

## **Constructive Alignment of an introductory university Geographic Information Systems course**

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**Key words:** Geographic Information Systems, GIS education, constructive alignment, SOLO taxonomy, curriculum objectives, teaching and learning activities, assessment, geomatics

### **SUMMARY**

John Biggs' concept of 'constructive alignment', as applied to an introductory Geographic Information Systems (GIS) course at the University of Cape Town is reported on. A brief explanation of the principles of constructive alignment is given, and the reason for its use in the intervention is discussed, together with a contextualization of GIS education in South Africa. Constructive alignment is a holistic framework, which assists in the design of the teaching/learning activities, curriculum objectives and assessment tasks. A constructive alignment model was developed for the GIS course and is described here. The preliminary findings of this action research are reported on. It was found to be a useful tool in GIS course design, and can be used on an ongoing basis to refine the total learning experience of students.

# **Constructive Alignment of an introductory university Geographic Information Systems course**

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## **1. INTRODUCTION**

This paper explains how John Biggs' concept of 'constructive alignment' has been used as the framework for the development and design of the total learning experience in an introductory Geographical Information Systems course ( hereafter referred to as "GIS 1") offered by the Geomatics Division in the School of Architecture, Planning and Geomatics at the University of Cape Town. The research focused on the question of how constructive alignment could be effectively applied to GIS 1, and serves as a good practice guide for higher education practitioners who teach GIS or are involved in GIS education. It presents some contemporary action research that is situated in a South African Geomatics undergraduate programme.

The methodology of action research is particularly useful in this type of research – action research in higher education can be defined as “collaborative, critical enquiry by the academics themselves (rather than expert educational researchers) into their own teaching practice, into problems of student learning and into curriculum problems. It is professional development through academic course development, group reflection, action, evaluation and improved practice” (Zuber-Skerritt, 1992: 1-2). This refinement of practice is a continuous, cyclic process, where action and research follow each other, and this paper reports on early learnings after two iterations of this process. Suggestions on how to improve future action are proposed.

## **2. THEORETICAL UNDERPINNINGS**

### **2.1 What is constructive alignment?**

Constructive alignment is a framework that can assist in developing the three main aspects of a course, namely curriculum objectives, the teaching and learning activities, and assessment. It is useful for “deriving curriculum objectives in terms of performances that represent a suitably high cognitive level, in deciding teaching/learning activities judged to elicit those performances, and to assess and summatively report student performance” (Biggs, 1996: 347).

It is a holistic approach that assists in setting up and maintaining a balanced learning system, through careful consideration of the critical components such as curriculum, teaching methods, assessment and the climate that is created in student-teacher interactions. This is of particular use to educators who are designing a course from scratch, or intend on making changes to an existing course.

Further details of constructive alignment can be found in Biggs' 1999 book “Teaching for

Quality Learning at University”, which explains the concept in depth, and provides many other references to aid good teaching. For a summary of the concept, see his 1999 paper entitled “What the Student Does: teaching for enhanced learning”.

## 2.2 Why constructive alignment?

The author started lecturing the GIS 1 course at the beginning of 2009. By that time, it had been in existence for approximately 15 years and was lectured by no less than 10 lecturers, with each lecturer making changes (large or small) to the course notes, method of delivery, practical components and assessments. The GIS 1 course was also the “dumping ground” for some content that was either shed from other courses due to excessive volume, or content that did not naturally have a home in any other course.

GIS 1 is a course that is intended to provide students with a theoretical understanding of the basic concepts underlying the field of GIS, as well as to train students to use GIS software during practical sessions. Due to the factors mentioned above, the course in recent years was experienced by students as a series of unrelated content areas, together with a lack of adequate hands-on practical training of the software. These factors led to the course being put together in a piecemeal fashion over time, and therefore lost its focus, thereby necessitating the need for a course review. Constructive alignment, as proposed by Biggs, made most sense as it guides the total learning experience.

From an epistemological and pedagogical perspective, the theoretical framework that guided the development of the course was *constructivism*, with a strong emphasis on *student-centred learning*. Constructive alignment thus draws on constructivism as a way of looking at learning, and helps in aligning teaching to aid deep learning.

## 2.3 Constructivism and GIS

There are many diverse views on what constitutes constructivism, but there seems to be convergence on two fundamental points, as reported by Duffy & Cunningham:

“(1) learning is an active process of constructing rather than acquiring knowledge, and (2) instruction is a process of supporting that construction rather than communicating knowledge” (Duffy & Cunningham, 1996: 171).

Constructivism emphasises *situated learning*, where subjects (e.g. science and mathematics) are learnt through vocations, as opposed to learning the vocation only. This type of learning which is anchored in a larger community of practice is particularly suited to a diverse knowledge domain such as GIS. Because of this diversity, a methodology that can be employed is problem-based learning, where students’ problem solving skills are enhanced so that they could potentially be applied in any one of a whole spectrum of industries.

### 3. CONTEXT

#### 3.1 Professionalization of GIS in South Africa

At the time of writing this paper, a professional qualification and a technical qualification in GIS in South Africa has been proposed. Core topics for the qualifications are likely to become prescribed, and these topic areas must be included in a university curriculum. This grouping of core topic areas represents the minimum knowledge required by graduates. This has implications in the curriculum design of GIS 1, which, as the introductory course, needs to contain an introduction to a significant portion of the knowledge required, with the rest of the minimum knowledge being covered in other courses in the degree programme.

#### 3.2 Student Diversity

As noted by Biggs, the modern university student population is diverse, and the proportion of 'non-academic' students in a class is significant. There are three main categories of student diversity, namely *learning styles*, *approaches to learning* and *intellectual development* (Felder & Brent: 2005). There are two main approaches to learning that a student may take to learning – the *surface* approach or the *deep* approach. A student might adopt a surface approach in order to meet the minimum requirements of an assessment, so as to get the task out of the way. Examples of surface learning in an academic environment may be “rote learning selected content instead of understanding it, padding an essay, listing points instead of addressing the argument, quoting secondary references as if they were primary ones; the list is endless” (Biggs, 1999a: 14).

On the other hand, the deep approach to learning is results from a need in the student to appropriately engage with the task at hand, and results in a meaningful understanding of the underlying principles or themes. This is not only something that happens in the student - it can be encouraged by setting up an environment that the students perceive to afford a deep approach to learning.

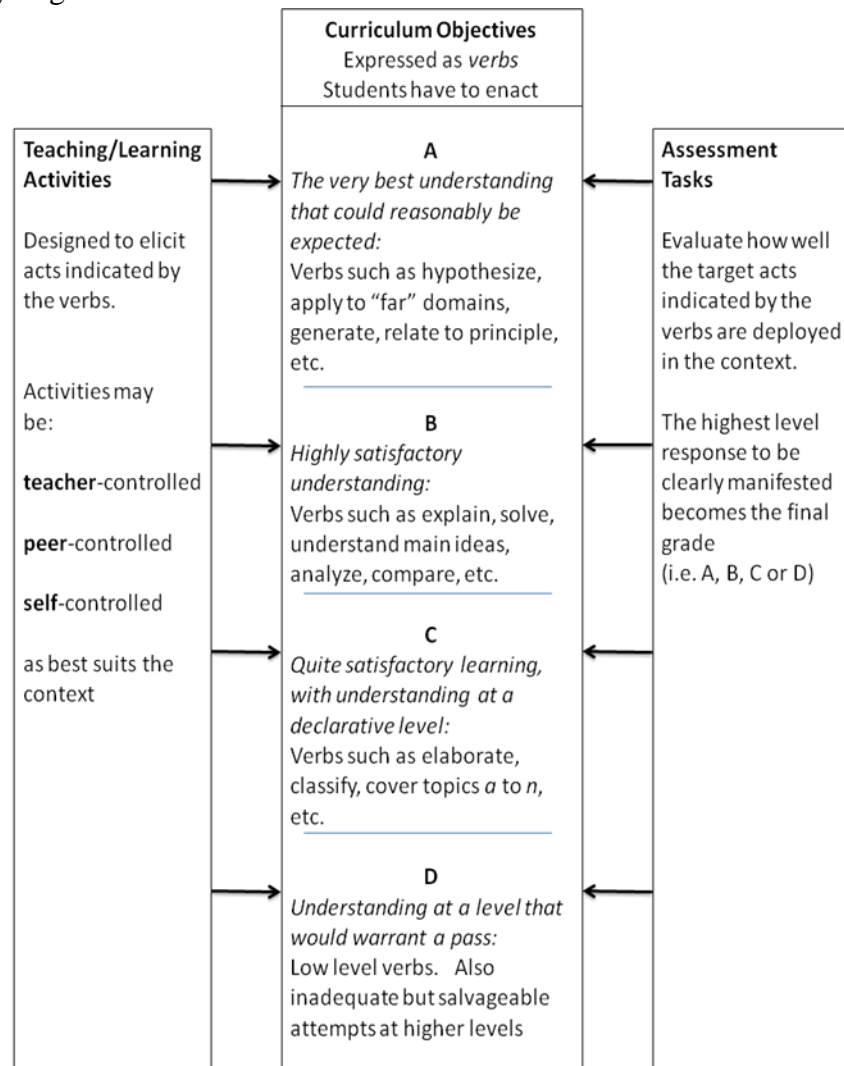
The learning experience, as experienced by a diverse group, needs to encourage and facilitate deep learning. Prosser and Trigwell support this by saying that students “who adopt surface approaches to learning are more likely to have learning outcomes of a poorer quality than those who adopt deeper approaches” (Prosser & Trigwell, 1999: 84).

The teaching and assessment style needs to be adequately diverse so as to steer students into new ways of engaging with the knowledge, but also needs to be focused. This is a challenging task as it involves constant reflection, and a certain measure of boldness on the part of the lecturer as it may require experimentation with teaching styles that do not come naturally. This parallel process of experimentation with new teaching and learning styles by both teacher and student can be useful within a discipline such as GIS where the only constant is change. The teacher needs to keep focused on what the student does, as opposed to worrying about what the student is.

## 4. CONSTRUCTIVE ALIGNMENT

### 4.1 The Total Learning Experience

The main aspects of the total learning experience were identified as Teaching/Learning Activities (TLAs), Curriculum Objectives and Assessment Tasks (Biggs, 1999b: 65). A constructively aligned course would have coherence between the three elements.



**Figure 1. Constructive Alignment Model** (from Biggs, 1999a: 27)

Figure 1 shows the constructive alignment model, and it can be seen that the curriculum objectives are central to the development of an aligned course. As Biggs puts it "When there is alignment between what we want, how we teach and how we assess, teaching is likely to be much more effective than when there is not" (Biggs, 1999a: 26).

The design of the curriculum was chosen as being the starting point, with teaching and assessment being worked on subsequently. The curriculum design starts off with *objectives*

that need to be met for each topic, together with the *level of understanding* that is required. These objectives are expressed as *verbs* that the students need to demonstrate.

## 4.2 Understanding understanding

Biggs uses the SOLO taxonomy to describe the different levels of understanding. Figure 2 shows a representation of the SOLO taxonomy, along with typical verbs that each level of understanding is associated with. Understanding can be viewed as hierarchical in nature, and as a student progresses through their studies, understanding should go through various transitions, starting at a unistructural understanding, and perhaps progressing to an extended abstract level of understanding.

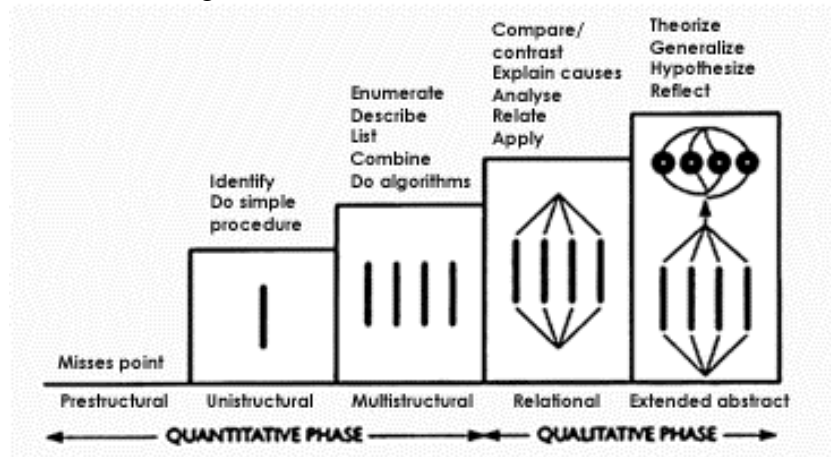


Figure 2. SOLO taxonomy (from Biggs 1999a: 47)

Another similar taxonomy of understanding or learning is the widely used, original *Bloom's* taxonomy, based on six hierarchical cognitive levels, namely *knowledge*, *comprehension*, *application*, *analysis*, *synthesis* and *evaluation*. It should be noted though, that applying these taxonomies to a course such as GIS 1 could create problems. In a study of introductory computer science programming courses, it was found that instructors did not find the last two levels of the Bloom's taxonomy (synthesis and evaluation) relevant, as they regarded the previous learning outcome (application) as being the highest ability that they wanted to develop in their students (Fuller *et al*, 2007: 153). This was also the case in certain parts of the GIS 1 course, such as Spatial Databases.

## 5. CURRICULUM OBJECTIVES

Breier points out a few themes that higher education institutions have had to become aware of as they change their curricula in response to a changing world. These themes include globalisation and internationalisation (e.g. how could the curriculum prepare students for participation in a global economy?), responsiveness (e.g. should the curriculum be responsive to specific societal needs?), disciplinarity (e.g. should the curriculum promote inter-disciplinarity?), and graduateness (e.g. what skills and knowledge do employers value?) (Breier, 2001).

A key concept in deciding on curriculum objectives is the *kind of knowledge* that a course designer may want to include in a curriculum. There are two main kinds of knowledge, namely *declarative* knowledge and *functioning* knowledge (Biggs, 1999a). Declarative knowledge is knowing-about things or knowing-what, so demonstrating declarative knowledge would be listing the components of a GIS, knowing what are the different types of raster image compression techniques, or identifying the major commercial GIS software packages. Functioning knowledge, on the other hand, puts declarative knowledge to work, and involves how-to knowledge, when knowledge, and why knowledge. If posed a question to calculate the shortest distance between a student's house and university, for example, functioning knowledge would be to know that a network analysis is needed, as well as how to carry out the analysis with a GIS. Thus, both declarative and functioning knowledge needed to be included in GIS 1.

The task of choosing curricular topics could be guided by looking at international practice. Research was conducted on the curricula of similar (i.e. introductory or first) GIS courses offered at university level around the world (at least two university courses each in South Africa, Canada, Australia and USA were analyzed), and broadly speaking; there was much consistency in the topics covered. There were some topics that were unique to specific institutions, and this phenomenon was likely to be a result of the importance that a particular degree programme placed on the subject areas in question. For example, a Geography department in a US university dedicated a chapter to spatial modelling applications in physical and human geography, and these content areas are absent in the curricula of departments that have a Geomatics focus. The topics that were covered by the majority of institutions studied were used as a starting point from which to choose a core of topics. Awareness of the minimum requirements for accreditation of the South African professional GIS qualification needed to be taken into account when choosing the topics for GIS 1.

This method of choosing curricular topics based on existing practice is not the only possible option. An initiative of the University Consortium of Geographic Information Science (UCGIS) was to develop the Geographic Information Science and Technology Body of Knowledge, which is meant as a resource to identify the broad spectrum of knowledge that constitutes the Geographic Information Science and Technology (GIS&T) domain (Prager & Plewe, 2009). It is a comprehensive document that can assist with curriculum planning and curriculum revision, and is also intended to be the successor of existing curriculum development efforts such as the NCGIA Core Curriculum (DiBiase et al, 2006).

The GIS 1 course needed to conform broadly to the objectives of the programme in which it is offered, in this case, the Geomatics programme. A Geomatics graduate who might go on to work in the field of GIS would need to possess an excellent understanding of the acquisition, management, analysis and display of spatial data. GIS 1 introduces students to some concepts that will be expanded on in later courses, so it is desirable that these concepts are introduced with the aim of cultivating an in-depth understanding.

A challenge that arose was deciding on which material to include, without overloading the

curriculum. In course development, there is always going to be some tension between coverage of topics and depth of understanding, particularly in a fast-developing professional discipline such as Geomatics. The literature on curriculum design makes it clear that “The greatest enemy of understanding is coverage” (Gardner, 1993:24).

This tension is evident in some introductory GIS texts:

“In my view, the pedagogical theme of a first course should be breadth, with depth in vital areas.” (Kennedy, 2009: xxxiv)

Taking all of the above factors into account, the curriculum was decided upon, being aware of its importance from a constructive alignment perspective. Depending on the level of understanding required, the verbs that describe the curriculum objectives were packaged together and related to teaching and assessment.

The appendix shows an extract of the constructive alignment model as applied to GIS 1, outlining a portion of two of the curriculum sections. The three columns that form the core of the model are (1) the Teaching/Learning Activities, (2) the Curriculum Objectives and (3) the Assessment Tasks. Columns have been added (Topic, Example of Assessment) to document more information. It can be seen from the verbs used in the Curriculum Objectives that some topics require mainly a multistructural understanding (such as Cartographic Basics), whereas other topics clearly show the need for a relational understanding (Map Projections). It is highly unlikely that in an introductory GIS course, students would achieve an extended abstract competency; this is expected from postgraduate students, or perhaps senior undergraduates.

## **6. TEACHING AND ASSESSMENT**

### **6.1 Teaching**

The pedagogical approach to the course as a whole was student-centred, with the aim of getting the students to engage in appropriate activities that encouraged deep learning. According to Vygotsky’s theory, for successful movement of knowledge, the learning needs to be interactive (Wertsch & Tulviste, 1996). An example of interactive learning of map projections was for students to carry out a simple perspective map projection using a small globe and a piece of paper. The lecturer talked the class through the process of projection, with the aim of embedding specific knowledge in the exercise, which included theory of projection surfaces, tangency/secancy, projection aspects, and projection techniques.

Setting up an environment in the classroom that encourages students to communicate is better for learning. This is directly linked to Vygotsky’s ideas on the relationship between the environment and the individual, in which the social and cultural processes that shape an individual play a critical role in the mental functioning of that individual (Wertsch & Tulviste, 1996). In this light, the GIS 1 pedagogy was aimed at making the classroom a safe environment for students to not only communicate with the lecturer, but also with each other. According to Tuitt,



“the central goal of transformative pedagogy is to make the classroom a democratic setting where everyone has the responsibility to contribute. Consequently, in an effort to alter power relationships in the learning environment, inclusive pedagogical models advocate for a dialogical relationship between professor and students” (Tuitt, 2003: 6).

It is especially important in a South African learning environment, where the lecturer can facilitate the transformation of previously-held destructive power relations towards a more democratic environment. This does not mean that a disciplined, focused learning environment was in any way compromised. Biggs gives many good pointers on how pedagogy can be effectively used to maintain a high level of learning.

According to Biggs, teaching/learning activities can be teacher-controlled, peer-controlled, or self-controlled. The TLAs need to be set up in such a way “so that students have every encouragement to react with the level of cognitive engagement that the objectives require” (Biggs, 1999b: 67). The GIS1 course was set up to allow for teacher-, peer- and self-controlled TLAs, as it was felt that different curriculum objectives would best be met by using appropriately diverse TLAs.

The need for instruction to move away from the talking head in front of the class to something that improved student learning was apparent. Demonstrating GIS software in class, by students and lecturer, is important because spatial science is a largely visual discipline. Numerous other strategies of involving the students in their own teaching were employed. One such strategy was the “GIS moment”. This peer-controlled activity involved giving one student the first five minutes (or less if they choose) of the GIS1 lecture to talk to the class about GIS. Thereafter, the student would get to choose who gave a GIS moment during the following day’s lecture. This continued until everyone in the class had contributed formally to the semester’s lectures. It was found that this aspect of the course was always popular, as it allowed students to share GIS knowledge in a relatively relaxed way (the 5 minute time constraint did not require too much preparation and therefore anxiety levels were generally low), it allowed them to practice their communication skills, and it often brought in an element of fun. An unintended, but positive consequence of the GIS moment was that an entire chapter of the curriculum (practical applications of GIS) was almost entirely covered. Most students chose to discuss a specific application of GIS, and by the end of the semester, many different applications were covered, making the teacher-controlled TLAs of the last curricular chapter virtually unnecessary, due to the fact that the students, through their discussions on how GIS is used across many different industries, already assimilated much of the theory to obtain a personal understanding of the section.

It was helpful to involve important role players from the GIS industry in the course. In 2010, the Managing Director of one of the largest GIS companies in South Africa delivered a talk to the class, which was well received. It is advantageous for students to be put into contact with people in positions to which they may aspire. Many students relate success to the amount of money they will earn, and having an external person remind them that the field of GIS could be a potentially lucrative one owing to the demand for people with qualifications and experience in the field is a big motivating factor.

## 6.2 Problem-Based Learning

One of the questions addressed by Prosser & Trigwell is whether teaching is “fundamentally about transferring information from the teacher to the learner, or is it, as we would contend, about creating contexts which make learning possible?” (Prosser & Trigwell, 1999: 11). This creation of *contexts* can be assisted by Problem-Based Learning (PBL), as it is the teacher’s role to present problems that would stimulate learning by arousing the student’s curiosity. It was found that the problems that work best in this regard are problems which are relevant, interesting and challenging.

PBL has proven to be particularly effective in professional training, and there is evidence that it can “increase the use of deep approaches, improve the retention of information and develop student independence and motivation” (Ramsden, 2003: 141). Prior to the revamp of the course, the first two practical sessions involved students completing online courses on ESRI’s Virtual Campus, a site containing many training courses for ESRI software. These modules were found to be helpful as training aids, but insufficient from a PBL standpoint. Also, the examples and sample data presented on the Virtual Campus were USA-specific, which prevented students in South Africa from being exposed to local problems and data.

After consultation with the 2009 cohort to assess the effectiveness of the online training, it was decided not to dispense with the ESRI Virtual Campus on-line modules entirely, but to use them as a starting point for students to familiarise themselves with the software. In 2010, the ESRI modules were used by the students in the first two weeks of term, getting them started with practical components of the course, long before the theory is reflected on. This is aligned with the Vygotskian social constructivist perspective of how it is easier for the student to construct knowledge in going from the specific to general. The author has confirmed by observation that learning appears to happen faster when students are first exposed to hands-on experience of GIS software, and then the theory behind what they have experienced is revealed.

One example of a problem-based group learning task was posed as follows:

‘Your group is to plan a lift club to transport all of the members to and from campus every day. Assuming that all members have cars, you have to use GIS to make the following decisions:

- Whose car will be used every day?
- On days when the driver is unable to drive to university (e.g. off sick), who is the second choice driver?
- Each member of the group is to contribute towards the fuel cost per week. Does it make sense for each member to contribute an amount proportional to the effort (in terms of time, distance travelled or some other variable) it takes to transport them to campus?’

Groups were assigned by the lecturer, and the groups were given a two week period in which to complete the task.

## 6.3 Assessment

In order for a course to be effectively aligned, the assessment practice needs to reflect the objectives of the course. While teachers might see the curriculum objectives as the central and most important aspect of the total learning experience, it is experienced in a different way by students. To students, the assessment determines whether they pass or fail, and determines what grade they achieve, so is central in their conception of the learning experience.

The two types of assessment that can be used are *formative* and *summative* assessment. Formative assessment is used as a method of providing feedback to students during a course, and is inseparable from teaching, whereas summative assessment is used to grade students at the end of a teaching episode. Formative assessment is not for grading, and can occur irregularly during the course of a semester, whereas summative assessment counts towards the students' final course grade. In GIS 1, the summative assessment took the form of class tests, assignments and an exam.

It was important to include a significant amount of formative assessment during the course, as this assisted in a better understanding of the learning taking place, while it was taking place. The main purpose of formative assessment is feedback. An example of formative assessment included posing specific questions relating to the content being taught at the time, and students were asked to carry out research to answer them, e.g. how might GIS be used if a specific oil pipeline was damaged and started leaking oil? The students then shared their answers with the class in a discussion a few days later. The lecturer directed the discussion, and provided critical feedback.

An example of a summative examination question that tests both declarative and functioning knowledge is:

How would you identify all the properties along a river that could get flooded if the river was to overflow?

In order to obtain maximum marks for this question, the type of analysis (buffer analysis) would need to be identified, together with the method of application, which tests declarative knowledge (unistructural and multistructural). However, identifying that buffer analysis is the correct type of analysis required a higher level of understanding (relational).

## 7. DISCUSSION & EVALUATION

### 7.1 Overview

It should be noted that the process of implementation of constructive alignment in the GIS1 course is an on-going one, and the research carried out in the preparation of this paper shall be continued for the purpose to align not just the GIS 1 course, but other courses in the Geomatics programme. On a larger scale, curriculum review of the entire Geomatics programme will also be aided and facilitated by a bottom-up process of aligning individual courses with the view of entire programme alignment. This paper presents a description of

how constructive alignment was used over a period of two years.

During the development of the course, the concept of alignment always needed to be considered. It was useful for the author to think of the course as comprising of three elements (curriculum, teaching and assessment), however, it is important to realise that they form a coherent whole. The differentiation between the three elements should not be evident to the student taking the course – this in fact would somewhat defeat the purpose of creating an aligned course.

## 7.2 Example of alignment

In the Spatial Data section, one of the subtopics that is covered is Generalization. Three of the curriculum objectives to be met are:

1. Define raster and vector generalization;
2. Describe reasons for generalization; and
3. Relate a scale problem to generalization.

These curriculum objectives, if accomplished, describe different levels of understanding viz. unistructural, multistructural and relational respectively. TLAs need to be designed that will give students a sufficient understanding to be able to demonstrate the verbs described in the objectives. This was done in numerous ways. In class, a demonstration by the lecturer at the beginning of the semester incorporated the Scale Range functionality that is found in most GIS software, showing how some layers are visible at certain zoom ranges, and are invisible once the user has zoomed out beyond a certain range so as not to clutter the map with too much unwanted detail. The class is reminded of this example when the section on Generalization is being covered, so as to relate the concept with the scale issue. Different types of generalization functions are described in class, and a guided discussion is conducted, going over examples of reasons for employing such functions. This, together with experience gained in the practical sessions, should provide ample groundwork for the achievement of the curriculum objectives. The following exam question was used:

‘In your GIS, you have created a detailed map of a Cape Town city block containing the following vector layers:

- suburbs,
- streets,
- detailed land use information,
- address points of every cadastral parcel.

You now want to create a map of the whole of Cape Town, using the same data. What operation will you need to carry out on the data for the new map to be legible? Describe two spatial operators that you will employ. In your answer, include: which layer(s) you will amend, which operator(s) you will use on each specific layer, what output you can expect. Use diagrams to support your answer.’

The successful answering of this question relies on students linking the scale problem with generalization (relational understanding), discerning which types of generalization would be used on the datasets given (functioning knowledge) and recalling specifics of generalization

(declarative knowledge). This method of thinking about alignment was employed to all the sections in the GIS1 curriculum, so as to maximise alignment.

### 7.3 Evaluation

At the end of each semester, online course evaluations were conducted, and these were used to gain an understanding of the students' experience of the course. Interviews were also conducted with students from both 2009 and 2010 cohort to qualitatively evaluate the impact of constructive alignment.

The online course evaluation rated various aspects of the course on a five-point scale. The numbers of students that took the evaluation were 31 (of 35) in 2009 and 24 (of 45) in 2010, which constituted samples of more than half the year's cohort. The mode of each response was used to ascertain the dominant response on a certain issue. The 2010 course showed a marked improvement on various aspects of the course, the main ones being:

Practicals/tutorial assignments – the score increased from a 2 to a 4, indicating that the relevance of the problem-based practical assignments were more appreciated.

Group work – went from 3 in 2009 to 4 in 2010.

Lectures – went from 2 in 2009 to 4 in 2010.

It should be noted that the analysis which can be carried out at this stage is probably incomplete due to only one cohort having been through constructive alignment. A more complete picture will be revealed in years to come, and so further quantitative analysis will be more meaningful.

With regards to the interviews, some constructive feedback was received. When discussing the activities that were carried out in class, an appreciation of formative assessment is evident in the comment:

“The discussions that we had in class was good, how to solve real problems using GIS was great.”

This comment was a reference to problem-based scenarios that were presented to the class, and subsequent discussions that were mediated by the lecturer on how to solve the problems using GIS (such as the Generalization discussions mentioned above). Problem-based assessment (both formative and summative) formed an important part of the overall assessment, as it was present in class discussions, practical assignments (such as the lift club problem) and in the exam.

There was great enthusiasm and discussion generated in class when GIS software was demonstrated in class as a method of augmenting curricular content or solving problems. Several comments by students indicate this:

“It was good when you showed us, when you physically did something on the GIS, so we can see how it's applied;” and

“It was useful that you demonstrated it in class”.

As noted earlier, there is a significant amount of *situated learning* which takes place in GIS 1.

As explained by Duffy & Cunningham, “rather than learning vocations, we learn science, math, literature, etc., through vocations” (Duffy & Cunningham, 1996). If we assume GIS to be the overarching vocation in this context, then content areas which are learnt include spherical trigonometry, map projections, database theory, cartographic basics and introductory remote sensing. These content areas are articulated over a semester to provide a coherent learning experience within the vocation of GIS. Evidence of alignment of the course was found in student comments about how they appreciated the practical application of the theory presented in class, and “The way it incorporates a lot of different ideas”.

A telling comment from a student who took the course pre-constructive alignment was “There is a lot of theory to learn which is actually not needed”. This points to a lack of alignment between assessment and the other elements of the learning experience.

#### **7.4 Future plans**

There are plans to keep in touch with former students who have been through the GIS1 course and are working in a GIS environment. Ongoing feedback in terms of constructive criticism will be obtained in order to constantly improve the course, not just in terms of content, but methods of delivery too.

There is a need to expose students to hands-on use of more than one GIS software package, as being taught one package only can result in a certain level of inflexibility, where a software user is only able to think of GIS in one way. In future, Open Source software should be used. This enables one to teach GIS theory, and set problem-based assessments so as to get students to solve the problems in principle and translate the solution across software platforms.

In order to further align the assessment practice, a system of continuous evaluation is likely to be adopted, where ongoing assessment events throughout the duration of the semester will cumulatively comprise the total assessment. This will allow for a more effective application of PBL opportunities, which are better suited to continuous evaluation.

### **8. CONCLUSION**

It is possible that higher education practitioners in GIS may not have heard of constructive alignment prior to reading this article, but may find that they are putting into practice some or most of its aspects.

Constructive alignment has been found to be a useful thinking tool in curriculum development, and it provides a set of guiding principles that assists in the holistic development of the students’ learning experience. After implementation, students have expressed appreciation for the changes in the course.

Good GIS educational practice should reflect advances in the field of GIS. Advantage should be taken of research into the pedagogy of this specialized field.

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**APPENDIX. Constructive Alignment of GIS 1 (extract)**

Topic	Teaching/Learning Activities	Curriculum Objectives	Assessment Tasks	Example of Assessment
<u>Spatial Concepts</u> Size & Shape of Earth, Coordinate Systems	Group discussion	Describe - ellipsoids, geoids, coordinate systems, coordinate transformations	Exam	
Map Projections	Development exercise with globe	Describe properties of sphere, ideal map, process of map proj, surfaces, distortion		
	Tutorial	Solve simple spherical problems	Exam	Give lat/long of two cities; calculate great circle/azimuth between them
	Lecture	Relate distortion theory to specific maps, choose appropriate projection	Exam	Give a list of countries; choose the best possible projection surfaces. Give a list of mapping requirements; choose best projection for the country.
	Tutorial, group discussion	Draw graticule of specific projection, calc h & k and evaluate property	Assignment	Give parameters; draw projection and show outline of continent Is it equal area/ conformal etc.?
	Demo	Relate to GIS		Which projection would you choose whilst digitising layers
<u>Spatial Data</u>	Lecture	Identify different attribute scales,		Give a list of data; identify which scale it represents
Elements of Geo-information	Discussion	Classify attribute scales	MCQ	Choose an appropriate scale for a described dataset
Generalization	Demonstration of scale range	Describe reasons for generalization	Exam	
		Relate a scale problem to generalization	Exam	Present a scale problem that can be solved by generalization