

# COLLABORATIVE AND INDIVIDUAL APPROACH IN THE FLIPPED LEARNING BY ASSESSING STUDENTS ON THE BASIS OF SPATIAL DATA QUALITY CONTROL

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## Abstract

A variant of flipped learning based on intensive usage of geomedial in geography and geoinformatics has been developed and presented in the article. Students assessed quality of mapping according to ISO standard. The results show that individuals are considerably better than groups, especially in tasks which required the use of critical judgement, deeper understanding and creative thinking. However, groups are more successful in finding unique differences, where synergy effect of the collaborative learning is an important factor.

**Key words:** flipped learning, individual and collaborative learning, Bloom's taxonomy, geomedial, didactics of geography, grading, spatial data quality

## SODELOVALNI IN INDIVIDUALNI PRISTOP PRI OBRNJENEM UČENJU Z OCENJEVANJEM ŠTUDENTOV NA PODLAGI KONTROLE PROSTORSKIH PODATKOV

### Izvleček

V članku je predstavljena inovativna različica pristopa obrnjenega učenja, ki temelji na intenzivni uporabi geomedijev pri poučevanju geografije in geoinformatike. Študentje ocenjujejo kakovost kartiranja na podlagi ISO standarda. Rezultati kažejo, da so posamezniki bistveno boljši v primerjavi s skupinami pri tistih nalogah, ki zahtevajo kritično presojo, poglobljeno razumevanje snovi in kreativno razmišljanje. Skupine so uspešnejše pri ugotavljanju unikatnih razlik, kjer prihaja do izraza sinergijski efekt kot posledica sodelovalnega učenja.

**Ključne besede:** obrnjeno učenje, individualno in sodelovalno učenje, Bloomova taksomija, geomediji, didaktika geografije, ocenjevanje, kakovost prostorskih podatkov

## I INTRODUCTION

The objective of this paper is to introduce and test the flipped learning approach based on intensive usage of geomeia in geography and geoinformatics teaching. We propose an experimental design of measuring and assessing the ‘derivative ground truth’ of the field campaigns with an aid of grading criteria and grading reference based on the outcome of combined individual and collaborative work. Experimental design enables deciphering the differences in the outcomes of individual and collaborative learning, where the collaborative learning is additionally aided with the interactive just-in-time instructions. We also aim to establish an innovative technique, which links a variant of flipped learning approach with a process of quality assessment of geographical data and should be suitable for teaching and learning material of various complexities. We foremost assess the impact of collaborative learning and the usage of interactive geomeia tools in the flipped learning settings.

The motivation of the study is to propose a design composed of complex tasks presented to students in order to obtain a powerful combination of the expected results:

In didactics:

- testing contemporary didactic approaches in geography and geoinformatics: flipped learning, individual/collaborative learning;
- giving practical knowledge to students;
- enabling more reliable grading of students’ knowledge.

In geoinformatics (for research purposes):

- testing international standard ISO/TC 211 19157:2013 geographic information – data quality standard (shortly: ISO 19157);
- testing the quality of mapping.

The study is focused on the goals important in didactics, but the context of geoinformatics will also be described.

### I.1 Flipped learning and collaborative work

The emergence and integration of digital technologies in the educational process, coupled with advances in data storage, media presentation and permanent, ubiquitous connectivity, have laid down the foundations for the appearance and establishment of new techniques, concepts and approaches in didactics. The traditional transmissive pedagogical approach is not appropriate nor sufficient in the utilization of information and communication technology (Tay et al., 2012). Consequently, new approaches, such as flipped learning and online learning, were developed to address progressive changes in society and the emergence of new technology in everyday life.

Flipped learning has turned the traditional information transfer model (usually transmissive pedagogical approach) literally upside-down (Mazur, 2009). Flipped learning has switched or flipped the concept of student’s work, where work traditionally done in class becomes the work transacted prior to in-class sessions (work done at home). Direct instruction and lecture are delivered to the students’ prior lesson, usually via an online

learning environment (platform) in a form of videos or podcasts. Consequently, the teacher can engage students in higher levels of Bloom's or SOLO (Bigg's) taxonomy during class time, such as application, analysis, and synthesis (Anderson, Krathwohl, 2001; Bergmann, Overmyer, Willie, 2013; Kim, Park, Joo, 2014; O'Flaherty, Phillips, 2015).

Student engagement is one of the primary components of effective teaching and is crucial for successful learning (O'Flaherty, Phillips, 2015). Flipped learning is student-centred, where student engagement is crucial, and includes more active learning strategies in the classroom teaching, like presentations, group discussion or problem based learning (Krevs, 2007; Calvo Melero, Palanques, Krevs, 2008; Kim et al., 2014). The teachers' role in flipped learning paradigm has moved from knowledge delivery (transmission model) to facilitating knowledge (Inae, Sung, 2013). Students participating in flipped learning classes are acquiring and sharing knowledge through active cooperation – collaborative learning, often with the aid of online forums (Kim, Park, Joo, 2014; Westermann, 2014). Collaboration is not just a simple cooperation as it triggers the whole process of learning (Dooly, 2008), which results in better performance of 'collaborative learning' students than non-collaborative students, especially for more difficult tasks (Tullis, Benjamin, 2011).

Flipped learning has many prospective benefits, such as one-on-one time with students (rarely used in traditional transmissive pedagogical approach), missed lectures (students can obtain material after the lesson), possibility to use collaborative learning, self-paced learning (students can align learning pace with their learning style) coupled with just-in-time instruction (Tullis, Benjamin, 2011; Bergmann, Overmyer, Willie, 2013; Kim et al., 2014; Roach, 2014). Just-in-time instruction (students receive instructions in the moment of confusion) and increased interactivity are integral part of flipped learning and is usually executed during in-class sessions (Novak et al., 1999; O'Flaherty, Phillips, 2015).

The basic concept of flipped learning, assigning pre-class 'reading' to the students, is not new (Moffett, Mill, 2014). However, what is new is the medium and learning environment that flipped learning is using to convey the learning material. New education technologies often referred to as information and communications technology (ICT) are the cornerstone of the revitalised basic concept of the flipped learning (Moffett, Mill, 2014). As an example of ICT we can refer to the E-learning system at the Faculty of Arts which was introduced back in 2004. Its role became progressively more pivotal as the repository of course reading material, monitoring students' progress, pre-class reading and online discussions.

The emergence of ICT is important twofold:

- it can enhance student learning, and
- the current millennial generation (millennials), individuals born between 1982 and 2002, are expecting the usage of ICT (Prensky, 2001).

According to O'Flaherty and Phillips (2015), the millennial generation requires learning and other learning activities to be reactive and immediate, which could be easily achieved with the flipped learning approach.

Immediate response in delivering, gathering or transmitting information is possible due to the internet. In flipped learning, the internet plays a crucial role in the learning

process as the medium for accessing learning software, or as the medium for networking with other learners and/or teachers (Carnoy, 2004). Moreover, millennials are expecting ubiquitous and permanent connectivity through the internet (Strobl, 2014). Massive amount of information produced and consumed nowadays contain a geographical (location based) component, which is essential part of geomeia. According to Lindner-Fally et al. (2010), a geomeia is defined as ‘any form of media that incorporates or portrays geographical information.’ This includes, for example, news, multimedia, telecommunications, social networks, geo-tagged pictures and written descriptions of paths and places (Donert, Parkinson, Lindner-Fally, 2010; Strobl, 2014). If we use the internet, search for travel directions or go on vacation, we are dealing with geomeia to access geographical information (Lindner-Fally et al., 2010). The major issue of massive production of geographical data is the lack of geographical data quality control and the scarcity of procedures for quality assessment of geographical data.

## **1.2 Grading and assessment of students**

### **1.2.1 Bloom’s taxonomy**

The original Bloom’s taxonomy has defined six categories in the cognitive domain, which are part of the learning process (Krathwohl, 2002). The categories are ordered from simple to complex and from concrete to abstract: knowledge, comprehension, application, analysis, synthesis, and evaluation. Except the application category, all other five categories are divided into subcategories (Anderson, Krathwohl, 2001).

The results of the intended learning outcome (e.g., to understand and explain the usage and outcome of intersect geoprocessing tool) are usually constituted of the learning content and description of the cognitive process. The objectives usually consist of a noun phrase (e.g., intersection geoprocessing tool) and a verb (e.g., to understand and explain – the cognitive process) (Krathwohl, 2002). Bloom’s original taxonomy is labelled as uni-dimensional as each category embodies both a noun and verb aspect (Krathwohl, 2002). This issue was addressed with the new revised Bloom’s taxonomy suggested by Anderson and Krathwohl (2001), which incorporated important changes of the six categories and their subcategories. The major difference is the change in category names from noun to verb form to fit the way they are used in objectives. The revised taxonomy is constituted of the following six categories: Remember (previously Knowledge), Understand (Comprehension), Apply (Application), Analyse (Analysis), Evaluate (Evaluation) and Create (Synthesis). However, in the higher education, applying SOLO (Bigg’s) taxonomy would be more suitable, where it is, in many cases, easier to follow the progress of students, but our paper is focused to the Bloom’s one.

### **1.2.2 Assessment and grading**

Our research has integrated the whole scope of Bloom’s cognitive domain of taxonomy. According to Maclellan (2001), it is very important to assess the full range of

learning, and should not be limited to only a few aspects (e.g., understanding and applying). This is especially important in conjunction with the overall grading as the final grade represent only a fraction of a student's activity and is therefore important to cover the full aspect of the learning process (Marentič Požarnik, Peklaj, 2002; Norton, 2004).

Many authors (Brown, Bull, Pendlebury, 1997; Birenbaum et al., 2005) argue that the assessment plays a crucial role in student's process of learning. As such, assessment must address the needs of students required in the pervasive, interactive and connected global world (Birenbaum et al., 2005). Assessment ought to be supported also by the ICT (Norton, 2009) and should incorporate the grading system, reporting of the student's achievements (student progress) and provided feedback to students (Hernández, 2012).

In our flipped learning settings, a continuous assessment practices are used, which is a formative function of learning (assessment for learning) (Norton, 2009) in order to provide effective just-in-time instructions to students. We have additionally encouraged students to use the collaborative online document to share their opinions and understanding of the assessment criteria.

## 2 DATA QUALITY, PARTICIPANTS AND COURSE AIMS

### 2.1 Elements of data quality according to ISO standard

Standards help to make our everyday lives easier and better even if we are not aware of using them. They increase interoperability that particular products or parts of them can reliably work together. However, in some cases they can inhibit the development of our society. To apply standards to a real world and everyday life they need to be unambiguous and easy to implement (Scholz, Lu, 2014).

The data quality is one of the key elements that affect not only the relevance, but also the usefulness of spatial data (Devilleers, Jeansoulin, 2006). Each basic category, with the exception of the usability, is composed of two to four elements (Table 1).

*Table 1: Structure of the ISO 19157  
Preglednica 1: Sestava standarda ISO 19157*

Completeness	Logical consistency	Usability element	Positional accuracy	Thematic accuracy	Temporal quality
Commission; Omission	Conceptual consistency; domain consistency; format consistency; topological consistency	–	Absolute or external accuracy; relative or internal accuracy; gridded data positional accuracy	Classification correctness; non-quantitative attribute correctness; quantitative attribute accuracy	Accuracy of a time measurement; temporal consistency; temporal validity

*Source/Vir: ISO/FDIS, 2013*

Although the ISO 19157 is intended to use for users and producers of data, it is often proved in practice that the popularity of particular data, e.g., number of downloads, spatial extent, availability, reputation of the manufacturer, cost, etc., is the only suitable criterion of data quality for users (Boin, Hunter, 2009). Further on, the data quality is usually associated to the fitness for using these data for a specific purpose. Most of the basic measures used for defining data quality are usually aggregating geographical information quality to the map level, rarely on a feature level (Leibovici, Pourabdollah, Jackson, 2013).

## 2.2 Students' characteristics description

The testing was carried out by 76 participants (students) who attended two academic courses. In the first group, there were 72 undergraduate students of the second year from the Department of Geography at the Faculty of Arts, University of Ljubljana (FA). In the second group, there were four postgraduate students (4 individual students) of the Faculty of Information Studies in Novo mesto (FIS). The group of FA students was composed of 28 male and 44 female students. The age of students ranged between 20 and 32 with the average of 22.7 years. The group of FIS students was constituted of 2 female and 2 male students with the minimum age of 28 and maximum of 42 years and the average of 34.5 years.

The main reason for selecting such distinctive groups of students was to assess whether the participants studying the relevant studies have significant advantage over the participants with a non-relevant studies background. Relevant studies are those where students are introduced to the geographical space and are trained to develop spatial perception, e.g., Geography, Geomatics, Geology, Urbanism, Forestry, etc.

The FA students formed 12 groups (teams of four to six students) and 3 individual students, in total 15 units. We specifically allowed FA students to work on the assignment individually to obtain voluntarily formed individual and groups – a crucial step to eliminate possibilities to procure unmotivated students (Reeve, 2013). All students got similar instructions during the lab work and tutorials, adjusted to their backgrounds, by the same mentor. All students also got detailed and precise instructions and three digitised, but not georeferenced, high resolution maps in scale 1 : 4,000. Thus, the participants studied the combination of information from the field surveys with the visual interpretation of the maps. The criterion for the evaluation of the submissions was equal for all FA and FIS students.

Table 2 summarizes general differences between FA and FIS students and the course of research for respective groups. We need to clarify the term 'submission time during exam period': it indicates that students had to submit their assignment during exam period.

Table 2: General information about FIS and FA students and the course of research  
 Preglednica 2: Splošne informacije o FIS in FA študentih in poteku raziskave

	FIS students	FA students
Average age (year) / range (year) / $\sigma$ (year) / variance (year)	34.5/14/6.2/39	22.7/12/1.6/2.4
Student of relevant studies	NO	YES
Time for submission (days)	21	35
Submission time during exam period	YES	NO
Number of students per unit	1 (only individuals)	4–6 (+3 individuals)
Availability of attribute data	NO	YES
Exact field work location known	NO	YES
Option to geoprocess enclosed data	NO	YES

### 2.3 Background research information, course aims, objectives and learning outcomes

In April and May 2009, a field survey campaign for mapping *Robinia pseudoacacia* was conducted. All tracts containing any *R. pseudoacacia* were charted on a map and later also digitised. The expected positional accuracy of mapping was  $\pm 1$  m. The second field campaign took place in September 2010. Repetitive nature of measuring the same phenomena, the same area by the same team members with identical surveying equipment, has induced the expected lack of motivation of the surveyors. Consequently, spatial data of a lesser quality was produced, which has (intentionally) provided us with a good background to examine students' understanding and interpretation of ISO 19157 data quality standards. Students were given a map of a mapped area of *R. pseudoacacia* (Figure 1). We need to point out that students participating in our research were not conducting the initial survey campaigns.

The study area is located in the lowland Pomurje region in the NE part of Slovenia, about 2 km south of Murska Sobota and 700 m away from a motorway A5, bordering a small Murska Sobota Airport. The observed area is limited to the following extent: 16°10'3" E, 46°37'33" N and 16°10'47" E, 46°37'47" N, resulting area size of 0.4 km<sup>2</sup>. In the wooded areas, considerable tracts are overgrown with invasive species *Robinia pseudoacacia* (Repe, 2009; Somodi et al., 2012) (Figure 1).

We conducted our research as a part of a course module at the Faculty of Arts in Ljubljana and the Faculty of Information Studies in Novo mesto. Research related course aims, objectives and learning outcomes were:

Course aims:

- to give an introduction to ISO 19157 standard;
- to give a representation of the usage of ISO 19157 in the real world case, and
- to emphasize the shortcomings of the standard.

Objectives and learning outcomes. Students will be able to:

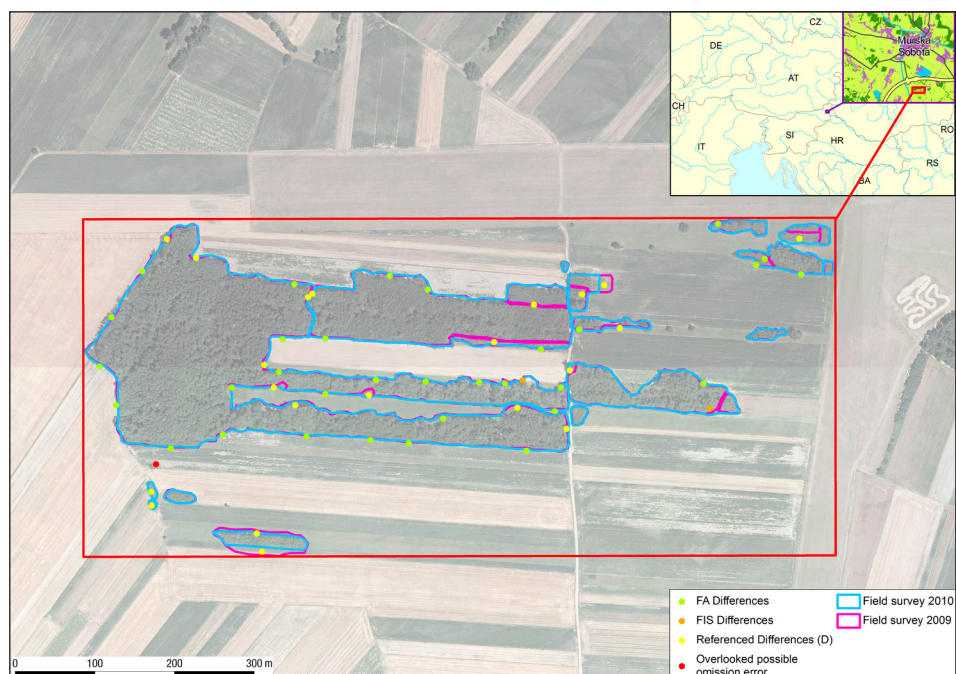
- categorise mapping errors based on ISO 19157;
- identify most common types of mapping errors;
- understand the importance of ISO 19157 for spotting and categorising mapping errors;

- use ISO 19157 to demonstrate common issues of the repetitive mapping;
- describe, explain and evaluate the source and cause of mapping errors.

The level of students' understanding and ability to apply their knowledge of ISO 19157 was assessed with an aid of six designated tasks.

Figure 1: Study area with digitised coverages: marked and referenced are differences between borders of areas of *R. pseudoacacia* in 2009 and 2010

Slika 1: Študijsko območje z digitaliziranimi slojema: označene so referenčne razlike med mejami območij *R. pseudoacacia* leta 2009 in 2010



Sources/Viri: Fieldwork survey digitised coverage 2009 and 2010; Orthophotos, DOP050, 2010 (The Surveying and Mapping Authority of the Republic of Slovenia); OpenStreetMap contributors, 2015

### 2.3.1 Designated tasks for students

The first task of students' assignment was to identify all errors presented on a given map (Figure 1) that could be depicted in accordance to ISO 19157. Using a Logical consistency category (Table 1) as an example, students should identify all conceptual, domain, format and topological consistency errors. More precisely, students should identify 'at least' 11 conceptual consistency errors (e.g., attribute table column names for both layers of *Robinia pseudoacacia* should have identical naming, column data type ...), 4 domain and 4 format



consistency errors. Phrase ‘at least’ indicates that authoritative grading reference number is only a representation of the ground truth. As Leibovici, Pourabdollah and Jackson (2013) are succinctly pointing out that not even authoritative data is without errors, a grading reference number should be treated as a relative measure and not absolute measure of the ground truth. To successfully complete Task 1, students had to use quantitative description and classification of identified errors. To obtain full marks on this task, students had to identify more than 21 errors out of 29 referenced ones. We need to remark that due to various reasons not all basic categories (Completeness, Logical consistency, Usability element, Positional accuracy, Thematic accuracy and Temporal quality) were included in the grading reference. The number of referenced errors (grading reference number) in Task 1 (referenced *E*) was obtained by identification of only the following selected basic elements of ISO 19157 (Table 1): Thematic accuracy and Logical consistency.

The usability category was excluded as students were not aware of the purpose of the data provided. Neither FA nor FIS students were able to sufficiently interpret the usability category as they were not aware of the purposefulness of the gathered data. Their interpretation would be based on speculation and wild guessing, thus the usability category was excluded from the grading reference. Positional accuracy was absent from our grading reference due to our previous practical experiences with students’ fixation on positional accuracy errors. Moreover, students were not given the information about the expected positional accuracy of mapping nor about the orthophotos’ – even though the students could obtain the latter information from The Surveying and Mapping Authority of the Republic of Slovenia website. Temporal quality category was excluded due to the lack of temporal data in the attribute data, and completeness category due to inclusion of this category in the grading reference of Task 6. To avoid unnecessary redundancy in data, we took Completeness category into consideration only for designated Task 6.

The FA students obtained additional geolocated data (spatial and attribute data) of the mapped *R. pseudoaccacia*, and not only plain non-georeferenced data in TIFF and PDF files as FIS students had. Therefore, FIS students could not fully complete Task 1, only FA students could. FIS students could only use Completeness and Positional accuracy category of ISO 19157 for interpretation and were therefore exempt from fully completing the Task 1.

The purpose of the second task (Task 2) was to evaluate students’ ability to answer an open-ended question while conforming to the structure of ISO 19157. Student task was to interpret one error identified in Task 1 according to ISO 19157. The interpretation of the error should be categorised using all basic categories (more information in Table 1). Grading reference number for this task was 6 points (1 point for each basic category), setting grading criteria of 6 points for full marks.

In Task 3 students had to describe all identified errors in Task 1 in conformance to the required form specified under section 8.5 of ISO 19157 (ISO/FDIS, 2013). The required form is composed of a list of components and includes in total 12 elements. Grading reference number for this task was 6 points, setting the limit at 5.5 points and above for full marks. In this task, students had to display ability to follow rigid structure of ISO standard and had to understand and use more in-depth classification of ISO 19157.

Students had to specify potential errors not included and defined in ISO 19157 and identify them on the map, if applicable. Task 4 required students to do the extra study on the selected case using strong analytical skills. Grading reference number for this task was at least 13, having grading criteria for full marks at 7 points and above. The reason for the very low grading criteria to obtain full marks lies in relatively high complexity of the task.

Task 5 was the most difficult task for students to accomplish. Students were required to use synthesis and evaluation in order to define, evaluate and explain the cause of errors. Deeper understanding of the problem was crucial to successfully complete this task. This task was the only task where grading reference number was left undefined. The reason for this decision was due to very high complexity of the task. Grading criteria to obtain full marks was set at 7 points.

Task 6 was the only task where only visual assessment could be used to successfully accomplish it. Students had to mark (with an aid of graphical or/and GIS program) identified differences (D) between polygons representing borders of *R. pseudoacacia* area between the years 2009 and 2010. Students obtained full marks for at least 22 identified differences. In grading reference number, 23 differences were included, marked and displayed in Figure 1.

Using Bloom's taxonomy (Anderson, Krathwohl, 2001) regarding obtained skills in the cognitive domain, students need to apply knowledge in Tasks 1, 5 and 6 (obtained skill knowledge), comprehend (comprehension) ISO 19157 in Task 2, apply their knowledge in Task 3 (application), classify in Task 4 (analysis), explain and define the cause of errors in Task 5 (synthesis and evaluation). Therefore, the six tasks were designed to encompass the whole scope of ISO 19157:

- tasks for which critical assessment is not needed (1, 2 and 6), and where only basic classification interpretation is required, and
- tasks for which critical assessment and deeper understanding of classification is crucial (Tasks 3, 4 and 5), coupled with the ability to make autonomous decisions on top of creative thinking.

With designated tasks we strove to set geomeia platform as a central environment of student's work and (in case of FA students) to furthermore incorporate collaborative work principles throughout research and during student assessment. Tasks 1, 4, 5 and 6 were specifically designed to consider collaborative work of students in the grading reference. As our main objective was to assess the impact of collaborative learning on the student performance, only the results of four tasks (Tasks 1, 4, 5 and 6) were included in our further research.

Student interpretation of datasets quality was twofold. Visual assessment of datasets quality was aided with geomeia tools (*ArcMap* with geoprocessing tools, map and metadata), while attribute inspection of datasets quality was executed in a form of *SQL* queries and (probably) visual comparison of both attribute tables. Visual and non-visual assessment of datasets in groups was the result of collaborative work (supported with just-in-time instructions).

## 2.4 Datasets considered as ground truth

The ‘ground truth’ data are referenced data used for quality control. The first set of referenced data are previously available reference datasets obtained as GIS coverages. The GNSS configuration was utilised with the support of digital orthophotos (Orthophoto, 2010) with resolution of 0.5 m and topographic base maps in scale 1 : 5,000 (Temeljni topografski ..., 2006) and 1 : 25,000 (Državna topografska ..., 1997). Obtained *R. pseudoacacia* areas were supplemented with the visual interpretation of the digital orthophotos taken during the flowering of the species in 2005 (Somodi et al., 2012).

The second set of referenced data considered as ground truth is authoritative reference of an experienced professional (teacher). We graded students’ work based on grading reference.

The third, innovative set of referenced data considered as ground truth are excellent authoritative grades to students from an experienced professional (teacher) who assessed their work. Grading reference numbers represent the ground truth since they are a derivation of all marked deviations of both datasets (polygons representing borders of *R. pseudoacacia* area from years 2009 and 2010) and signify divergence from the ground truth. Therefore low students’ score (low percentage) is an indicator of the poor student’s performance in perception and assessment of the ‘derived ground truth’.

## 3 METHODS FOR ASSESSMENT OF STUDENTS’ LEARNING PERFORMANCE

Instead of using transmission instruction model to delegate assignment to the students, we opted to use a flipped learning approach. The choice of this approach was possible due to heavily integrated information and communications technology (ICT) in the learning process. Strong integration of ICT is possible due to relatively low costs of software and hardware, thus the use of geomeia is accessible to the less destitute individuals (Long, Siemens, 2011). Research was conducted with a variant of flipped learning settings, with one major distinction from a classical flipped learning, i.e., the order of the execution of exercises. A typical flipped learning class incorporates active-learning exercises (e.g., small group discussions, case study, scenarios ...) during in-class time (Roach, 2014; O’Flaherty, Phillips, 2015), while we moved active-learning exercises onto web collaborative platform.

Our in-class group discussion and case study presentations were moved to online collaborative document (*Google Docs*) and/or messaging replies on students’ questions via message board to provide just-in-time instruction. Just-in-time instructions were delivered only for a specific time period. Face to face class time was used, with our role as mentor and facilitator, to clarify necessary concepts and usage of certain GIS tools. We additionally recorded a set of videos with comments for the given tasks. Moreover, formed teams were also encouraged to hold small group discussions (basically a brainstorming). Even though there was no direct control over group discussions (Roach, 2014), students could (and they had) received online guidance via collaborative document, or for more team specific questions, via message board.

The implementation of the experimental design is based on a concept – assessment procedure framework coupled with the introduction of the core terminology and description of the assessment procedures, i.e. methods that are important in this study: elements of data quality and tools for quality control used in the learning environment. We foremost assessed the impact of collaborative learning and the usage of interactive geomeia tools in the flipped learning settings. This is the most important, analytical part of this study. A framework of assessment procedures is presented in Table 3.

Table 3: A framework of assessment procedures  
Preglednica 3: Ogradje za postopke ocenjevanja

Assessment of students	
Synergy assessment concerning student's quality assessment results in order to test a collaborative learning	No association (individual learning)
	Group association (collaborative learning)
Grading reference system	
Quality assessment of the students' results with comparison and classification concerning students' learning performance	
Individual and cluster level analysis (relative measures)	Individual students level analyses
	FA versus FIS students comparison (each group or individual student is treated as a separate entity)
	Clusters of students level analyses
	FA versus FIS students (FA and FIS students are treated as two distinctive entities)
Students' results versus authoritative 'true ground' (absolute measure)	

### 3.1 Tools for quality control

We describe all used tools to ensure the quality control of obtained data and results:

- tools used by students (didactics purposes), and
- tools for student's learning performance assessment (didactics purposes).

#### 3.1.1 Tools used by students

Several tools/techniques to assess datasets quality and for quality control were available for the students. First, their adherence to ISO 19157 was the most important quality control of provided datasets. FA students had, for visual assessment tasks, the following geomeia tools at their disposal: possibility to zoom in/zoom out, to change colours and thickness of polygon borders, to use the geoprocessing tools and to exchange ideas, findings and even collaboratively share knowledge (via *Google Docs*). Individual students and groups also used *ArcGIS Map* package tool, however only groups could utilise

*ArcGIS Map* package to collaboratively share and distribute the whole work process among peers. Groups could use aforementioned tool to complete individually Tasks 1 and 6, and then, as a part of flipped learning process, perform peer review or small group discussions and (if applicable) brainstorming sessions. FA students also had several tools for non-visual tasks at their disposal: *SQL* joins, examination of metadata and even possibility to take another fieldwork survey.

### **3.1.2 Tools for student's learning performance assessment**

For student's quality assessment specific tools or methods were used to:

- analyse the quality of obtained data according to ISO 19157 (see Section 3.1.3),
- determine grading reference (see Section 3.1.4), and
- to evaluate synergy assessment and characteristics of students (see Section 3.1.5).

### **3.1.3 Analysing quality of obtained data according to ISO 19157**

Quality of field survey results in 2009 and 2010 versus ground truth – tasks 1 to 5: To determine grading reference (necessary to obtain ground truth for student's assessment), the following tools, techniques and standards were used:

- Task 1: predefined *SQL* queries (for attribute data) and *ArcGIS* geoprocessing tools (for geometry data);
- Task 4: a compiled list of 13 referenced errors (grading reference number) based on our previously related experiences and additionally cross-referenced with mainly Leibovici, Pourabdollah, Jackson (2013);
- Task 5: as a base reference Veregin (2005).

The quality of field survey results in 2009 versus in 2010 (relative quality) – task 6: Completeness category of ISO 19157 was accounted only in Task 6 (but not in Task 1). The reason for this was our request to design and incorporate only visual assessment of completeness component defined in ISO 19157, more specifically to identify commission and omission data quality elements. According to ISO 19157 (ISO/FDIS, 2013), an omission error (element of Completeness category) defines the absence of data from a dataset (e.g., tract of *R. pseudoacacia* area from the year 2010). Our data of the borders of *R. pseudoacacia* areas were visually assessed by students. Students could find potential or possible omitted tracks of *R. pseudoacacia* located in the orthophotos, which were overlooked during surveying campaigns. We differentiated between (possible) omission errors that students and experts found and between omission errors only students identified. The latter omission errors were labelled as overlooked possible omission errors.

### **3.1.4 Determination of grading reference**

Due to limited scope of the paper, we are going to analyse only the results obtained from Tasks 1 and 6, and descriptive statistics of grade results. As already mentioned, the

Task 1 was not fully feasible for FIS students. Tasks 4, 5 and (partially) 3 were more demanding tasks to accomplish. To mitigate the social facilitation effect (Anderson-Hanley et al., 2011), simpler tasks were more appropriate to assess the influence of cluster level (for FIS – combined work of all individuals; for FA – combined work of all individuals versus groups) on the overall score and to examine individual students ( $I_s$ ) versus groups ( $G$ ) performance (for more see section 4.2.1). Based on our assessment of all given tasks, the most appropriate tasks for evaluation were Tasks 2 and 6. We ruled out Task 2 as the main focus of our research was to assess the impact of collaborative learning on students' performance, which could not be deciphered from the results of Task 2. The reason for this was absolute measurement of grading criteria (it was not possible to score more than 100% against the grading reference – for more see section 4.1.2). Task 6 also had a slight advantage over Task 2, mostly due to the simplicity to depict results with the use of geomedial. Thus Task 6 was the only task in which only visual assessment (and coincidentally also only with geomedial) could be used to successfully complete it.

For Task 6 the students' assignment was to identify, based on visual assessment of a given map (Figure 1), and mark all positional differences of *R. pseudoacacia* borders from years 2009 and 2010. Due to visual assessment restrictions, certain non-visual methods were used (queries, algebra, metric and geometric) to select valid positional differences.

To be able to fully distinguish non-overlapping borders between two objects at map scale 1 : 4,000, an object size should have at least 1 mm of length/width and resulting area size of 4 m<sup>2</sup> (Goodsell, 1997). We do need to underline that despite clear instructions not to change map scale of the maps, students were able to change manually the zoom level in graphics software (e.g., *GIMP*, *IrfanView*, etc.) or zoom level/map scale in GIS software (*ArcGIS for Desktop* or *QGIS*).

Students' work for Tasks 1 and 6 was evaluated based on grading reference of specific set of variables used in these two tasks. Those variables were:

- Identified differences ( $D$ , shortly differences) – Task 6;
- contains only Completeness category;
- Identified errors ( $E$ , shortly errors) – Task 1 is composed of;
- Logical consistency errors, and
- Thematic accuracy errors.

The differences could be, according to ISO 19157, one of the following elements: Commission/Omission, Topological consistency, Absolute or External accuracy or Relative or Internal accuracy and also those accounted under Task 1. However, we separately examined Task 6 where visual assessment could exclusively be used to complete the task, from all other tasks.

Several identified differences ( $D$ ) were obtained by students with an aid of visual assessment of the provided map. The students' task (Task 6) was to compare visually any geometric differences between the borders of *R. pseudoacacia* area in the years 2009 and 2010, and to mark them onto the provided map. Methods to ascertain grading reference (23 referenced differences) are based on visual assessment.

### 3.1.5 Evaluation of synergy assessment and characteristics of students

The number of referenced errors (referenced  $E$ ) was directly derived from compliance to ISO 19157. Grading reference was obtained by identification of all errors introduced in the selected classified elements of ISO 19157 (Table 1). We selected only basic elements for our analyses: Thematic accuracy and Logical consistency due to various (already specified) reasons. Errors in Topological consistency, an element of Logical consistency category, were counted per number of different types of errors and not per occurrence (e.g., identified 10 slivers were counted as one error).

To describe contribution of each individual or group within the population of FA or FIS students (at least) the following measurements were available for use:

- counting the number of all contributions made by a specific individual or group;
- comparing the full number of contributions per individual or group with an average number of contributions;
- measuring man-hours of all contributions per individual or group;
- counting the number of unique contributions per individual or group.

To obtain the number of unique contributions, we need to identify unique differences ( $UD$ ) derived from Task 6 or unique errors ( $UE$ ) originated from Task 1. The variables unique differences ( $UD$ ) and unique errors ( $UE$ ) were derived from variables differences ( $D$ ) and errors ( $E$ ). The terms unique difference of FA ( $UD_{FA}$ ) and unique difference of FIS ( $UD_{FIS}$ ) are used to describe unequalled contributions of each individual/group within a population of FA and FIS students (Equations 1 and 2).

To obtain the number of unique contributions between the outcomes of each individual/group against the rest of the population the following equations were used:

$$UD_{FA} = a_1 \ominus a_2 \ominus a_3 \dots \ominus a_{15} \quad (1)$$

$$UD_{FIS} = b_1 \ominus b_2 \ominus b_3 \ominus b_4 \quad (2)$$

and

$$UD = UD_{FA} \ominus UD_{FIS} \quad (3)$$

where  $UD$  is unique identified differences ( $D$ ) between all individuals/groups FA ( $a_1 \dots a_{15}$ ) and FIS ( $b_1 \dots b_4$ ) individuals.

Unique differences were measured against FA ( $UD_{FA}$ ) and FIS ( $UD_{FIS}$ ) students separately, which means that one cannot simply do a summation of  $UD$  ( $UD_{FA} + UD_{FIS}$ ) of all units to obtain the total number of unique differences produced by the whole population (Equation 3).

The set of chosen variables used in the analyses was labelled as demographic/sociographic variables. The purpose of these variables was to delineate potential differences of students' performance based on different characteristics of students. These variables are:

- difference in years between the age of students (*AgeUnitRange*);
- simple arithmetic mean of the group age (*AverageUnitAge*);
- group gender (male, female and mixed), and
- individual student ( $I_s$ ) and a group ( $G$ ).

## 4 RESULTS

The results of this study answer to the objectives with considering assessment procedures methodology and methods in Section 3.

### 4.1 Assessment of students

#### 4.1.1 Synergy assessment

Synergy assessment concerning student's learning performance was used in order to test collaborative learning. We considered two types of association between students:

- no association – it indicates individual work/learning where an assignment is carried out by an individual student ( $I_s$ ), and
- group association – it signifies group (collaborative) work/learning where an assignment is performed by a group of students ( $G$  – composed of 4 to 6 students).

We distinguished individuals versus groups to examine unexplained difference between results of  $I_s$  and  $G$ , which could be a consequence of possible synergy effect indicated in the groups. Our research included 7 individual students ( $I_s$ ) and 12 groups ( $G$ ). The analyses performed on individual level considered each individual/group as a separate entity (e.g., a group or individual contributed 10 identified differences irrespective of the possible identical contributions of other groups/individuals). With the individual level type of analyses we could answer the following questions:

- average score on particular tasks for  $G$  or  $I_s$ ;
- minimum score of specific task obtained by  $G$  or  $I_s$ .

With a cluster level type of analyses we could get additional information not obtainable by individual level type of analyses:

- the number of (unique) features identified by individual students ( $I_s$ ) or/and by groups ( $G$ );
- the number of unique contributions made by individual students ( $I_s$ ) or/and by groups ( $G$ ).

Analyses performed on a cluster level treated  $I_s$  and  $G$  as separate entities while the upmost level of observation (whole observed population) as a single entity. The purpose of individual and cluster level analyses is to make a clear distinction between individual performance and group performance, and also in the case of cluster level analyses, to obtain information about (unique) contributions of the groups/individuals.



### **4.1.2 Grading reference system**

To measure, compare and evaluate student performance, an appropriate grading reference system was used. In this study, a grading criterion was also established to evaluate how close the students were to the ground truth. We need to point out (Leibovici, Pourabdollah, Jackson, 2013) that not even the authoritative data (acquired and processed by professionals) is without errors. Consequently, the grading reference numbers should be treated as a relative measure of the ground truth. In other words, grading reference number could be exceeded by students, e.g., a student could achieve more than 100% per specific task. The perceived authoritative ground truth was the reference for the relative grading criteria. We need to emphasise that grading criteria for tasks 1, 4, 5 and 6 are relative and not absolute measurement. Grading reference defined for all tasks had a referenced number which served as a measurement of students' successfulness.

Student's performance was evaluated using norm-referenced grading (Nilson, 2010), as the main purpose of grading was to assess how well the students comprehended and interpreted ISO 19157. The grading criteria varied between the tasks and were based on a couple of factors:

- on the level of task difficulty (Task 5 – to obtain at least positive grading mark (6) in this task, where deeper understanding was needed, only two defined (out of at least 7) and explained causes of errors were needed);
- the number of all elements to be identified or marked by students (larger grading reference number also resulted in higher thresholds of the grading marks for grade 6 and above);
- the rate between the shares of identified elements against the number of referenced elements (e.g., Task 1 had 29 grading reference points and Task 6 had 23 grading reference points. Task 1 was marked as failed (mark below 6) if less than 9 errors were found, while Task 6 had a criterion set for less than 6 identified differences.

All students' performance was evaluated in percentage. The gained percentage was calculated as a fraction of gained points divided by the grading reference number and multiplied by 100 (identified or marked elements against a grading reference), e.g., in Task 1 the grading reference number was 29 points. The average score of 76% at this task of the particular group/individual would mean that this group/individual achieved 22 points at Task 1.

It was necessary to use a more holistic approach in evaluation of the students' understanding of ISO 19157. The main purpose of such design was to ascertain suitability of a specific task for individual and/or group settings, based on the difficulty of the task. The other aim was to establish whether any type of association has advantage over the other, for tasks where only recognition (of patterns, symbols, shape, format, etc.) and learned facts are sufficient, and tasks where (deeper) understanding of learning material is needed to complete successfully the designated task. The last aim was to cover the full scope of Bloom's taxonomy, from using knowledge skills to analysis, synthesis and evaluation of divergences (in accordance to ISO 19157) from the ground truth.

The designed tasks were aimed to put students of relevant studies (geography, geology, geodesy...) at vantage over students of non-relevant studies. To exhibit successfully the understanding of ISO 19157, an integrated knowledge of physical geography, topography, geoinformatics, GIS (software and geoprocessing tools) on top of visual assessment and understanding of data quality was required. However, we need to point out that FA students were basically the beginners, only in their second semester of the second year of study. Despite this fact, we were expecting that FA students would have greater advantage over FIS students and consequently perform better than FIS students. Our expectation was based on the fact that students in their second year should have far better developed 'spatial way of thinking' (Kolvoord, Uttal, Meadow, 2011) than the average student of non-relevant studies.

We conducted only descriptive statistics to obtain necessary data for further analyses. The purpose of individual level analyses was to gather general characteristics of FA and FIS students' performance. The results are delineated into groups based on grade results and general characteristics. Additional information is displayed in Figure 2:

General characteristics:

- the average score of all tasks combined was 78% for FIS students (identified or marked elements against the grading reference), while FA students gained only 29%;
- FIS students scored on average more than 62% at each task, while FA students scored on average at least 17%;
- FIS students achieved on average 88% of the total possible score for two tasks, whereas FA achieved a maximum of 40%.

According to the above presented results, we need to emphasise that the maximum achieved score for FA students of 40% was less than the minimum achieved score (62%) for FIS students.

Best graded tasks:

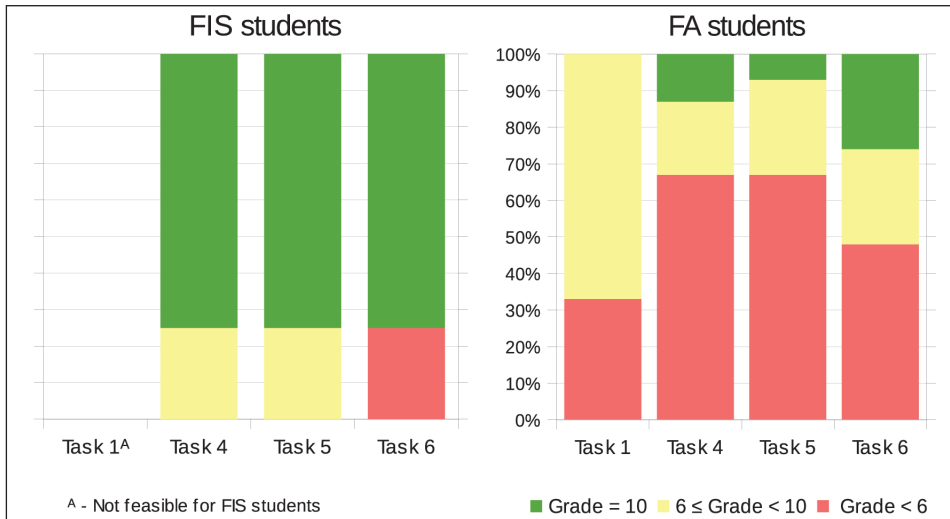
- FIS students: Tasks 4 and 5;
- FA students: Task 6.

Worst graded tasks:

- FIS students: Task 6;
- FA students: Tasks 4 and 5.

Despite the number of referenced differences (23), the FA students could, with appropriate use of geoprocessing tools, successfully identify all 451 differences. We need to emphasize that initially students had no prior knowledge about geoprocessing to use all necessary tools to efficiently complete a given task. However, students could, with the aid of Google docs, course lectures and practicals and recorded videos, gain enough knowledge to identify successfully all 451 differences.

Figure 2: Percentage of grading scores per task  
Slika 2: Rezultati ocenjevanja glede na delež po nalogah



## 4.2 Quality assessment of the students' results with comparison and classification concerning students' learning performance

### 4.2.1 Individual and cluster level analysis

The main objective of these analyses was to assess whether there is a statistically significant difference between the results of individuals and groups. With these analyses we obtained results necessary to carry out the next comparison (*Students' results versus authoritative 'true ground'*). Unfortunately, due to a small sample size (N=19), the diversity between FIS and FA students (see Section 2.2 and Table 2), we cannot make firm conclusions about statistically significant differences between individuals and groups.

#### 4.2.1.1 Individual students level analyses

This set of analyses is already included in the section 4.1.2 (Grading reference system) as it pertains only to grades.

#### 4.2.1.2 Clusters of students level analyses

To confirm possible synergy effect (the consequence of collaborative work) indicated in groups, we conducted three additional sets of analyses (relative measures).

#### 4.2.1.2.1 FA versus FIS students (FA and FIS students are treated as two distinctive entities)

In Task 6, FIS students identified on average 12.5  $D$  (differences), while FA students only 7.3  $D$ . With the use of an independent t-test we determined that there is a statistically significant difference ( $t(17) = 2.16, p = 0.046$ ) between FIS and FA for aforementioned variable  $D$ . To analyse possible synergy effect of the collaborative work, the most suitable task for further analyses was selected.

We scrutinised Task 6 and estimated that FIS students could on a cluster level identify altogether  $20 \pm 2$  differences ( $D$ ) ( $\approx 88\%$  of the referenced score – 23  $D$ ), whereas FA students  $9 \pm 1$  differences ( $D$ ). Our estimation was based on the achieved highest average score per task for FA (40%) and for FIS (88%) students.

Comparing results of Task 6 between both groups revealed the following findings:

- FIS students achieved the estimated result of 21 identified differences ( $D$ ) out of 23 referenced  $D$ ;
- FIS students also found 2 potential omission errors;
- FA students greatly exceeded our expectations with 55  $D$  on top of 8 omission errors.

Therefore, FA students observed 34 more  $D$  than FIS students, and additionally found six potential omission errors more than FIS students.

Our results are accentuating significant difference of variable  $D$  between FA and FIS students, which is in diametrical opposition to our previous ascertainment. To ascertain the source of this contradiction, a dichotomy of summed variable  $D$  is needed. Consequently a variable  $UD$  was used to do a throughout comparison, quality assessment and classification of observed differences.

Based on the outcome of Equations 1 and 2 (Section 3.1.5), the following results can be derived:

- on average a group of FA students identified 2.67 unique differences ( $UD_{FA}$ );
- a group of FIS students identified on average 1.25  $UD_{FIS}$ .

The presented results indicate the origin of enormous deviation between the observed and expected results of FA students. Significant deviation between the results could be contributed to the potential synergy effect of the collaborative work.

#### 4.2.1.2.2 All individuals (FA and FIS) versus all groups (FA) and FA individuals versus FA groups

The comparison of results of individuals versus groups versus whole population (relative measure) was crucial to uncover how many contributions were made by individuals, groups and how many by all of them combined. Our aim was to display the relationship between unique contributions (unique differences  $UD$  and unique errors  $UE$ ) of individuals versus unique contributions of groups versus unique contributions of the whole population.

The comparison between  $I_s$  (individual students) and  $G$  (group) is obvious and the logical choice to use for discovering any differences derived from different types of association. What needs to be assessed is whether there is any statistically significant difference between  $I_s$  and  $G$  for variables  $UD$ ,  $UE$  and/or  $D$ ,  $E$ . Nonetheless, we need to underline once again that, for any solid statistical analyses, we had a sample size too small ( $N = 19$ ) to make any firm conclusions about statistically significant differences.

Since variables differences ( $D$ ) and unique differences ( $UD$ ) were determined by students with an aid of simple visual assessment, we extended our study with further analyses of variables errors ( $E$ ) and unique errors ( $UE$ ). As there were more data collected for FA students (logical consistency error, thematic accuracy errors, errors ( $E$ ) and unique errors ( $UE$ )) than for FIS students, we excluded FIS students from analyses based on variable  $E$ . The outcome of descriptive statistics and independent t-test gave us the following results:

- even though there are differences between means of  $D$  for  $I_s$  (11) and  $G$  (7), they are not statistically significant ( $t(17)=1.85, p = 0.08$ );
- the independent t-test showed no statistically significant difference for the variable  $UD$  between  $I_s$  FA and FIS (FIS ( $0.5 \pm 0.35$ ), FA ( $0.67 \pm 0.38$ ),  $t(5) = -0.10, p = 0.92$ );
- there is a statistically significant difference ( $t(17) = 2.4, p = 0.03$ ) between  $I_s$  and  $G$  for the variable  $UD$ ;
- there is a statistically significant difference between  $I_s$  FA and  $G$  FA students for the variable  $UE$  ( $t(13) = 3.75, p = 0.00$ ) and  $UD$  ( $t(9.3) = 2.23, p = 0.05$ );
- although variables  $D$  and  $E$  are different between  $I_s$  FA and  $G$  FA students, they are not statistically significant ( $p = 0.53$  and  $0.11$  respectively).

The last set of analyses tried to confirm the notion that our previous findings can be extended from ‘visual’ orientated tasks to the ‘non-visual’ tasks as well.

Despite all analyses we have performed so far, we still cannot answer one simple question: how many contributions in total would be made by individual students ( $I_s$ ), how many by groups ( $G$ ) and how many by all of them combined. To answer this question we need to make four syntheses – the first synthesis for  $I_s$ ,  $G$  and variables  $D$  and  $UD$ ; the second synthesis for  $I_s$  (FA students only),  $G$  and additionally variables  $UE$ , thematic accuracy errors, logical consistency errors; the third synthesis per groups and individuals and variables  $D$  and  $UD$ , and the fourth synthesis per FA groups and individuals and variables  $D$ ,  $UD$ ,  $UE$ , thematic accuracy errors and logical consistency errors. These four syntheses are essential to distinguish the source of the main contributions (based on the type of association) for visual and non-visual tasks (Figure 3).

Figure 3: Overall contributed data by individuals and groups  
 Slika 3: Skupni prispevani podatki po posameznikih in skupinah

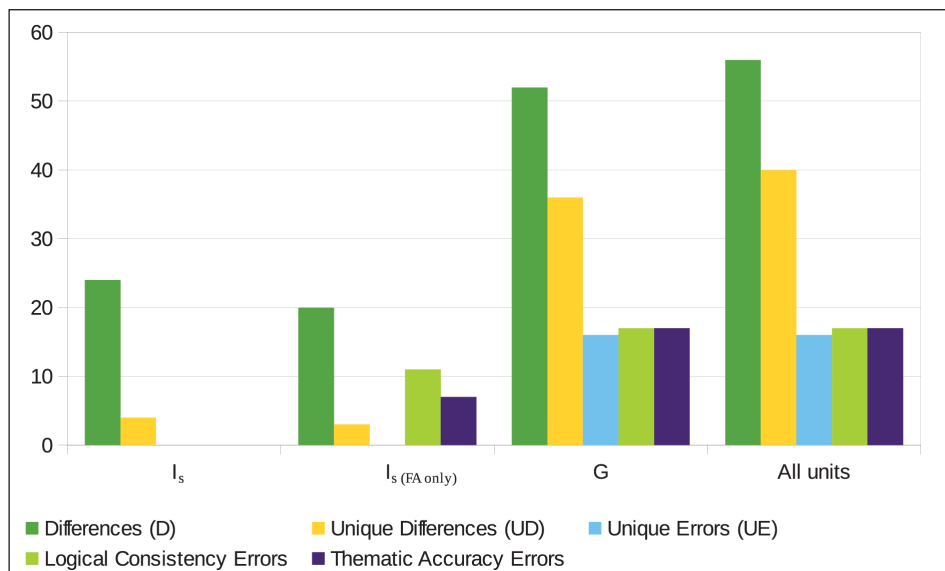


Figure 3 is clearly displaying a very large disproportion of variables *UD* and *UE* between groups (*G*) and individual students ( $I_s$ ). Individual students contributed in total only 4 unique differences and did not contribute identified unique errors at all. On the other hand, groups contributed 36 unique differences and 16 unique errors. In other words, *G* contributed in total 93% of all unique contributions, whereas  $I_s$  only 7%.

The purpose of this comparison was to confirm/reject our notion that unit type (groups or individuals) is, due to collaborative synergy effect, highly correlated to the students' performance and is the major cause of statistically significant differences between unique contributions (*UD* and *UE*) of individual students and groups. Variable unique difference is a novel approach of attempted measurement of synergy effect of the collaborative work for visual assessment tasks whereas variable unique errors for 'non-visual' tasks.

#### 4.2.2 Students' results versus authoritative 'true ground'

We conducted a comparison of students' results (performance) versus the authoritative and absolute measure ('true ground') to discover how close to the ground truth were the students. We took into account the whole population, using the results of Tasks 1 and 6. The grading reference was considered as the ground truth, however it was not considered as the absolute ground truth. Moreover, the students could identify more differences (*D* – Task 6) and errors (*E* – Task 1) than the grading reference number for a particular task was. We need to stress that not all deviations from the grading reference ground truth

were accepted as valid. All deviations were carefully examined and additionally tested for invalidity with the aid of geoprocessing tools.

FIS students did not exceeded more than 100% of the grading reference at the analysed task (Task 6). Furthermore, they did not identify any non-referenced element (commission or omission error). They reached 91% of the grading reference number (21 out of 23) overall.

Before we carry on, we need to emphasize that the measuring performance of a single FA group against the grading reference has in general displayed poor results of groups. However, the population of FA students was, in comparison to their FIS counterparts, much more successful in identifying differences/errors and identified in total:

- 34 errors (Task 1 had 29 referenced errors);
- 18 out of 29 referenced  $E$  (18 non-repetitive (unique) errors);
- 16 non-referenced identified errors (out of 34);
- 55 differences out of 23 referenced differences.

We also need to mention that FA students additionally found one possible omission error that we overlooked (overlooked possible omission error).

The most important finding is that FIS students (individuals) contributed not even one unique contribution as all unique contributions were made by FA groups. The findings were derived by using Equation 3.

Based on the presented results, we can assess with a comfortable certainty that there are significant differences in group means between both associations (FA versus FIS and individual students ( $I_s$ ) versus groups ( $G$ )). We can also ascertain that the main contributions were, on the level of the whole population, made by groups, which very well accentuates our notion of the synergy effect of the collaborative work.

## 5 DISCUSSION

### 5.1 Unique contributions as a novel approach

As all initial analyses and comparisons indicated better or even superior results for individual students ( $I_s$ ) against groups ( $G$ ), it was very hard to explain successfully the unexpected results of the overall identified differences (Task 6 – marking differences based on visual assessment). Our inability to explain successfully the difference urged us to approach the problem from a different perspective.

We decided to include a novel approach of indicating unique contributions to decipher the origin of this discrepancy. Our analyses indicate that there is no statistically significant difference for identified differences ( $D$ ) and identified errors ( $E$ ) (Tasks 1 and 6) between  $I_s$  and  $G$ . Nonetheless, there is a statistically significant difference for variables unique differences ( $UD$ ) and unique errors ( $UE$ ). Groups ( $G$ ) account for more unique errors and unique differences than individual students ( $I_s$ ), which encompasses our findings that groups excel in registration of marginal phenomena in comparison to individuals very well.

We need to point out that our initial research counted unique contributions (unique differences and unique errors) for FIS and FA students separately. Our findings urged us to measure unique errors (*UE*) and unique differences (*UD*) on the level of the whole population (FA and FIS students). Thus measuring unique contributions gave us even more pronounced differences between individuals ( $I_s$ ) and groups (*G*). The contribution made by individuals to the number of all identified differences was minuscule in comparison to the contribution of groups. Only 4 contributions out of 56 were made by individual students. Furthermore, individual students did not contribute a single identified error (*E*) as all identified errors (thematic accuracy errors and logical consistency errors) made by individuals were also identified by groups, while groups contributed 16 uniquely identified errors. At first glance it makes no sense to integrate individual students' work if the same task is carried out by groups as well. We will later explain this fact, for now we can claim that in the case of mixed  $I_s$  and *G* settings, the inclusion of individuals' contributions makes a perfectly valid stance and individual students should not be excluded during data integration process.

## 5.2 Usage of geomedia

According to Ainsworth and Loizou (2003), the usage of geomedia should establish a more efficient learning environment, however the level of efficiency is dependent on the type of task and student's learning style. We furthermore expected that FA students as millennial generation, for which the learning activities are expected to be interactive and immediate (O'Flaherty, Phillips, 2015), to have significant advantage in performance over FIS students.

Even though FA students were not trained in particular geoprocessing tools (Symmetrical difference, Explode multipart feature, Minimum bounding geometry, Feature vertices to points) necessary to identify all 451 spatial differences between the two layers of *Robinia pseudoacacia*, they were trained in other geoprocessing tools (Union, Intersection, etc.) and GIS software (*QGIS*, *ArcGIS for Desktop*). We expected that the knowledge of GIS tools, GIS software and training in understanding, visualising and dissecting geospatial processes will give them the distinct advantage over FIS students, especially as FA should have already developed 'spatial thinking' (Kolvoord, Uttal, Meadow, 2011; Sinton et al., 2013).

The usage of interactive geomedia tools has no direct influence on the improved perception and memorising of information and consequently on better student performance. We can conclude, on the basis of comparison between individuals of FA and FIS, that the usage of geomedia tools was only beneficial in the identification of less noticeable differences (*D*: Task 6 – finding differences based on visual assessment) but not on the overall performance. However, the obtained results underline the fact that students' collaborative work was the deciding factor in the better students' performance.

## 6 CONCLUSIONS

In the paper, flipped learning with geomedia was studied through practical tasks for students. The students practiced their abilities in collaborative and individual learning,



research work and holistic approach to the studied problem. The proposed concept was tested for two different groups of students at the Faculty of Arts of the University of Ljubljana and the Faculty of Information Studies in Novo mesto, both in Slovenia. For their study, the students used two datasets (vector coverages) of the same phenomenon, *Robinia pseudoacacia*, mapped in two successive years with the same team members and equipment. This was a special challenge for students who needed to assess the quality of the mapping according to ISO 19157 Geographic information – Data quality standard. On the other hand, the results of individuals and groups of students were a challenge for the researcher to propose a concept for assessing and grading their learning outcome. Nevertheless, the interactive just-in-time instructions were provided by the teacher through the flipped learning process.

Through several different comprehensive analyses using statistical and GIS software, the following significant findings need to be exposed:

(1) Better background in geography, better spatial perception (as students are trained in spatial thinking) and even additional option of usage geoprocessing tools has not proven to be an advantage for students' comprehension with the exemption of identifying some minor details. The students learned about the standards for spatial data quality through identification and classification of errors, and creative thinking to understand the nature of spatial data concerning reality.

(2) The individuals were on average considerably better than groups of students for all types of tasks, especially in tasks which required the use of critical judgment, deeper understanding of the problem and creative thinking. The groups were in general more successful, but still less than the individuals, with tasks that did not require the use of critical judgment. Concerning 'derived ground truth' based on grading, the individuals were practically not contributing to its definition. Here, the groups were considerably more successful. The groups were also much more successful in finding unique differences, where synergy effect of the collaborative work was an important factor. The analysis of demographic data showed no significant differences according to age, age range or gender, except for the type of association (individuals or groups), which proved to be the main reason for the difference in performance among students.

This study opens several questions in didactics (of geography), such as how to practically optimize deeper, but holistic knowledge and understanding of the studied content to improve learning outcomes. Since methods of teaching are much interdependent with learning strategies of the students, it is necessary to obtain valuable delivering learning material and information presentation, comprehensive feedback and assessment (grading) of knowledge. We plan to implement adapted framework proposed in this paper on the level of high and primary schools. The proposed framework is also suitable to use in game based learning, where students can learn specific subjects through experiments.

*(Translated by the authors)*

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## **SODELOVALNI IN INDIVIDUALNI PRISTOP PRI OBRNJENEM UČENJU Z OCENJEVANJEM ŠTUDENTOV NA PODLAGI KONTROLE PROSTORSKIH PODATKOV**

### **Povzetek**

Z vpeljavo digitalnih tehnologij v proces izobraževanja so se pojavile zahteve za vzpostavitev novih tehnik poučevanja, ki bi bolj izkoristile razpoložljivo tehnologijo kot ga izkorišča tradicionalni transmissijski pedagoški pristop. Ena izmed primernih razpoložljivih tehnik je pristop obrnjenega učenja, ki temelji na uporabi digitalnih (predvsem spletnih) tehnologij.

Osnovni namen prispevka je razviti in testirati inovativno varianto pristopa obrnjenega učenja, ki temelji na intenzivni uporabi geomedijev pri poučevanju geografije in geoinformatike. Predlagana varianta pristopa obrnjenega učenja se razlikuje od klasične v tem, da prenese aktivne oblike učenja (skupinske razprave, igra vlog itd.) iz učilnice v spletno sodelovalno računalniško okolje. Tako npr. poteka skupinska diskusija prek sodelovalnih dokumentov (*Google Docs*) namesto iz 'oči v oči'. Prednost tega načina pred klasičnim je v tem, da omogoča hiter pregled nad celotno vsebino diskusije in da se ohranja njena celotna zgodovina. Pristop obrnjenega učenja praviloma temelji na konceptu posredovanja znanja v okviru sodelovalnega dela, ki ga pogosto podpirajo tudi tehnika t. i. ravno ob pravem času navodil (ang. *just-in-time instructions*), skupinska diskusija, ipd. (Westermann, 2014).

Karta je eden pomembnih učnih pripomočkov pri poučevanju geografije. Z vpeljanjem digitalne in spletne tehnologije so se načini uporabe karte pri poučevanju geografije spremenili. Karta kot del geomedijev je pomemben učni pripomoček za prikaz, oblikovanje, obdelavo, izdelavo (kart ali novih prostorskih slojev) in celo nadzor nad kakovostjo prostorskih podatkov. Geomediji so kakršnakoli oblika medijev, ki vsebuje ali prikazuje prostorsko geografsko informacijo (običajno z informacijsko-komunikacijsko tehnologijo) in je glede na definicijo lahko celo vsakršna novica, ki je vezana na lokacijo na Zemlji (Donert, Parkinson, Lindner-Fally, 2010; Strobl, 2014).

V prispevku predlagamo eksperimentalno zasnovano meritev nominalne osnove in ocen teh meritev na podlagi kriterijev ocenjevanja in ocenjevalne lestvice. Ocenjevalna lestvica je osnovana na rezultatih, ki so produkt individualnega in sodelovalnega učenja. S predlagano eksperimentalno zasnovano je mogoče razbrati razlike v doprinosu posameznikov ter skupin. V študiji povežemo predlagano varianto pristopa obrnjenega učenja s procesom ugotavljanja in ocenjevanja kakovosti geografskih podatkov.

Pri izvedbi eksperimentalne zasnove se osredotočimo na zasnovano postopkov ocenjevanja študentov s posebnim poudarkom na vplivu sodelovalnega učenja in uporabi interaktivnih geomedijskih orodij v obrnjeni učilnici. Ogrodje za ocenjevanje tvorijo naslednji elementi:

- ocenjevanje študentov;
- ocenjevanje sinergijskih učinkov sodelovalnega učenja;
- vrednotenje študentovega dela na podlagi ocen;
- ocenjevanje kakovosti s pomočjo primerjave in klasifikacije kakovosti študentov;
- analize na nivoju posameznikov in skupin (relativne meritve);
- rezultati študentov v primerjavi s profesionalno ocenjeno nominalno osnovo (absolutna meritev).

Orodja, s pomočjo katerih se je ocenjevala kakovost izvornih podatkov na podlagi razlik med mejo *Robinia pseudoacacia*, kartirane leta 2009 in 2010, ter razlik med atributnimi podatki, so:

- orodja, ki so jih za nadzor in preverjanje uporabljali študentje;
- orodja za ocenjevanje kakovosti študentovega dela;
- analiziranje kakovosti pridobljenih podatkov na podlagi ISO 19157;
- vzpostavitev referenčnih kriterijev za ocenjevanje;
- vrednotenje sinergijskih učinkov in lastnosti študentov.

V raziskavi je bilo zajetih 76 študentov, in sicer 72 s Filozofske fakultete (FF) v Ljubljani in štirje s Fakultete za informacijske študije (FIŠ) v Novem mestu. Študentje FIŠ so delo opravljali individualno, študentje FF so poleg treh prostovoljnih posameznikov tvorili tudi 12 skupin (4–6 študentov). Študentje so bili ocenjeni na podlagi referenčnega kriterija, ki je temeljil na razumevanju *ISO/TC 211 19157:2013 Geographic information – Data quality standard* (ISO 19157) standarda in na oceni nominalne osnove. Slaba ocena študenta pomeni, da je študent pri ocenjevanju daleč od nominalne osnove.

Pri analizi rezultatov posameznikov in skupin smo ugotovili, da so bili posamezniki v povprečju mnogo uspešnejši kot skupine. To še posebej velja za naloge, pri katerih je bila nujna uporaba kritičnega in kreativnega razmišljanja. Starostna in spolna sestava nista imeli vpliva na uspešnost posameznikov ali skupin. Pri uspešnosti študentov se relevantnost študija, t. j. študija, kjer se študentje urijo v prepoznavanju in definiranju geografskega prostora, ni izkazala kot bistvena prednost. Z izjemo identificiranja manj opaznih razlik uporaba interaktivnih geometrijskih orodij ni imela bistvenega vpliva na stopnjo zaznavanja in prepoznavanja prostorskih razlik.

Pri zaznavanju razlik med individualnim delom in delom skupin smo razvili postopek ugotavljanja unikatnih razlik z namenom ločiti doprinose ene in druge skupine študentov. V ta postopek je zajeta sinteza podatkov na nivoju dveh skupin: študentov FF in FIŠ skupaj ter posamezniki in skupine. Pri sintezi podatkov smo dobili obrnjeno sliko, in sicer da so skupine doprinesle bistveno večji delež prispevkov (93 %) k opredelitvi nominalne osnove kot posamezniki. Glavni vzrok za te razlike pripisujemo sinergijskemu učinku, osrednjemu elementu sodelovalnega učenja.

Študija odpira številna vprašanja v didaktični geografiji, kot npr. kako praktično optimizirati podajanje holističnega znanja in razumevanje učne vsebine, z namenom zagotovitve kakovostnejšega končnega izdelka študentov. Ker so metode poučevanja tesno povezane z učnim stilom in učno strategijo študentov, je nujno potrebno vzpostaviti najbolj optimalno metodo prenosa in predstavitve učne snovi, ki hkrati zagotavlja tako povratno informacijo med akterji kot primeren sistem ocenjevanja. Opredeljeno ogrodje za ocenjevanje in inovativno varianto pristopa obrnjenega učenja bomo poizkusili vzpostaviti tudi v osnovnih in srednjih šolah.