, 2012).

Pored već spomenute uloge u procesu učenja u mnogim radovima ističu se najvažnije temeljne vrijednosti GIS-a koje su u daljnjem tekstu razmotrene i sagledane u kontekstu razvoja GIS-a na Geografskom odsjeku PMF-a.

ULOGA GIS-A U POUČAVANJU I GEOGRAFSKOM ISTRAŽIVANJU

Na prvom mjestu ističe se da GIS potiče razvoj prostornog mišljenja. Tako Goodchild (2006) ističe da je prostorno mišljenje potrebno uključiti kao četvrti R u dosadašnji pojam 3R-a za temeljne vještine (**R**eading, w**R**iting, a**R**ithmetics) koje se stječu tijekom obrazovnog procesa zbog njegovog značenja u suvremenom društvu u kojem se mnoštvo različitih tipova prostornih informacija umnožava zahvaljujući novim ICT tehnologijama. Razvijanje sposobnosti kritičkog prostornog mišljenja u geografiji jest vrlo važno jer pomaže studentima da postanu svjesni važnosti pristupa i davanju značenja geoinformaciji (Gryl i dr., 2010) kako bi se razumjela kompleksnost mnogih prostornih problema s kojima se suočava svijet današnjice (Bearman i dr., 2016) jer geografija je znanost koja naglašava međupovezanost prostornih pojava i procesa i prostorne razine njihova promatranja (Hardwick i Holtgrieve, 1996). Takva međupovezanost jednako je relevantna za GIS kao i

Consequently, two challenges can be expected in the contemporary development of GIS through the service-oriented architecture (SOA) paradigm: simplification of use and learning of GIS functions, i.e. commands (simplification of GIS functionality), and creation of standard terminology for these services, as the service-oriented architecture (SOA) emerges as a new paradigm of computing, in which tasks are performed by chaining together online services rather than by desktop operations (Goodchild, 2011). There is no need to emphasize the importance of GIS as a general value that enables the acquisition of basic competencies required in an information and communication technologies based society (80% of information requirements of local authorities and policy makers is related to spatial location) (Biggs and Garson, 1992; Franklin and Hane, 1992), or to emphasise its importance in the creation of the new knowledge about space, in particular in using existing spatial data to create new qualitative spatial information, which affirms its role in the learning process, and in the management and efficient use of space as a limited resource from local to global levels. It can be said that geographic information systems have become the *Conditio sine qua non* of successful space management. Therefore, market and industry research emphasise that the acquisition of GIS competencies has become necessary for work in the overall economic and business environment (Sinton, 2012).

In addition to its role in the learning process, many papers outline the most important fundamental values of GIS, which are discussed and analysed below in the context of GIS development at the Department of Geography of the Faculty of Science.

THE ROLE OF GIS IN TEACHING GEOGRAPHY AND RESEARCH

Firstly, it should be emphasised that GIS fosters the development of spatial thinking. In this context, Goodchild (2006) notes that spatial thinking should be added as the fourth R to the current three Rs (**R**eading, w**R**iting, a**R**ithmetic), i.e. the skills acquired throughout education, due to its importance in contemporary society where a myriad of different types of spatial information is multiplied thanks to new ICT technologies. The development of critical spatial thinking in geography is very important because it helps students to become aware of the importance of the approach and the meaning imparted to geoinformation (Gryl et al., 2010) to be able to understand the complexity of problems the world is facing today (Bearman et al., 2016). This is because geography is a science that emphasises the interconnections between spatial phenomena and processes on the one hand, and the spatial level of their observation on the other (Hardwick

za geografiju, posebice kada se GIS promatra u svjetlu koncepta razvoja digitalne Zemlje (digital Earth; Goodchild, 2008) i razvoja kvantitativne geografije (Longley, 2000). Pored toga GIS može integrirati različite razine promatranja svojstvene prostornim pojavama, procesima i značenjima (Bearman i dr., 2016).

Nacionalno istraživačko vijeće (National Research Council) u SAD-u u knjizi „Learning to think spatially" definira prostorno mišljenje (NRC, 2006) kao skup „kognitivnih vještina koje se koriste kako bi se u svakodnevnom privatnom i profesionalnom životu tako i u znanosti strukturirali problemi, pronašli odgovori i rješenja uzimajući u obzir posebnosti prostora. Može ih se poučavati i formalno naučiti koristiti odgovarajuće alate, tehnologije i kurikulum". U dokumentu se konstatira da se u formalnom kurikulumu općeg obrazovanja, unatoč tome što se radi o primarnom obliku inteligencije (Eliot, 1987; Gardner, 1983), prostornom mišljenju ne posvećuje dovoljna pažnja. Upravo na ovom tragu u Hrvatskoj tek valja osmisliti kako GIS iskoristiti, ne samo kao tehnologiju već i kao pomoć u usvajanju teorijskih osnova potrebnih za razumijevanje prostornih problema. Tako neki autori (Bearman i dr., 2016) ističu da se u modulima u kojima se uči GIS više vremena pridaje razvoju tehničkih vještina povezanih sa korištenjem GIS softvera nego li razumijevanju temeljnih teorijskih principa funkcioniranja i modeliranja prostora u GIS-u koji su sastavni dio područja geoinformatike (GISc). Autori isto tako zaključuju da je GIS ušao u novu fazu tehnološkog razvoja koja nam omogućuje da se odmaknemo od striktno tehničkog pogleda na GIS (ograničenja što softver može) i nastavimo s razvijanjem aspekta kritičkog prostornog razmišljanja svojstvenog geografiji u okviru koji nam omogućuje GIS (Bearman i dr., 2016). Međutim, nedovoljno je empirijskih istraživanja koja bi potvrdila ulogu GIS-a u razvoju prostornog načina mišljenja i potrebna su daljnja istraživanja odnosa između komponenti GIS kurikuluma i elemenata prostornog mišljenja (Wakabayashi i Ishikawa, 2011).

Bez GIS-a ne bi bilo moguće prikupljanje velikih količina informacija o promatranim događajima, ne bi bila moguća izgradnja i testiranje teorijskih postavki o geografskom razmještaju i procesima, mnogi bi geoznanstveni problemi ostali nerazumljivi i nedovoljno objašnjeni (Maguire, 2008).

Pored toga, poznato je iz svjetske literature da su upravo učitelji GIS-a u visokoškolskom obrazovanju prigrlili koncept aktivnog učenja (Drennon, 2005; Carlson, 2007) kao okvir za mnogobrojne međusobno povezane tehnike (problemski i istraživački utemeljeno učenje, učenje otkrivanjem, empirijsko učenje) utemeljene u konstruktivističkom pristupu učenju (Foote i dr., 2012).

Prema tome, naglasak je na razumijevanju geografskih koncepata korištenjem GIS-a, aktivnom i u nekoj mjeand Holtgrieve, 1996). Such interconnection is equally relevant for both GIS and geography, in particular when GIS is analysed in light of the digital Earth development concept (digital Earth; Goodchild, 2008) and the development of quantitative geography (Longley, 2000). Additionally, GIS may include various levels of observation inherent to spatial phenomena, processes and meanings (Bearman et al., 2016).

In the book *Learning to Think Spatially*, the U.S. National Research Council defines spatial thinking as "a cognitive skill that can be used in everyday life, the workplace, and science to structure problems, find answers, and express solutions using the properties of space. It can be learned and taught formally to students using appropriately designed tools, technologies, and curricula" (NRC, 2006). The report documented the lack of attention to spatial thinking in formal curricula, despite assertions that it is a primary form of intelligence (Eliot, 1987; Gardner, 1983). This is exactly the way for Croatia to define how to use GIS, not only as a technology, but also as an aid in the acquisition of the theoretical foundation required in order to understand spatial problems. Therefore, some authors (Bearman et al., 2016) emphasise that as far as GIS modules are concerned, more time is dedicated to the development of technical skills relating to the use of GIS software than to the development of fundamental theoretical principles of spatial functioning and modelling that are integral parts of geoinformatics (GISc). The authors also emphasised that GIS has reached a new phase in its technological development, enabling us to move from considering GIS from a purely technical point of view (i.e. from being limited by what GIS software can do) to further developing critical spatial thinking inherent to geography within the framework provided by GIS (Bearman et al., 2016). However, empirical research that would confirm the role of GIS in the development of spatial thinking is insufficient, and therefore further research of the relationship between the components of the GIS curriculum and spatial thinking elements is required (Wakabayashi and Ishikawa, 2011).

Without GIS, it would be impossible to collect such a large amount of information about observed events or design and put forth hypotheses on geographic distribution and processes. Furthermore, many geoscientific problems would have remained incomprehensible and insufficiently elucidated (Maguire, 2008).

Moreover, the global literature shows that GIS teachers in higher education institutions who those most willing to embrace active learning (Drennon, 2005; Carlson, 2007) as a framework for a range of interrelated techniques (problem-based learning, inquiry-based learning, discovery learning, empirical learning) all rooted in the constructivist learning theory (Foote et al., 2012).

ri samostalnom otkrivanju prostornih zakonitosti i svojstava promatranih objekata. U takvom procesu obrazovanja, učenje otkrivanjem postaje jedna od češće korištenih strategija. Za strategiju učenja otkrivanjem karakteristično je da se radi o iskustvenom učenju, pri čemu se to iskustvo stječe ili u stvarnosti ili u zamišljenoj stvarnosti. Obično govorimo o tri metode učenja otkrivanjem: o istraživanju, o simulaciji i o projektnoj metodi (Varošanec, 2006).

Istraživanjem studenti proučavaju stvarnu situaciju (npr. terenskim radom i sl.), ali u velikom broju slučajeva to nije moguće te simulacijski GIS modeli mogu biti odgovarajuća zamjena ili mogu pomoći u usmjeravanju i intenzifikaciji terenskog rada. Istraživanjem i GIS modeliranjem studenti istražuju i rješavaju probleme pokušavajući otkriti geografske zakonitosti i strukturna obilježja prostora koje dotada nisu poznavali. Tako Wanner i Kerski (1999) otkrivaju potencijal GIS-a u usvajanju istraživačkih vještina studenata kao i u analizi i prikazivanju geografskih podataka, a Pottle (2001) definira GIS kao koristan alat za učenje i motiviranje studenata u procesu stjecanja važnih vještina i znanja iz geografskog kurikuluma.

Studentsko istraživanje ima iste korake kao i znanstveno istraživanje, a to su (Bognar i Matijević, 2005, prema Varošanec 2006; Cindrić i dr., 2016):

- uočavanje i definiranje problema
- određivanje plana i metoda istraživanja
- prikupljanje podataka, postavljanje pretpostavke (hipoteze)
- analiziranje podataka, opovrgavanje ili potvrđivanje hipoteza

Ovakav slijed postupaka uvodi studente u samostalni znanstveno-istraživački rad. Zbog toga nije nimalo čudno što aktivno učenje i GIS&T idu ruku pod ruku i djeluju sinergijski. (Schultz, 2012). No, ponekad uključivanje GIS-a u geografsko obrazovanje može biti i neuspjeli pokušaj kao što je to bio slučaj u Turskoj gdje se pokazalo da „većina nastavnika zna što je GIS, ali nema dovoljno znanja o tome kako učiti geografiju pomoću GIS-a“ (Incekara, 2012).

GIS I PRIMIJENJENA GEOGRAFIJA - JAČANJE ZNAČENJA GEOGRAFIJE (APLIKATIVNA KOMPONENTA)

Na primijenjenu geografiju ne treba gledati kao na jednu od geografskih subdisciplina (kao što su ekonomska, socijalna ili historijska geografija) već kao na pristup koji nadilazi umjetne granice pojedinih disciplina i kojeg obilježava problemsko orijentirani istraživački rad i u društvenoj i u fizičkoj geografiji (Pacione, 2004). Iz perspektive primjenjene geografije najvažniji je problem koji motivi-

Consequently, the emphasis is placed on the understanding of geographic concepts with the help of GIS, and on the active and, to some extent, independent discovery of spatial laws and features of the observed objects. In such an educational process, discovery learning becomes a frequently used strategy. This strategy is characterised by learning through experience, whereby this experience is acquired either in reality or in contrived reality. There are usually three methods of discovery learning: research, simulations and the project method (Varošanec, 2006).

Through research, students explore an actual situation (e.g. through field work, etc.), though in many cases this is not possible and GIS simulation models can be an appropriate substitute, or they can facilitate in directing and intensifying fieldwork. By conducting research and GIS modelling, students explore and solve problems, trying to discover geographic laws and structural features of a space previously unknown to them. Wanner and Kerski (1999) discovered that GIS had the potential to accelerate geographical inquiry skills in students, as well as their skills to analyse and display geographic data, while Pottle (2001) defined GIS as a tool for learning and motivating students as they learn important skills and knowledge from geography curriculum.

Student research includes the same steps as any scientific research, namely (Bognar and Matijević, 2005, according to Varošanec 2006; Cindrić et al., 2016):

- detecting and defining a problem
- designing the plan and research methods
- collecting data, setting the hypothesis
- analysing data, rejecting or confirming a hypothesis

This sequence of procedures introduces students to independent scientific research. It is therefore no wonder that active learning and GIS&T go hand in hand and act in synergy (Schultz, 2012). However, the inclusion of GIS in geography education may occasionally be unsuccessful, as was the case in Turkey where it was shown “that most of them know what GIS is, but they lack the knowledge of how to teach geography with GIS” (Incekara, 2012).

GIS AND APPLIED GEOGRAPHY – RAISING THE IMPORTANCE OF GEOGRAPHY

Rather than being considered as a sub-discipline of geography (akin to economic, social or historical geography), applied geography refers to an approach that crosscuts artificial disciplinary boundaries to involve problem-oriented research in both social and physical geography (Pacione, 2004). The problem, i.e. the motive for the research, is the most important element from the perspective of applied geography. In this aspect, GIS is an excellent guide on how to

ra istraživanje: u tom smislu GIS je sjajan putokaz kako rješavati primijenjene geografske probleme (Gettis, 2004). GIS rješava stari problem kombiniranja općeg znanstvenog znanja sa specifičnim informacijama i daje im praktičnu vrijednost (Longley i dr., 2015). O tome govore sve brojniji diplomski studijski programi u svijet u čijem nazivu su povezani primjenjena geografija i GIS.

Doista, šira relevantnost geografije kao discipline može se održati samo kroz prizmu korisnosti za istraživanje i razumijevanje svijeta oko nas pri čemu je potrebno raspolagati određenim znanjima o problemu u kojem se primjenjuje GIS i razumijeti analitičke postupke prilikom njegovog rješavanja kako bismo znali koja pitanja postaviti, koje varijable koristiti i kako bismo izbjegli besmislene postupke i odgovore (Longley i dr., 2015).

HIPOTEZE I METODOLOGIJA ISTRAŽIVANJA

Na temelju konzultacije relevantne literature nameću se temeljne hipoteze ovog rada povezane s razvojem primjene GIS-a na Geografskom odsjeku PMF-a Sveučilišta u Zagrebu.

1. Ograničeno individualno korištenje GIS-a bez značajnije nastavne komponente nije značajnije utjecalo na znanstvenu i stručnu produkciju Geografskog odsjeka
2. Uvođenje novog diplomskog sveučilišnog studija i GIS smjera na njemu znatno je uvećalo znanstvenu produkciju radova vezanih uz GIS.
3. Struktura preddiplomskog i diplomskih studija na Geografskom odsjeku postavljena je u skladu s konceptom stupnjevitosti: prvotno učenje GIS tehnologije kasnije otvara brojne mogućnosti učenja o geografskim pojavama, strukturama i procesima pomoću GIS-a.
4. Aplikativna komponenta GIS-a tek počinje jačati kroz znanstvene i stručne projekte Geografskog odsjeka.

Podaci za analizu značenja primjene GIS-a u geografskom obrazovanju prvenstveno su prikupljeni iz postojećih publikacija PMF-a (Red predavanja za određene akademske godine), elaborata studijskih programa i repozitorija diplomskih radova studenata pri Središnjoj geografskoj knjižnici na Geografskom odsjeku PMF-a (Izvori 1-3). Budući da su uočene određene pogreške u pojedinim izdanjima Reda predavanja podaci o predmetima i nastavnicima koji su izvodili nastavu korigirani su prema podacima prikupljenima naknadno iz referade Geografskog odsjeka. Prilikom prikupljanja podataka iz repozitorija na temelju dokumentacijskih kartica (naziv i ključne riječi) ustanovljeno je da određeni dio radova studenata u kojima je pri-

resolve geographic problems (Gettis, 2004). GIS resolves the ancient problem of combining general scientific knowledge with specific information and gives practical value to both (Longley et al, 2015). This is confirmed by the increasing number of graduate study programmes worldwide whose titles combine applied geography and GIS.

Indeed, the broader relevance of geography as a discipline can only be sustained in relation to its usefulness for research and understanding the world around us. In this process, we should have certain knowledge about the problem to which GIS is applied and we should understand the analytical procedures in the problem-solving process to know which questions to ask, which variables to use and how to avoid meaningless procedures and answers (Longley et al., 2015).

RESEARCH HYPOTHESES AND METHODOLOGY

The relevant literature was consulted to form the basic hypotheses of this study work connected with the development of GIS use at the Department of Geography, Faculty of Science, University of Zagreb:

1. Limited individual use of GIS without any considerable teaching component has not significantly impacted the scientific and expert production at the department
2. Introduction of the new graduate study programme and GIS study programme has significantly increased the scientific production of GIS-related papers.
3. The structure of undergraduate and graduate studies at the department complies with the concept of stages: initial learning of GIS technology later opens a number of learning options related to geographical phenomena, structures and processes supported by GIS.
4. The GIS application component only becomes strengthened through scientific and expert projects of the department.

The data for the analysis of importance of GIS in geography education was primarily collected from the existing publications of the Faculty of Science (Schedule of lectures for specific academic years), study programmes and repositories of Master's theses kept by the Central Geographical Library at the Geography Department, Faculty of Science (Sources 1-3). Since some mistakes were observed in certain editions of the Schedule of lectures, and the data on subjects and teachers were corrected in accordance with the subsequently collected data from the student administration service of the Department of Geography. During the collection of data from repositories using documentation cards (title and key words), it was found that some student papers where

mijenjen GIS ostaje izvan dosega pretrage. Stoga je izvršen uvid u sadržajni dio radova kako bi se pretraživanjem izdvojili svi potrebni radovi (najvećim dijelom naknadno su pridruženi radovi novijeg datuma). Naime, riječ je o tome da su GIS metode postale sastavni dio svakog geografskog istraživanja te studenti nisu smatrali potrebnim GIS naznačiti u ključnim riječima rada. Valja naglasiti da su u ovom radu u odabiru diplomskih radova u kojima je primijenjen GIS prvenstveno uzimani u obzir oni radovi u kojima je primijenjena jedna od metoda prostorne analize, tj. gdje je došlo do stvaranja nove vrijednosti geoinformacija (preradbom je dobivena nova informacijska vrijednost ulaznih podataka). Tako u selekciju GIS radova studenata nisu ušli oni radovi u kojima je GIS korišten samo kao vizualizacijska podrška glavnoj temi diplomskog rada. Ovaj konstriktivni pristup u odabiru GIS radova primijenjen je i kasnije na doktorskim radovima (Izvor 4) i na znanstvenoj produkciji djelatnika Geografskog odsjeka.

Podaci o znanstvenoj produkciji djelatnika Geografskog odsjeka prikupljeni su iz CROSBI bibliografske baze (Izvor 5), no u slučajevima gdje nije bilo moguće detektirati jesu li u radu primijenjene GIS metode analize podaci su individualno prikupljeni od samih djelatnika ili putem uvida u cjelokupni objavljeni rad. Dakle, prilikom kvalitativnog istraživanja primijenjena je metoda analize sadržaja (Cohen i dr., 2018) ocjenskih i znanstvenih radova studenata i djelatnika Geografskog odsjeka.

RAZVOJ GIS-A NA GEOGRAFSKOM ODSJEKU PMF-a

NASTAVNA KOMPONENTA

Pionirsko razdoblje razvoja GIS-a na Geografskom odsjeku obilježava prvenstveno primjena GIS-a u znanstveno-istraživačkom radu znanstvenih novaka početkom 1990-ih (sl. 3). Tada Geografski odsjek pribavlja jedno računalo, digitalizatorsku ploču i GIS softver, što omogućava, zahvaljujući entuzijazmu mladih asistenata, prve korake u nastavi GIS-a na našim visokoškolskim institucijama: počinje se izvoditi praktična nastava iz GIS-a za studente geografije u obliku seminara. Temeljni znanstveni interes bio je vezan uz mogućnosti primjene GIS-a u analizama prostornih sustava i njihovih temeljnih dijelova: prometne, urbane, riječne mreže. Zbog ograničenih resursa (hardver, softver, kadrovi) primjena GIS-a nije imala obilježja sustavnog povezivanja znanstvenog i nastavnog segmenta djelovanja GO već je bila usmjeravana poglavito na pojedini istraživačkih interes ograničenog broja djelatnika Odsjeka. Nastava koja se održavala na jednom od ukupno dva računala na Geografskom odsjeku tražila je izuzetni nastavni angažman izvođača te nije bilo moguće trajnije održati takav oblik nastave. Zbog takvih, krajnje nepovoljnih

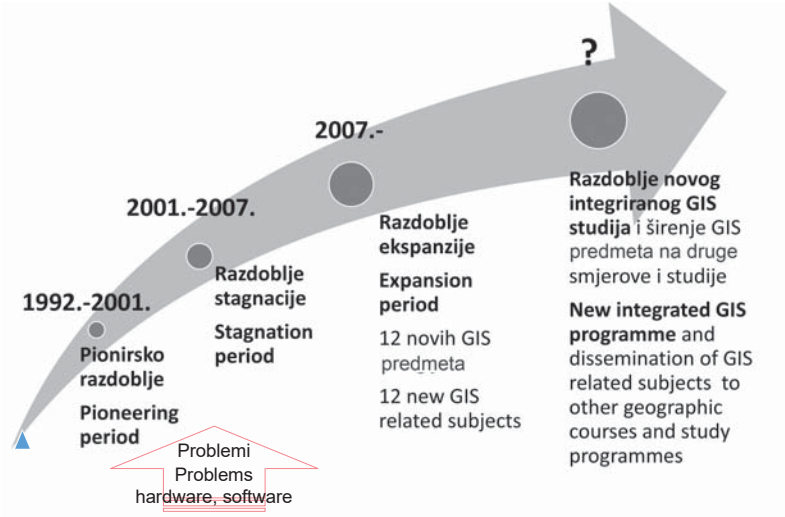
GIS was applied were not covered by this search. Therefore, we inspected the content of these papers to ensure that our search would encompass all the relevant papers (most subsequently added papers were of a more recent date). In fact, GIS methods have become an integral part of any geographic research and therefore students did not consider it necessary to include GIS as one of the key words of their paper. It should be emphasised that Master's theses with GIS included in this paper are primarily those where spatial analysis methods were applied, i.e. where new value of geoinformation was created (processing yielded new information value of incoming data). Therefore, the selection of student papers did not include those papers where GIS was used only as geovisualization support for the main topic of the Master's thesis. This restrictive approach to the selection of GIS papers was later applied to Doctoral dissertations (Source 4) and to the scientific production of department staff.

Data on the scientific production of staff of the Department of Geography were collected from the CROSBI bibliographic database (Source 5). However, in cases where it was not possible to detect whether GIS analysis methods were applied in certain papers, the data were collected individually from the employees or following an inspection of integral published works. Therefore, the method applied during qualitative research was the method of content analysis (Cohen et al., 2018) of review and scientific papers of department students and staff.

DEVELOPMENT OF GIS AT THE DEPARTMENT OF GEOGRAPHY, FACULTY OF SCIENCE

TEACHING COMPONENT

The pioneer period of GIS development at the Department of Geography is marked primarily by the use of GIS in scientific-research papers of junior researchers in the early 1990s (Fig. 3). At that time, the department procured a computer, digitizer panel and GIS software, which thanks to the enthusiasm of junior assistants, enabled the first steps in teaching GIS at a higher education institutions, offering geography students practical GIS training through seminars. The basic scientific interests were related to the possibilities of using GIS to analyse spatial systems and their basic components: road, urban and inland waterway networks. Due to the limited resources (hardware, software, human resources), the use of GIS was not accompanied with the creation of systematic links between scientific and teaching components in the department, but was instead mainly oriented on individual research interests of a limited number of department staff. The classes held on one of the two departmental computers required exceptional engagement and it was not possible to hold such classes for a longer period. Due to these unfavourable circumstances, it



Sl. 3: Karakteristične etape razvoja GIS-a na Geografskom odsjeku

Fig. 3: Characteristic periods of GIS development at the Department of Geography

uvjeta, nije bilo više moguće izvoditi nastavu iz GIS-a te je uslijedilo nekoliko godina u kojima se GIS primjenjuje samo u znanstvenim istraživanjima (razdoblje stagnacije).

Doduše, početkom 2000-ih uvodi se jednosemestralni kolegij GIS na nastavničkom smjeru profesor geografije koji izvode kolege sa Geodetskog fakulteta Sveučilišta u Zagrebu. Jednosemestralni kolegij predstavljao je tek stjecanje temeljnih kompetencija za rad sa prostornim informacijama u GIS-u koje su bile povezane prvenstveno s osnovnim kartografsko-geoinformatičkim kompetencijama, najviše u domeni vizualizacijskih mogućnosti GIS-a s tek rudimentarno prisutnim metodama prostorne analize (u smislu preradbe i stvaranja nove informacijske kvalitete prostornih podataka). Glavno obilježje ove etape razvoja jest usvajanje tehnologije per se (bez ulaženja u teorijsko-metodološki sklop geoinformatike i geografije).

Tek od 2005. godine poglavito zahvaljujući suradnji s Geoinformatičkom jedinicom Geografskog odsjeka Sveučilišta u Potsdamu (posebice profesorom Hartmutom Ascheom i njegovim suradnicima) pokrenuta je sustavnija izobrazba djelatnika GO iz područja GIS-a i vizualizacije. Kroz rad na zajedničkom projektu izrade web utemeljenog atlasnog informacijskog sustava (Demographic Atlas of Croatia, DACIS) u obliku nekoliko radionica osposobljavaju se naši djelatnici i studenti u Potsdamu i Zagrebu. Također, ostvaren je niz boravaka naših studenata i asistenata u Potsdamu putem Erasmus projekta i sredstava zagrebačkog Sveučilišta za međunarodnu suradnju. Zahvaljujući početnom odsječkom financiranju projekta postavljeni su temelji (izgradnja baze podataka i idejno rješenje Web atlasa) i objavljeno je nekoliko zajedničkih znanstvenih radova

was no longer possible to hold GIS classes and for several years, GIS was used in scientific research only (stagnation period).

However, in the early 2000s, a one-semester GIS course was introduced at the department and taught by colleagues from the Faculty of Geodesy, University of Zagreb. This one-semester course covered only the basic competencies required for working with spatial information in GIS. These competencies were primarily connected with basic cartography and geoinformatics, mostly in the area of visualisation capabilities of GIS, using basic methods of spatial analysis (in terms of processing and creating new information quality of spatial data). The main feature of this development phase was the adoption of technology (without analysing the theoretical and methodological aspect of geoinformatics and geography).

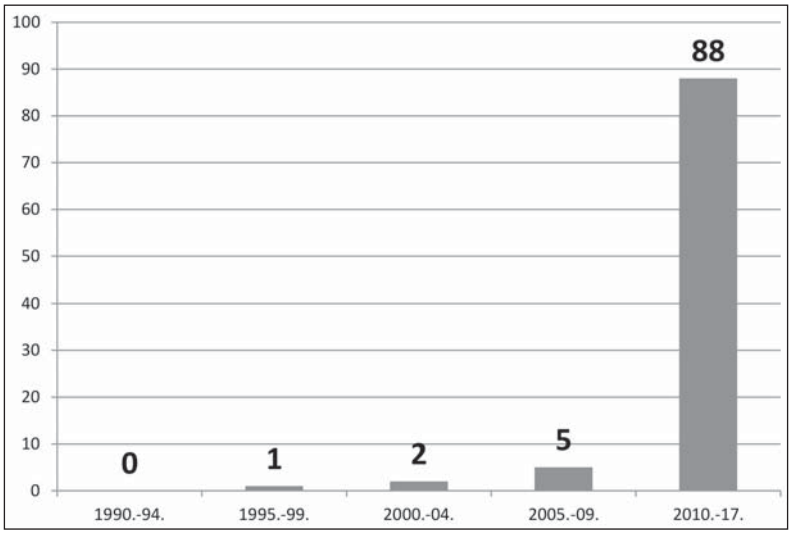
It has only been since 2005, thanks mainly to cooperation with the Geoinformation Unit of the Department of Geography, University of Potsdam (in particular Professor Hartmut Asche and his associates), that more systematic GIS and visualisation training of staff of the department started. Through the joint project to build a web-based atlas information system (Demographic Atlas of Croatia, DACIS) carried out via several workshops, both teachers and students received training in Potsdam and Zagreb. Also, students and staff did training and received valuable experience in Potsdam via an Erasmus project and using the funds of the Zagreb University earmarked for international cooperation. Thanks to the project initially financed by the department itself (building the database and concept of the web atlas), several joint papers were published on

na tu temu, no projekt nije završen zbog nedostatka financijskih sredstava. Međutim, znanja i vještine stečene u toj suradnji u velikoj su mjeri pomogle u stvaranju koncepcije budućih predmeta (posebno Geoinformatike, Analiza u GIS-u i Vizualizacije prostornih podataka u GIS-u) te olakšale izvođenje nastave na novom GIS smjeru te općenito u okviru našeg preddiplomskog i drugih diplomskih studija.

Ustrojavanjem novih studijskih programa na Geografskom odsjeku (2005.), poglavito preddiplomskog istraživačkog studija geografije te diplomskog istraživačkog studija geografije počinje razdoblje intenzivnog razvoja kako obrazovne (GIS smjer na diplomskom istraživačkom studiju geografije), a kasnije i istraživačke i primjenjene komponente GIS-a. O tome svjedoči čitav niz novih predmeta vezanih uz GIS kako na preddiplomskom studiju geografije (Geoinformatika, dvosemestralni predmet) i preddiplomskom studiju Znanosti o okolišu (zajednički studij Biološkog, Geografskog i Geološkog odsjeka PMF-a, jednosemestralni predmet Kartografske osnove GIS-a) tako i na diplomskom istraživačkom studiju geografije (Analize u GIS-u, Vizualizacija prostornih podataka u GIS-u, Digitalna analiza reljefa, GIS analiza kulturnog pejzaža, Primjena GIS-a u analizi popisnih podataka, Daljinska istraživanja, Računalne statističke analize, Katastar nekretnina, Primjena računala u nastavi geografije). Pored toga, uvedeni su novi predmeti: GIS kao obvezni i Analize u GIS-u kao izborni na studiju Znanosti o okolišu. Takvo naglo povećanje broja predmeta vezanih uz GIS rezultiralo je i povećanjem broja i udjela diplomskih radova studenata u kojima je tema GIS ili njegova primjena.

this topic, though the project was not completed due to the lack of funds. However, the knowledge and skills acquired as part of this cooperation greatly contributed to designing the concept of future courses (in particular Geoinformatics, Analysis in GIS and Visualisation of spatial data in GIS) and facilitated teaching both in the new GIS study programme and in general within the undergraduate and other graduate study programmes.

The organisation of new study programmes at the Department of Geography (2005), in particular the undergraduate and graduate research study programmes in geography, marked the beginning of the period of intensive development of both teaching (GIS courses in graduate research geography) and later the research and application components of GIS. This is confirmed by a number of new GIS-related courses in the undergraduate study programme (Geoinformatics, a two-semester subject), undergraduate study of Environmental Sciences (joint study programme of the Departments of Biology, Geography and Geology of the Faculty of Science, a one-semester subject on the Fundamentals of GIS Cartography) and graduate research study of geography (GIS Analyses, Visualisation of Spatial Data in GIS, Digital Terrain Analysis, GIS Analysis of Cultural Landscape, GIS in Census Data Analysis, Remote Sensing, Computer Statistic Analyses, Property Cadastre, Use of Computers in Teaching Geography). Additionally, new subjects were introduced: GIS as a compulsory course, and GIS Analyses as an elective course as part of the Environmental Sciences study programme. Such a sudden increase in the number of GIS-related subjects resulted in



Sl. 4: Broj diplomskih radova studenata Geografskog odsjeka 1990. - 2017. u kojima je primijenjen GIS (jedna ili više metoda prostorne analize)

Fig. 4: Number of Master's theses with applied GIS methods at the Department of Geography in the period from 1990 to 2017 (including one or more spatial analysis methods)

Ukoliko kao pokazatelj razvoja GIS-a u nastavnoj komponenti Odsjeka koristimo broj predmeta i diplomskih radova vezanih uz GIS možemo reći da je bolonjskim procesom kreiranjem novog GIS smjera i uvođenjem GIS-a na preddiplomske i druge studije ostvarena svojevrsna ekspanzije GIS-a na Geografskom odsjeku PMF-a u nastavi, a to je bilo popraćeno i naglim povećanjem interesa studenata za primjenom GIS-a i u svojim završnim (diplomskim) radovima (sl. 4).

U prethodnom razdoblju, prije jačanja nastavne komponente GIS-a stupanj interesa studenata za GIS i njegovu primjenu u okviru diplomskih radova bio dosta nizak, iako su studenti tijekom nastave iz Kartografije bili u osnovnim crtama upoznati sa osnovnim obilježjima GIS-a.

Napredovanjem iz suradničkih u znanstveno-nastavna zvanja mlađih kolega otvorena je mogućnost, u okviru novoakreditiranih studijskih programa (2016.), uvođenja GIS-a i na nastavničke smjerove te uvođenja novih predmeta povezanih s primjenom GIS-a na sve diplomske smjerove na Odsjeku ili uključivanja GIS sadržaja u već postojeće predmete.

Ukoliko se pogledaju nastavni planovi i programi Geografskog odsjeka razvidno je da oni predstavljaju svojevrsni odraz teorijskih postavki vezanih uz GIS tehnologiju i dvojnost njezine primjene u obrazovanju: učenje GIS-a (teaching about) i učenje pomoću GIS-a (teaching with) (Sui, 1995) – koncept koji možemo primijeniti i na ostale informacijske tehnologije u kojima se pedagoški fokus može usmjeriti prema unutra (učenje same tehnologije) i izvan (učenje uz pomoć tehnologije) (Tate, 2012) (sl. 5).

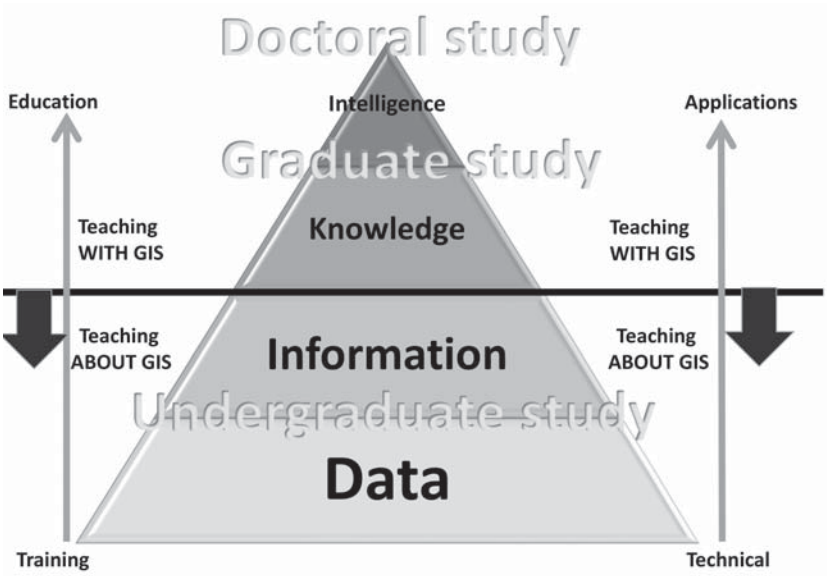
an increased number and a higher ratio of Master's theses focusing on GIS or its implementation.

If we use the number of GIS-related courses and the number of Master's theses as indicators of GIS development in teaching, it can be seen that the GIS courses created by the Bologna process and the introduction of GIS into undergraduate and other study programmes resulted in an expansion of GIS teaching at the Department of Geography, which was accompanied by a sudden increase of student interest in using GIS in their final (Master's) theses (Fig. 4).

In the previous period, prior to strengthening the GIS teaching component, student interest in GIS and its application within the scope of Master's theses was low, although students were acquainted with the basic features of GIS through their classes in Cartography.

With the promotion of young colleagues from researcher positions to scientific and teaching positions, the possibility arose of introducing GIS to study programmes within the scope of newly accredited study programmes (2016), introducing new GIS-related subjects to all graduate study programmes at the department, and including GIS-related content into existing courses.

Teaching plans and programmes of the Department of Geography are evidently a reflection of the theoretical hypotheses related to GIS technology and duality of its use in education: teaching about GIS and teaching with GIS (Sui, 1995) – as a concept that can be applied to other information technologies in which the teaching focus is directed inwards (teaching about technology) or outwards (teaching with the aid of technology) (Tate, 2012) (Fig. 5).



Sl. 5: Učenje GIS-a i učenje pomoću GIS-a (prema Sui, 1995, dopunjeno)

Fig. 5: Teaching about GIS and teaching with GIS (according to Sui, 1995, modified)

Štoviše, neki autori naglašavaju da svojevrsna konvergencija GIS-a i srodnih tehnologija odnosno koncept poznat u računalnoj znanosti kao „ubicomp“ (Ubiquitous computing) – kompjutorizacija uvijek i svugdje – može dovesti do pojave tehnološke nesvjesnosti u društvu (Thrift, 2004). Kombinacija Mooreovog zakona, pojava neogeografije nadopunjena pojavom novih teorija i praksa učenja pomoću tehnologija zasigurno otvara Pandorinu kutiju u smislu GIS&T obrazovanja (Tate, 2012). No, u pogledu razvoja GIS-a na Geografskom odsjeku, a u skladu s navedenim postavkama, jačanjem novih tehnologija u obrazovanju zasigurno će se spuštati „granica“ između učenja GIS-a kao tehnologije i učenja pomoću GIS-a prema nižim godinama na studiju (sl. 5). To možemo već vidjeti u novim studijskim programima na Geografskom odsjeku u kojima je geoinformatika pomaknuta s treće na drugu godinu studija, no to nije još popraćeno odgovarajućim „spuštanjem“ bilo predmeta koji su tematski vezani uz primjenu GIS-a, bilo sadržaja koji se usvajaju uz pomoć GIS-a u postojećim temeljnim predmetima.

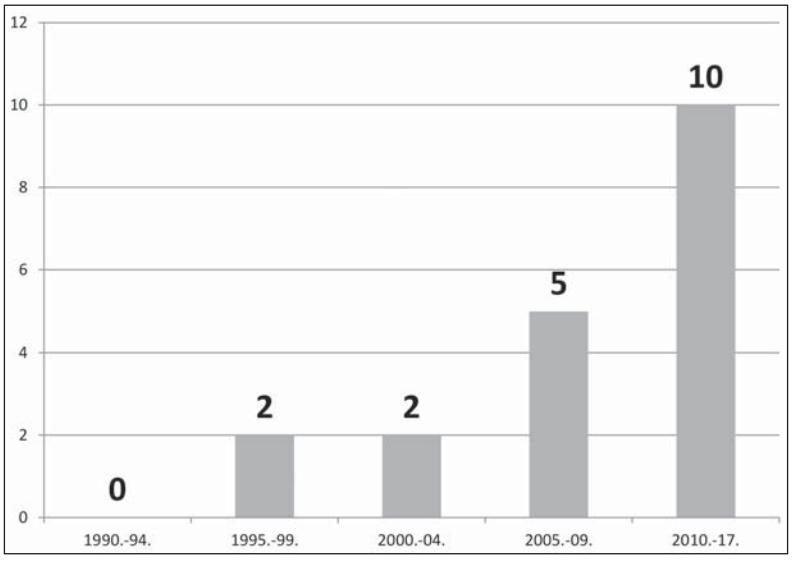
Furthermore, certain authors have emphasised that the convergence of GIS and related technologies, i.e. a concept known in the computer science as “ubicomp” (Ubiquitous computing) – computing anytime and everywhere – may lead to technological unawareness in society (Thrift, 2004). The combination of Moore’s law, the emergence of neogeography supplemented with new learning theories and technology-aided practices certainly opens a Pandora’s box in terms of GIS&T education (Tate, 2012). However, as far as the development of GIS at the Department of Geography is concerned, the “gap” between teaching about GIS and teaching with GIS will certainly be bridged by introducing the latter to the first years of study, in line with these postulates and thanks to the strengthening of new teaching technologies (Fig. 5). This can be seen in the new study programmes at the department, i.e. Geoinformatics has been transferred from the third to the second year of study. Nevertheless, this has not been accompanied with the transfer of GIS-related courses or content in other courses taught with the aid of GIS to lower years of study.

ZNANSTVENA KOMPONENTA

U analizi znanstvene komponente razvoja GIS-a pokušat će se utvrditi u kojoj se mjeri GIS primjenjuje u geografskim istraživanjima. Kao temeljni pokazatelj bit će upotrijebljen broj doktorskih radova koji su obranjeni na doktorskom studiju geografije na Geografskom odsjeku PMF-a i broj znanstvenih radova djelatnika Geografskog odsjeka u kojima je GIS utkan u metodološki dio rada (dakle, kao jedna ili skup više metoda prostorne analize, a ne samo kartografska vizualizacija) (sl. 6).

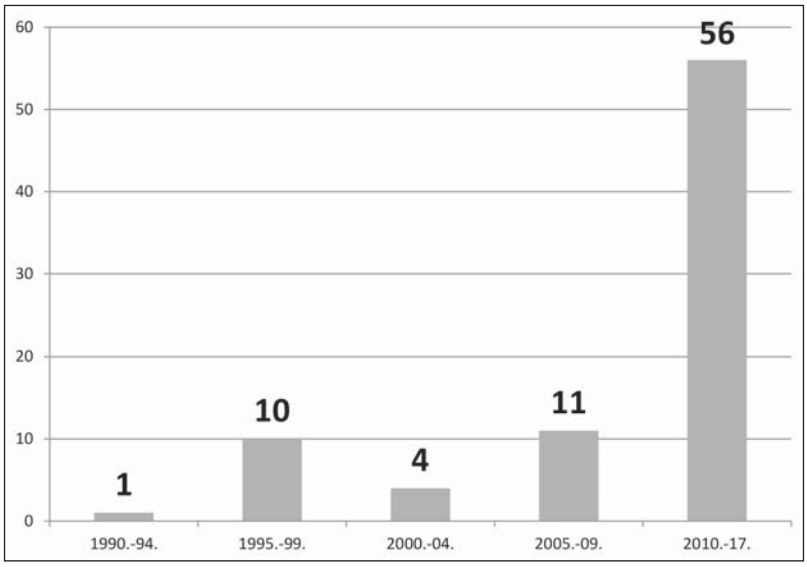
SCIENTIFIC COMPONENT

The analysis of the scientific component of GIS development aims to establish the extent to which GIS is used in geographic research. The number of doctoral theses in geography at the Department of Geography, Faculty of Science, and the number of research papers by department staff with GIS embedded in the methodology of the paper (i.e. as a method or a group of spatial analysis methods, and not just as map visualisation) were used as the basic indicators (Fig. 6).



Sl. 6: Broj doktorskih radova na Geografskom odsjeku u kojima je primijenjen GIS (jedna ili više metoda prostorne analize)

Fig. 6: Number of PhD thesis at Department of Geography with applied GIS methods (one or more spatial analysis methods)



Sl. 7: Broj znanstvenih radova djelatnika Geografskog odsjeka u kojima je primjenjen GIS (metoda prostorne analize)
Fig. 7: Number of scientific papers of the teaching staff at the Department of Geography with applied GIS methods

Razvidno je da je broj doktorskih radova u kojima je primijenjen GIS u samo sedam zadnjih godina (2010-17.) više nego dvostruko veći od broja radova u dvadesetogodišnjem razdoblju koje mu je prethodilo (1990.-2010.). Zanimljivo da u zadnjem razdoblju (2010-17.) gotovo da nema doktorskog rada u kojem nije GIS iskorišten u pogledu vizualizacije prostornih pojava i procesa. Očito da je uvođenje GIS-a u nastavi na Geografskom odsjeku imalo itekako odraza na znanstveno-istraživački rad koji je kanaliziran kroz poslijediplomski doktorski studij.

Sljedeća komponenta GIS-a na Geografskom odsjeku vidljiva je iz znanstvene produkcije u obliku znanstvenih radova u časopisima (sl. 7).

Također je vidljiva izrazita podudarnost između uvođenja samog GIS smjera na diplomskom studiju geografije te uvođenja većeg broja predmeta vezanih uz GIS i znanstvene produkcije djelatnika Geografskog odsjeka. Očito da je angažman djelatnika u nastavi povezanoj s GIS-om motivacijski djelovao i na znanstvenu produkciju djelatnika Geografskog odsjeka. Broj radova u zadnjem sedmogodišnjem promatranom razdoblju veći je gotovo četiri puta od broja radova u kojima je GIS primijenjen u dvadesetogodišnjem razdoblju koje mu prethodi.

Analizom temeljnih pokazatelja vezanih uz razvoj nastavne i znanstvene komponente GIS-a na Geografskom odsjeku PMF-a potvrđene su prve dvije hipoteze. Naime, ograničeno individualno korištenje GIS-a djelatnika Geografskog odsjeka bez opsežnije implementacije GIS-a u nastavnim programima na Odsjeku nije značajnije utjecalo na znanstvenu produkciju djelatnika i doktoranada. Pojavilo se tek nekoliko doktorskih radova i na njima utemeljenih

It is clear that the number of PhD theses with applied GIS methods has more than doubled over the last seven years (2010-2017) in comparison with the preceding 20-year period (1990-2010). It is interesting to note that there was almost not a single PhD thesis in this last period (2010-2017) that did not use GIS to visualise spatial phenomena and processes. It is obvious that the introduction of GIS into teaching at the Department of Geography greatly affected the scientific research work channelled through postgraduate doctoral studies.

The next GIS component at the Department of Geography is visible from the scientific production, i.e. scientific papers in various journals (Fig. 7).

A strong correlation between the introduction of GIS into graduate studies of geography and an increasing number of GIS-related courses and scientific production of the teaching staff at the Department of Geography is also visible. The engagement of the teaching staff in GIS-related courses has also motivated scientific production. The number of papers in the last observed seven-year period was almost four-fold compared to the number of papers applying GIS methods in the preceding 20-year period.

The analysis of basic indicators related to the development of GIS teaching and scientific components at the Department of Geography, Faculty of Science, has confirmed the first two hypotheses. The limited individual use of GIS by the department staff, without any comprehensive implementation of GIS in the department teaching programmes, had no significant impact on the scientific production of either the staff or PhD candidates. Only a few PhD theses and the ensuing scientific papers were published contain-

znanstvenih radova u kojima su primijenjene GIS metode analize i to poglavito prometne i riječne mreže te urbanog sistema. Analiza broja doktorskih radova i znanstvenih radova djelatnika Geografskog odsjeka u kojima je primijenjen GIS potvrdila je drugu hipotezu ovog rada da su novi diplomski programi, a posebno, u okviru njih, GIS smjer utjecali na izrazito povećanje znanstvene produkcije vezane uz GIS. Analizom nastavnih planova i programa na Geografskom odsjeku potvrđena je i treća hipoteza o dvojnosti GIS-a u geografskom obrazovanju s tim da učenje GIS-a kao tehnologije prevladava na preddiplomskom studiju, a na diplomskim studijima sve više jača koncepcija učenja pomoću GIS-a. Pored toga, popis tema diplomskih radova pokazuje da u razdoblju novih diplomskih studija dolazi do povećanja udjela istraživački i problemski orijentiranih tema. Očito su proširene GIS kompetencije studenata Geografskog odsjeka omogućile značajniju primjenu GIS-a u geografskom znanstveno-istraživačkom i stručnom radu.

Za četvrtu hipotezu možemo reći da je potvrđena, no jačanje aplikativne komponente geografskih istraživanja koje započeto u znanstvenim projektima MZOŠ-a u razdoblju (2007. -2011.) nastavilo se kroz realizirane znanstvene projekte (GIS atlas ruralnih područja Hrvatske kao dio nedavno završenog projekta financiranog sredstvima Hrvatske zaklade za znanost), projekte edukacijske naravi (educiranje nastavnika iz GIS-a, stvaranje novih kurikuluma GIS-a za gimnazije i srednje strukovne škole) i druge stručne projekte koji se provode ili su završeni (pretežito za potrebe lokalne zajednice).

ZAKLJUČAK

Prateći sam rad studenata na određenim predmetima povezanim s GIS-om i na temelju rijetkih diskusija sa studentima na diplomskim studijima te u raspravama s nastavnicima na studijskim programima Odsjeka može se zaključiti da je daljnji razvoj GIS-a na Geografskom odsjeku potrebno usmjeriti prvenstveno na razvoj prostornog mišljenja: naime pokazalo se kroz nastavnu praksu da je studentima najlakše ovladati tehnologijom, ali je daleko teže objediniti geografska znanja, usvojiti određeni prostorni način mišljenja i primijeniti ga u identifikaciji i rješavanju prostornih problema. Razvoj prostornog mišljenja uz pomoć GIS tehnologije zasigurno će pridonijeti jasnijem profiliranju identiteta geografije i pridonijeti njezinoj aplikativnosti. Pored toga, potrebno je unaprijediti ulogu GIS-a u geografskom poučavanju. Kvalitativnim pregledom radova studenata i djelatnika Geografskog odsjeka može se utvrditi da je primjena GIS-a ne samo povećala mogućnosti već i dosege znanstveno-istraživačkog rada na Geografskom odsjeku.

Pored toga, daljnji razvoj GIS kompetencija studenata geografije trebalo bi usmjeriti prema poboljšanju

ing applied GIS methods of analysis, mainly from the field of road and inland waterway network and urban systems. The analysis of the number of PhD theses and scientific papers of the department staff, where GIS was applied, has confirmed the second hypothesis of this work, i.e. that new graduate programmes, and in particular GIS related courses, have influenced a marked increase in GIS-related scientific production. The analysis of teaching plans and programmes at the Department of Geography has confirmed the third hypothesis on the dual nature of GIS in geography teaching, whereas teaching of GIS is predominant in undergraduate studies and teaching with GIS in graduate studies. Furthermore, the list of topics of Master's theses shows an increase in the ratio of research and problem-oriented topics in the period of new graduate studies. The obviously strengthened GIS-competencies of students at the Department of Geography have enabled more significant use of GIS in geographic science research and expert work.

We can say that the fourth hypothesis has been also confirmed. However, the application component of geographic research started in research projects of the Ministry of Science, Education and Sports in the period 2007 to 2011. This then continued through science projects (GIS atlas or rural areas of Croatia as part of a recently finished project financed by the Croatian Science Foundation), educational projects (GIS training of teachers, creation of new GIS curricula for secondary preparatory and vocational schools) and other expert projects that are either underway of have been completed (mainly for the needs of local communities).

CONCLUSIONS

By following the work of students in some GIS-related courses and on the basis of rare discussions with graduate students and teaching staff at the Department of Geography, it can be concluded that the further development of GIS at the department should primarily focus on the development of spatial thinking. The teaching practice has shown that students find it easiest to master technology, but that it is far more difficult to compile knowledge, adopt a certain way of spatial thinking and apply it to identifying and solving spatial problems. The development of spatial thinking with GIS technology will certainly contribute to a clearer profiling of identity of geography and its application. Additionally, the role of GIS in geography teaching should be upgraded. A qualitative review of papers published by the students and staff of the department confirms that the use of GIS has not only increased the capabilities, but also the scientific research achievements at the Department of Geography.

Additionally, the further development of GIS competencies of geography students should be directed towards the

matematičko-informatičkih temelja (matematika, programiranje) i proširenju kompetencija vezanih uz sinergiju GIS-a i drugih informacijsko-komunikacijskih tehnologija. Uspostava novog samostalnog GIS studija otvorila bi ne samo nove opcije u primjeni i unapređenju GIS metoda u geografskom znanstveno-istraživačkom radu, već bi otvorila nove mogućnosti uvođenja novih predmeta, prvenstveno povezanih s WebGIS tehnologijom, koji bi značajno nadopunili kompetencije naših studenata i poboljšali njihovo pozicioniranje na tržištu rada. Međutim, trenutni materijalni i prostorni resursi te ljudski potencijali Geografskog odsjeka predstavljaju značajno ograničenje uvođenju zasebnog GIS studija.

improvement of mathematical and information foundations (mathematics, programming) and the expansion of competencies related to the synergy between GIS and other information-communication technologies. The establishment of a new independent GIS study programme would open not only new options in the implementation and improvement of GIS methods in geographic research, but also new possibilities in the introduction of new courses, primarily related to WebGIS technology, which would significantly broaden student competencies and improve their position on the labour market. However, the current material, spatial and human resources of the Department of Geography pose significant limitations to the introduction of separate GIS studies.

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