

https://dspace.org/

Enhancing a South African Grade 5 mapwork lesson with a geographic information system (GIS)

Steggink, Dominique

2021
https://hdl.handle.net/10539/32893

Downloaded from a DSpace repository. https://dspace.org/

Dominique Steggink 1096198

Supervisor: Dr Nokulunga Ndlovu

Enhancing a South African Grade 5 mapwork lesson with a geographic information system (GIS)

Final Research Report

A research report submitted to the University of the Witwatersrand in partial fulfilment of the requirements for the Master's Degree in Education by Coursework and Research. (MEd).

University of the Witwatersrand

2021

Abstract

South African educational policies have been put in place to ensure that Information and Communication Technology (ICT) integration is adopted and successfully implemented in the educational domain. For instance, the national curriculum, the Curriculum and Assessment Policy Statement (CAPS), makes recommendations regarding software tools, such as a geographic information system (GIS), that teachers should use in their teaching and learning. However, there is very little practical guidance on how these tools can be used in the classroom.

This research focuses on demonstrating how a GIS can be used to enhance the learning process of a Geography lesson with a focal point on vegetation regions in South Africa. Diana Laurillard's conversational framework and Karl Maton's semantic wave are the theories that were used in this study to make explicit what could happen in the classroom if GIS is integrated into the teaching and learning process. The findings were used to develop a prototype of the lesson that can guide teachers on using a GIS to teach this concept. The GIS proved to be a valuable tool in the classroom in which learners can interact in the learning process and apply concepts in the real world.

Declaration

I hereby declare that this research report is my own work. It has been submitted exclusively to the University of the Witwatersrand in partial fulfilment of the requirements for the Master's Degree in Education by Coursework and Research (MEd).

The Wits School of Education ethics committee constituted under the University of the Witwatersrand Human Research Ethics Committee (Non-Medical) has approved this research project unconditionally on the 17th of June 2020 by issuing a clearance certificate protocol number: 2020ECE011M.

Dominique Steggink



_____

20th of February 2021

Table of Contents

Abstract ..... **i**

Declaration ..... **ii**

Table of Contents ..... **iii**

List of Figures ..... **vi**

List of Tables ..... **viii**

List of Appendices ..... **ix**

List of Acronyms ..... **x**

Definition of Key terms ..... **xi**

Chapter 1: Introduction ***1***

Scope of Study **1**

Purpose Statement **2**

Research Questions **2**

Outline of the Chapters **3**

Chapter 2: The Conceptual Framework and Literature Review ***4***

CAPS Document **4**

The CAPS Policy outline for Geography 5

Map Work in Grade 5 Geography **5**

The Geographic Information System (GIS) **6**

Conversational Framework **7**

Learning activities 8

Media forms 9

ICT Affordances **11**

Multimodality 12

Immediacy 12

Collaboration 12

Diversity 13
Articulation 13
The Legitimation Code Theory (LCT) 14
Semantic gravity and semantic density 14
Semantic waves 15
The purpose of a semantic wave 16
Conceptual Framework 17
Chapter 3: Research Design and Methods 19
Research Method 19
The analysis of a Geography lesson 19
Ethical Considerations 22
Chapter 4: What Is a GIS? 23
What Affordances and Pedagogical Values Do a GIS Have? 25
Adaptive media form 26
Models 26
Narrative Media Form 30
Productive Media Form 32
Communicative Media Form 34
Interactive Media Form 36
Chapter 5: Integrating a GIS into the Lesson 37
Lesson Step 1.1 37
Introduction 39
Conclusion 41
Lesson Step 1.2 41
Introduction 41
Conclusion 44

Lesson Step 2 ..... **44**

Introduction 46

Conclusion 47

Lesson Step 3 ..... **48**

Introduction 49

Conclusion 50

Lesson Step 4 ..... **51**

Introduction 51

Conclusion 53

Lesson Conclusion **53**

Chapter 6: Discussion ***54***

Proposed Semantic Wave **59**

Chapter 7: Conclusion and Recommendations ***61***

Conversational Framework **62**

Semantic Wave **62**

GIS **62**

Making Decisions About the Learning Pathway **63**

Being Aware of ICT Affordances **63**

Continuous teacher development 64

Future Recommendations **65**

Conclusion **65**

Reference List **66**

Appendices **71**

Appendix A: Video Player **71**

Appendix B: Language Editing Certificate **73**

List of Figures

Figure 2.1: The conversational framework (Ndlovu, 2015, p. 28). 8

Figure 2.2: A descriptive figure of a semantic wave (Raspberry Pi, n.d., p. 1)....16

Figure 2.3: The conceptual framework....18

Figure 3.1: The proposed lesson steps for the Geography lesson (adapted from Western Cape Education Department, n.d., p. 17) 20

Figure 3.2: The pedagogic value of a GIS is placed on the semantic wave (Raspberry Pi, n.d., p. 2) 21

Figure 4.1: Vector data 24

Figure 4.2: Comparing vector and raster data (Yusuf, 2016) 24

Figure 4.3: An electronic orthophoto map of an area in Gauteng, South Africa (Planet GIS, n.d.) 27

Figure 4.4: An attribute table representing a database of different roads (University of Washington, 2013)....28

Figure 4.5: An image of an area in Gauteng, South Africa (Planet GIS, n.d.) 29

Figure 4.6: Data layers in a GIS (National Geographic, Resource Library)....31

Figure 4.7: An attribute table being exported to a Microsoft spreadsheet (Made 4 Geek, 2019) 33

Figure 4.8: An illustration of spatial data 34

Figure 5.1: The discursive process (Ndlovu, 2015, p. 28)....38

Figure 5.2: Indigenous vegetation vs alien vegetation in South Africa (Daniel Williamson, OpenStax cnx, Rice; Giordano, Thierry & Blignaut, James & Marais, C, 2012)....42

Figure 5.3: Using a GIS to isolate vegetation regions in South Africa (Daniel Williamson, OpenStax cnx, Rice) 43

Figure 5.4: The adaptive process (Ndlovu, 2015, p. 28)....45

Figure 5.5: The interactive process (Ndlovu, 2015, p. 28) 46

Figure 5.6: A map showing the savannah regions in South Africa (South African National Biodiversity Institute, PlantZAfrica.com).....47

Figure 5.7: The reflective process (Ndlovu, 2015, p. 28).....49

Figure 5.8: Integrating layers.....50

Figure 5.9: An example of a way to compile data using GIS.....52

Figure 6.1: A semantic wave for teaching vegetation regions in South Africa.....59

List of Tables

Table 2.1: Analytical tool developed by Ndlovu from Laurillard's media forms and Conole and Dyke's taxonomy of affordances (Ndlovu, 2015, p. 106) 14

Table 3.1: Analytical tool to determine what is of pedagogical value in the use of a GIS, with colour codes (Ndlovu, 2015, p. 106).....21

Table 6.1: Summary of lesson step 1.1 54

Table 6.2: Summary of lesson step 1.2 55

Table 6.3: Summary of lesson step 2 56

Table 6.4: Summary of lesson step 3 57

Table 6.5: Summary of lesson step 4 58

List of Appendices

Appendix A: Video Player.....71

Appendix B: Language Editing Certificate.....73

List of Acronyms

CAPS: Curriculum and Assessment Policy Statement

GIS: Geographic Information System

ICTs: Information and Communication Technologies

LCT: Legitimation Code Theory

GPS: Geographic Positioning System

SG: Semantic Gravity

SD: Semantic Density

Definition of Key terms

GIS (geographic information system): A computer system used to capture, store, analyse and display data about the science of the world.

ICT affordances: The capabilities technology can offer its user.

ICT pedagogical integration: The incorporation of technology into the teaching and learning process.

ICT pedagogical value: The advantage of using technologies to enhance the learning process.

Semantic wave: A concept derived from the legitimation code theory (LCT) used to depict the ideal journey a learner should embark on during the learning process.

Chapter 1: Introduction

The use of digital technology has become a prominent feature in the contemporary South African classroom. It has been shown that the use of technology in the classroom makes teaching and learning more effective. It is necessary to demonstrate that there is value in the use of whichever information and communication technology (ICT) in the conversation between the teacher and the learner in the learning experience (Laurillard, 2002).

The South African National Curriculum Statement, the Curriculum and Assessment Policy Statement (CAPS) (Department of Education, 2011) advocates for a learner-centred approach to teaching Geography using ICTs. It focusses on ensuring that learners engage with selected aspects of mapwork and other visual sources within each grade. According to Van der Merwe (2016, p. 120), "map literacy is an essential communication tool necessary to interpret complex information displayed visually through maps, a competence that cannot be ignored in the development of geographers". Thus, the CAPS (Department of Education, 2011) document recommends that Geography teachers should use a geographic information system (GIS) in their teaching. When this software is used on technological devices such as tablets and computers, it can support "a number of educational goals, such as promoting inquiry processes in science and social studies, advancing problem solving in real-world contexts, and facilitating learning transfer across school subjects" (Jadallah et al., 2017, p. 2). Teachers must be adequately prepared for the effective use of this valuable software to enhance the learning of mapwork and various geographic concepts.

ICT integration into teaching is not an easy process if teachers do not have the pedagogical knowledge and skills they need to infuse it without compromising the quality of learning. It is therefore important to provide guidelines on how to use available technologies to teach various concepts with these tools. This is a call to all involved, education department officials, schools, teachers and learners, to play their part in supporting this innovation for "geography [to] retain a strong presence in transformed education" (Mphaphuli & Luneta, 1996, para. 13).

Scope of Study

This study primarily focused on the teaching of a Grade 5 Geography lesson on vegetation regions in South Africa. It is a conceptual research that aimed to provide details on how to use a GIS to teach a geographic concept in South African schools that have access to the hardware

and software in its classrooms. The study used concepts from Ndlovu (2015), Laurillard (2002) and Maton (2013) to demonstrate how a particular Grade 5 Geography lesson that is aligned to the CAPS document (Department of Education, 2011) can be enhanced by the integration of a GIS.

Purpose Statement

The aim of the study was to engage with teaching and learning theories that can help develop a prototype of a Grade 5 lesson in which a GIS is used. This should inform digital pedagogies in terms of providing theoretical accounts of the dialectal relationship between technological software and effective teaching and learning. This study focused on demonstrating how Geography concepts in Grade 5 can be enhanced using a GIS.

Therefore, this study's problem statement can be stated as follows: How can this study's theoretical framework help develop a prototype of a Grade 5 Geography lesson that integrates ICTs to enhance the teaching and learning process?

Research Questions

How can the integration of a GIS enhance the teaching of Grade 5 learning of vegetation regions in South Africa?

The following sub-questions were posed to answer the main research question:

- What are the affordances of a GIS?
- How can GIS affordances enhance the teaching of vegetation regions in South Africa for Grade 5 learners?

Outline of the Chapters

Chapter 1: Introduction

This chapter asserts that ICT integration in the South African educational domain must focus on the ICT policy implementation, justifying the undertaking of this study. The purpose statement and research questions are included in this chapter.

Chapter 2: The Conceptual Framework and Literature Review

This chapter outlines the concepts that were used in this study and the conceptual framework that were used to model a prototype of the lesson under study.

Chapter 3: Research Design and Methods

The adopted research design and methods are unpacked and justified in this chapter. The intent is to discuss why the research approach is appropriate for this study.

Chapter 4: What is a GIS?

This chapter focuses on discussing the nature of a GIS, with the intent to give some insight on the pedagogical affordances of a GIS that is later incorporated into the lesson.

Chapter 5: Integrating a GIS into the Lesson

The semantic wave and the conversational framework are used to unpack the Geography lesson where a GIS is incorporated to demonstrate its use. The intent was to develop a prototype lesson to demonstrate to teachers how to possibly use the affordances of a GIS and integrate them into the lesson.

Chapter 6: Discussion

This chapter focuses on the lesson where a GIS is used to teach vegetation regions in South Africa.

Chapter 7: Conclusion and Recommendations

An overall discussion on the study is presented in this chapter, focusing on the concluding thoughts of this study and recommendations for future studies.

Chapter 2: The Conceptual Framework and Literature Review

This study drew on various concepts from Ndlovu (2015), Laurillard (2002) and Maton (2013). These are discussed in this literature review to inform how the use of a GIS can be incorporated into a Grade 5 Geography lesson. It includes a review of the South African National Curriculum Statement, the CAPS (Department of Education, 2011) document, to provide a context in which this study is based.

The conversational framework, coined by Laurillard (2002), in conjunction with Ndlovu's framework (2015) are adopted as lenses to determine the pedagogical value that ICTs bring to the teaching and learning process. The interaction determines the effectiveness of the teaching process as both the teacher and the learner get feedback as the learning of the concept is developed. Lastly, the use of semantic waves, derived from the legitimation code theory developed by Karl Maton (2013), allows one to depict and analyse the relationship between theory and practice in the classroom. These concepts should make visible the pedagogical value of a GIS as a teaching technology in the classroom.

The CAPS Document

One of the aims of the CAPS document (Department of Education, 2011) is to ensure that school children are given opportunities to acquire and apply knowledge and skills in their everyday lives to promote a learner-centred environment. A learner-centred environment aims to provide learners with opportunities that ensure they are actively involved in the learning process. The policy refers to principles that the learning process should be based on. The idea of passive learning is discouraged. Instead, the policy proposes an active and critical approach to learning in which content is contextualised and its delivery shows an active progression from simple to complex ideas. The CAPS document (Department of Education, 2011) mentions the following attributes that learners should develop: Identify and solve problems; make decisions using critical and creative writing; work effectively independently and collaboratively with others as a team; organise and manage their activities responsibly and effectively; communicate effectively through the means of various modes, such as visual or language skills; use technology and science effectively to critically show responsibility towards the environment; and demonstrate an understanding of the world as a set of related systems. All these attributes relate to the characteristics of a GIS, which can be used in the Geography curriculum to achieve desired outcomes.

Grade 5 Geography and History are considered Social Science in the CAPS document. This study focused only on Geography and subject-specific technology use. An important element in Geography as a Social Science is bringing it into the classroom, making visual resources an important tool to make information more accessible and meaningful to learners. The use of a GIS gives learners a chance to critically look at the world and exposes them to a world beyond their own realities.

The CAPS Policy outline for Geography

According to the CAPS document (Department of Education, 2011), Geography focuses on the human and physical environment. Geography involves integrating disciplines that relate to both physical and human processes, and these are examined over space and time. Geographical education therefore contributes to literacy, oracy (listening and speaking), numeracy (mathematics) and graphicacy (visual literacy) or spatial literacy.

The CAPS document (Department of Education, 2011) espouses learning constructivists' theory principles. The constructivist model asserts that "knowledge is constructed in the mind of the learner" (Bodner, 1986, p. 874) through activity and actions. It is through acting in and on the world that learners seek to find and create their own meaning. Thus, learners construct their own knowledge by actively participating in the learning process. The CAPS document (Department of Education, 2011) suggests that learners can engage with, construct and support their ideas through developing skills such as problem solving, critical thinking, communication, and effective use of technology and science.

Map Work in Grade 5 Geography

According to Van der Merwe (2016), "understanding maps and interpreting the vast amount of information contained in maps is considered an essential part of Geography" (p. 120). The CAPS document (Department of Education, 2011) alludes to this view as it places special focus on ensuring that learners engage with selected aspects of using maps and other visual sources in each grade. Furthermore, Van der Merwe (2016, p. 120) argued that "map literacy is an essential communication tool necessary to interpret complex information displayed visually through maps, a competence that cannot be ignored in the development of geographers". Thus, map literacy is a skill that should be developed in South African schools. With the introduction of digital technologies, the understanding and interpretation of maps is no longer "confined to

printed atlases" (Van der Merwe, 2016, p. 120). The use of technologies in education, such as tablets with appropriate software like a GIS in Geography, can be used as learning resources.

The Geographic Information System (GIS)

The CAPS document (Department of Education, 2011) recommends that a GIS be used to expose learners to various ways to develop map skills. The recommendation is given because a "GIS supports a number of educational goals, such as promoting inquiry processes in science and social studies, advancing problem solving in real-world contexts, and facilitating learning transfer across school subjects" (Jadallah et al., 2017, p. 2). This software can be used to contribute to the development of map analysis skills, spatial literacy, visual literacy, and numeracy. The software has been accepted as "a powerful tool for spatial analysis and problem solving" (Jadallah et al., 2017, p. 2).

Spatial literacy can be defined as a "set of abilities related to working and reasoning in a spatial world, like the ability to communicate in the form of a map, understand and recognise the world as viewed from above, recognise and interpret patterns" (Zwartjes, 2014, p. 1). Teaching spatial literacy is important because it plays an integral role in our everyday lives. For instance, spatial data is frequently used for GPS and car navigation, and this is a tool that people use often nowadays. GIS is recommended for the acquisition and management of spatial data, thus promoting the development of spatial literacy. In terms of education and "in teaching with GIS, a positive effect can be created on the development of spatial thinking and reasoning" (Zwartjes, 2014, p. 5).

Although a GIS can be used for each grade for teaching concepts in Geography, this research focused on Grade 5. By then learners in Grade 4 would have been introduced to map work as per the CAPS document (Department of Education, 2011). Given that learners have been exposed to basic map skills in Grade 4, Grade 5 is a suitable level to begin using a GIS in the development of these skills and to intervene in the understanding of the concepts while still early. This includes increasing the ability of learners to integrate spatial descriptions, reading, and analysing informational texts that become an important activity in Grades 6 and 7 and later in high school. Teachers need guidance on how best to use this valuable tool in their teaching as they interact with learners in the classroom. Given that the CAPS document (Department of Education, 2011) promotes using a GIS, the conversational framework should help identify

where a GIS can be used to enhance the dialogic relationship between the teacher and their learners as learning is developed.

Conversational Framework

The conversational framework coined by Laurillard (2002) explicitly emphasises the importance of the relationship between the teacher and the learners in terms of the dialogue between the two that should contribute to learners constructing their knowledge. It is constructivist based and aligned with the teaching approach advocated for by the CAPS document (Department of Education, 2011). According to Laurillard (2002), this framework "is intended to be applicable to any academic learning situation: to the full range of subject areas and types of topics" (p. 87). The conversational framework explicates that the learning process involves a continuous iterative conversation within the classroom that is characterised by the conversation between the teacher and learner and an independent conversation internalised by the learner or teacher alone.

The role of the teacher in this framework is to fundamentally stimulate and mediate the learning process in which learners engage with a continuous exchange of knowledge. ICTs have the potential to provide new and different ways in which this exchange of knowledge can be enhanced as learners engage in successful meaning making. The conversational framework has been used to assist teachers with the integration of technology into their classrooms. It "provides an overarching theoretical design frame for thinking about how to assist and encourage learning using technology to support meaning making" (Holmberg, 2016, p. 6). Thus, the conversational framework helps identify the role of the teacher alongside the learner where they participate in individual and collaborative meaning making (Holmberg, 2016, p. 5): "Laurillard describes how the teacher's role is to motivate the internal cycles generating and modulating the learner's concepts and practice, which is what facilitates learning".

This study used the conversational framework to provide descriptions on how this conversation between the teacher and the learner can be enhanced as a GIS is used in the learning process.

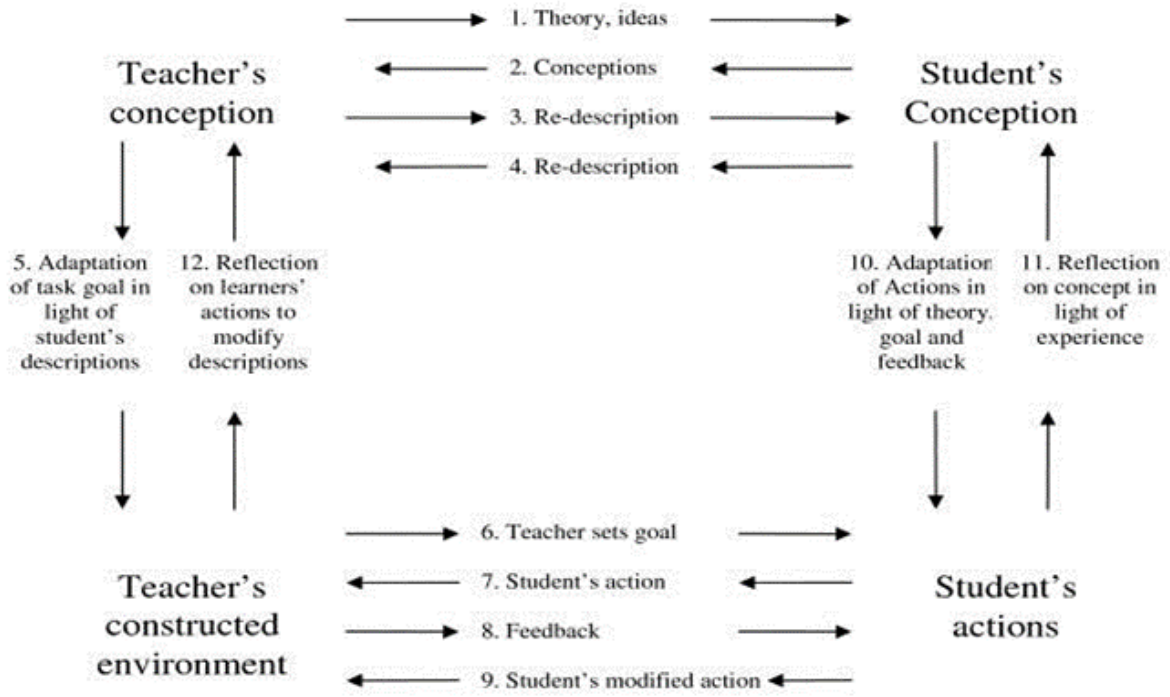


Figure 2.1: The conversational framework (Ndlovu, 2015, p. 28).

Learning activities

Laurillard (2002) mentioned that learning activities that the teacher and learners engage in during the learning process in the conversational framework firstly constitute the discursive process where the teacher and the learners share (in dialogue) the conceptions they have with regard to a particular topic. According to Laurillard (2002, p. 78), the teacher and the learners deliberate and agree upon particular desired learning goals and the teacher provides a "discussion environment for the topic goal, within which students can generate and receive feedback on descriptions appropriate to the topic goal". Secondly, the adaptive process explicates that the onus is on both the teacher and the learners to internally adapt their actions towards a particular task. Thirdly, the interactive process describes the importance of dialogue in which the teacher and learners participate to encompass the importance of meaningful feedback from the teacher, which should be used by the learners to "act to achieve the task goal" (Laurillard, 2002, p. 78). Lastly, the reflective process encourages the teacher to guide and support learners where "the student[s] must reflect on the task goal, their action on it, and the feedback they received, and link this to their description of their conception of the topic goal" (Laurillard, 2002, p. 78). Thus, the conversational framework shows us how learners are

able to transcend their own interpretations of the concepts and then adapt those pre-existing concepts to fulfil the learners' overall goals while the teacher facilitates this process.

Thus, the use of a GIS for teaching Geography means that it is used in a learning environment where teachers and learners can continuously interchange ideas as concepts are developed. For this study, it would be necessary in this interaction between the teacher and learners to locate where and how these activities are enhanced as the GIS is used to teach and develop skills in the identified Geography concept.

Media forms

A medium is a tool that is used to relay messages from one point to the next. Laurillard (2002) established five media forms that can be used in relation to this framework to assist teachers as they integrate technology into their 'conversation' with learners and their pedagogical practices. It is important to unpack the different media forms with the intent "to focus on their essential pedagogical characteristics and to identify the unique contribution made by each one" (Laurillard, 2002, p. 89). The five media forms Laurillard coined are narrative, interactive, communicative, adaptive and productive. Each media form has "different kinds of learning experiences and require different kinds of production and presentation resources" (Laurillard, 2002, p. 89).

Narrative media form

Narrative media "share the core common property that they are non-interactive, which distinguishes them from all the computer-based media" (Laurillard, 2002, p. 91). Narrative media is used to present content and the way in which content is structured. The narrative media form can be used to present content in various ways to promote learner participation and to exercise inclusivity. According to Ndlovu (2015), narrative media form should be used in a non-linear way if it will add value to the learning experience. This can be accomplished by promoting multimodality in which media, such as audio, visual, text and videos, can be incorporated into the teaching and learning process. In terms of a GIS, the representation of data for particular places can be structured to show different types of data using different features such as using videos, dynamic maps and images. This allows for content, or data in this case, to be structured in particular ways for learners to engage with. The way in which data can be structured using a GIS gives learners the opportunity to discuss and deliberate on concepts, paving the way for concepts to be described and re-described. This is particularly

important because it allows learners to engage in the process that is aligned with the discursive phase that Laurillard (2002) put forward in her framework.

Interactive media form

The important aspects of the interactive media form "from a pedagogical point of view, are the scope of the access and the nature of the user control" (Laurillard, 2002, p. 107), which allow for the learners' continuous participation in an activity. The "essence of the interactive media is to offer resources for students to explore" (Laurillard, 2002, p. 124), giving learners the opportunity to participate in learning, and thus, promoting a learner-centred educational environment. Although the use of interactive media, such as hypermedia, can provide learners with control within activities, learners are not given direction on where they should get information, leaving learners unsupervised. Therefore, feedback is an important component needed that has been a "challenge in its use in the Conversational Frameworks' learning activities" (Ndlovu, 2015, p. 31). When GIS is used within the learning environment, it is important that the learners are given the opportunity to explore and engage with the software. In order to ensure that learners can actively interact during the learning process, each learner needs to have access to GIS either on individual computers or tablets. Bearing that in mind, GIS can be used as a way for learners to explore dynamic maps and isolate particular spatial data on various maps. When learners engage with the maps, they receive feedback by the teacher facilitating their actions and with the way the maps change and adapt to the learners' actions.

Communicative media form

Communicative media aims to "serve the discursive level of the conversational framework, having the specific task of bringing people together to discuss" (Laurillard, 2002, p. 145). The main aim of communicative media is to allow for individuals to communicate together efficiently, and the determining factor of its benefit is the quality of interaction by a mediator such as a teacher. The use of "email, telephone and videoconferencing" (Laurillard, 2002, p. 145) are a few examples of particular media that can be used to support effective digital communication. GIS is not software designed for communication purposes; however, it can be used for individuals to collaborate on the same project without having to physically interact with each other. This means that learners can share data, such as maps, and construct and adapt

them to form one complete project. Therefore, GIS can be used for individuals to share and construct data collaboratively.

Adaptive media form

The adaptive media form allows individuals to use "the modelling capability of computer programs to accept input from the user, transform the state of the model, and display the resulting output" (Laurillard, 2002, p. 126). This means that the individual can receive output that can be changed to extend learning and adapt understanding of new knowledge. Examples of adaptive media forms are simulations, virtual environments and educational games. The use of GIS gives learners the opportunity to explore physical environments with images, maps and videos. The use of maps especially promotes the modelling capability of the computer that learners can engage with to change and adapt maps according to particular specifications. Therefore, GIS gives learners the opportunity to 'adapt' data in a variety of ways.

Productive media form

The productive media form is used to "enable students to produce their own contributions" (Laurillard, 2002, p. 161). In this case, learners are able to produce presentations of content and knowledge using digital applications like PowerPoint and spreadsheets. Using GIS, learners can consolidate concepts learnt by producing presentations of data by displaying maps and symbols. The productive media is important as it gives learners the opportunity to engage with knowledge and construct knowledge, which promotes "repeated reference to action by the student, and articulation of their conceptions" (Laurillard, 2002, p. 161).

Each media form has particular implications for the way GIS can be used in a mapwork lesson, and GIS affords particular opportunities that can be used to enhance a mapwork lesson. It is important to unpack various ICT affordances in relation to a GIS as this will shed light on its pedagogical value and the impact it has on the teaching and learning process.

ICT Affordances

This section mainly uses Conole and Dyke's (2004) taxonomy of ICT affordances to present the characteristics of ICTs that can be used to enhance teaching and learning. The term 'affordance' can be described as the properties of a particular object that indicates how it can be used by an individual for a particular purpose. There are 10 ICT affordances in the taxonomy, namely accessibility, speed of change, diversity, communication and collaboration,

reflection, multimodal and non-linear, risk, fragility and uncertainty, immediacy, monopolisation and surveillance. ICT affordances such as accessibility and surveillance could be used in this study given their usefulness in an education context. However, this study used only the following five ICT affordances: Multomodality, immediacy, collaboration, diversity and articulation. This is because these affordances align with the framework that were used to determine the value of GIS in teaching Geography. In this study, the term 'articulation' was used in place of the term 'reflection' because 'reflection' is something that can be "applied anywhere and anytime in the learning activity" (Ndlovu, 2015, p. 33). The term 'articulation' is derived from the productive media form that Laurillard (2002) mentioned, and it shows that a learner is able to contribute and demonstrate their understanding of the content taught. Unpacking the five ICT affordances provides clarity on the pedagogical value they can bring to teaching and learning in relation to the various media forms.

Multimodality

Multimodality is often associated with a non-linear approach to presenting material, which entails using various modes of resources and communication to explain a particular concept. This allows for the teacher to give learners the opportunity to engage with multiple sources of information depicted in various forms. The use of multimodality is linked to the narrative media form and promotes "non-linearity as learners are able to move from one type of text to the other" (Ndlovu, 2015, p. 34). This is valuable because it enables learners "to make their own links between topics, and follow their own line of investigation" (Laurillard, 2002, p. 124).

Immediacy

Conole and Dyke (2004) believed that ICTs can be used to provide effective responses for individuals to communicate. It is important that during the teaching and learning process, the teacher and learners have the "opportunity to get feedback instantly" (Ndlovu, 2015, p. 34), which is a vital component needed to modify and develop learning. Therefore, in this ICT affordance, the reconstruction of concepts can happen during the learning process to alleviate misconceptions.

Collaboration

ICTs have made it possible for individuals to form learning environments, so individuals can communicate with each other on the basis of shared or similar interests. Similarly, in

communities of practice individuals can 'connect' with each other using ICTs. Conole and Dyke (2004) explained that this affordance allows for the establishment of connections with other individuals. Individuals are able to engage in the learning process in which information can be constructed and shared through collaboration with others. In fact, with the use of ICTs, such as the computer, "the Internet will open up new learning opportunities, enabling new types of 'knowledge-building communities' in which children and adults around the globe collaborate on projects and learn from one another" (Resnick, 2011, p. 61).

Diversity

This particular affordance describes the value ICTs bring where learners get an opportunity to engage with different people's experiences, allowing learners to expand on their own knowledge, going beyond their own experiences. Simulations are a good example of giving learners the opportunity to go beyond their everyday experiences. Although some "authors express reservations on the validity of simulations" (Ndlovu, 2015, p. 35), they give learners the opportunity to engage with real-life problems. Therefore, utilising this affordance in education enables learners to engage with and delve deeper into experiences, exposing them to new experiences to acquire knowledge, also enabling diversity and inclusivity.

Articulation

Laurillard (2002) mentioned the importance of having learners construct their own descriptions of the world. This affordance allows individuals to produce models in which to depict and present their opinions and views of knowledge, giving learners a voice in knowledge construction.

Ndlovu (2015) used Laurillard's (2002) media forms to identify the pedagogical value they can bring into a variety of activities in any learning process. The framework in Table 2.1 helps identify the value in the use of ICTs, and in a way, it captures the concepts discussed so far.

The implementation of a GIS in the Geography classroom can engage specific affordances and add pedagogical value to the classroom. The evidence column in Table 2.1 portrays what will be visible in the use of the technology in the teaching and learning experience.

Table 2.1: Analytical tool developed by Ndlovu from Laurillard's media forms and Conole and Dyke's taxonomy of affordances (Ndlovu, 2015, p. 106)

Media forms	Affordances ⟶	Evidence ⟶	What pedagogical value does it add?
Narrative	Non-linear	Multimodality	Apprehending structure/ connections
Interactive	Immediacy	Immediate feedback	Exploring: misconceptions amended
Communicative	Collaboration	Discussion: class/ group	Re-descriptions of concepts
Adaptive	Diversity	Reproduction: experiment/ role play	Concretising theory: practice
Productive	Articulation	Product: animation/model	Knowledge construction

What remains now is knowing how and when the affordances of media forms within a GIS would be engaged in a lesson. The legitimation code theory (LCT) is unpacked and explored in the following section to further understand where a GIS can be used during a lesson and the implications thereof.

The Legitimation Code Theory (LCT)

The LCT developed by Karl Maton "is a sociological framework for researching and informing practice" (Maton, 2020, p. 62). Thus, this theory can be used as a diagnostic tool that allows for knowledge building and the process of cumulative knowledge building to be analysed in the context of a lesson. The use of the LCT framework is becoming an increasing prominent feature in research today because "LCT is being used not only to interpret the world in various ways but also to change it" (Maton et al., 2016, p. 3). LCT makes fundamental reference to Bernstein, who explored the idea of 'codes' and their use as 'descriptions of the world'.

Semantic gravity and semantic density

The term 'semantic gravity' can be described as the way in which meaning relates to a particular context. The stronger the semantic gravity (SG+), the more dependent the meaning is on its context, and the weaker the semantic gravity (SG-), the less dependent the meaning is on its context. Semantic gravity is a dynamic concept in which it is possible for an individual to analyse the change over time by exploring the "weakening of semantic gravity, such as moving from the local to particulars of a specific case towards generalisations; and strengthening semantic gravity, such was moving from generalized ideas towards concrete and delimited cases" (Maton, 2020, p. 63).

Semantic density, on the other hand, refers to the "degree of condensation of meaning within practices" (Maton, 2020, p. 63), which dictates the degree of complexity within a particular practice. The stronger the semantic density (SD+), the more meanings are condensed together, creating a complex practice, and the weaker the semantic density (SD-), the fewer meanings are condensed together, resulting in a simpler practice. In terms of practice, this may refer to terms, concepts, expressions or gestures that is embodied in particular practices. It is important to note that all practices are characterised by the concepts of semantic gravity and semantic density, and the difference between the practices lie within the strength of the semantic gravity and semantic density.

Semantic gravity and semantic density affect the description and the 'journey' the teacher takes when engaging in a particular practice as depicted on a semantic wave.

Semantic waves

A concept derived from the LCT is the concept of semantic waves. Semantic waves describe the journey a learner follows in the learning process. This journey comprises of "shifting between expert and novice understanding, abstract and concrete context, and technical and simple meanings" (Raspberry Pi, n.d., p. 1).

Figure 2.2 illustrates the way in which the teacher can downshift and upshift from "simpler, contextualized meanings towards more complex, decontextualized meanings" (Maton, 2020, p. 77), which results in supporting learners during the learning experience to understand technical terms and concepts within a particular subject.

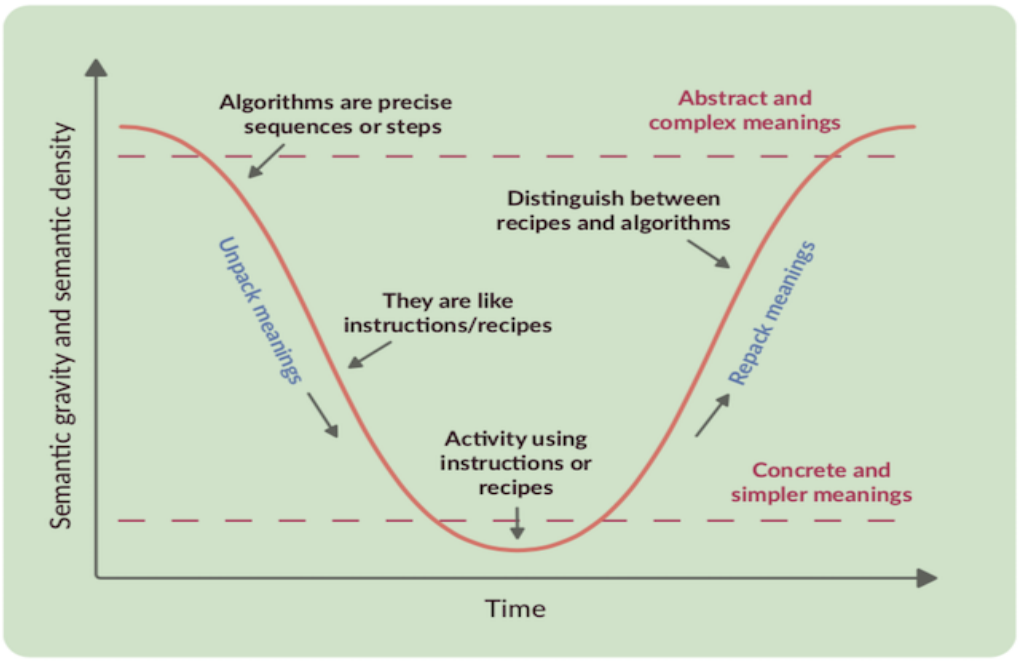


Figure 2.2: A descriptive figure of a semantic wave (Raspberry Pi, n.d., p. 1)

A semantic wave cannot be identical across any two learning situations and will vary according to what is suitable for what purpose, with who and what level of expertise within a particular academic discourse. Figure 2.2 shows the semantic wave starting at a high level (abstract and complex meanings) but semantic waves often can begin at a low level (concrete and simpler meanings). In terms of the semantic wave in a lesson, the teacher aims to transform "academic discourse into everyday discourse and then back again, weaving together different forms of knowledge to explain a key aspect of the knowledge students are being asked for by the question" (Maton, 2020, p. 77).

To master map work and concepts in Geography and to develop map skills and spatial literacy, it is important that learners are able to master the terminology used in map work as well as acquire a deep understanding of the concepts used in that particular domain. If jargon is merely used for explanations and the cumulative building of knowledge consists of building complex concepts on top of another, teaching and learning map work can be a difficult task. Therefore, "the secret to providing good learning experiences is to make your explanations and learning activities follow Karl Maton's (2013) semantic wave structure" (Curzon, 2020, para. 27).

The purpose of a semantic wave

The concept of a semantic wave has been used as a translation device that "provides the means of distinguishing different degrees of strength of semantic gravity and of semantic density"

(Maton, 2020, p. 67). The nature of a semantic wave can be used to illustrate a learning pathway that shows the shifts between complex concepts and general experiences. “Semantic waves involve recurrent movements in the SG [semantic gravity] and SD [semantic density] of knowledge” (Hassan, 2017, p. 101), thus paving the way to sequence lesson steps to enhance the teaching and learning process.

The CAPS document “aims to ensure that children acquire and apply knowledge and skills in ways that are meaningful to their own lives” (Department of Education, 2011, p. 4), while “being sensitive to global imperatives” (Department of Education, 2011, p. 4). Further, the aim of the CAPS document is to promote the knowledge and context learners engage with to progress from simple to complex, hence explicating for cumulative knowledge building (Department of Education, 2011). According to Maton (2020, p. 81), “almost everyone in education shares a desire for cumulative knowledge-building, but this requires tools that can explore the organizing principles of knowledge practices”. The semantic wave is one of those valuable tools. Thus, the semantic wave can be used to illustrate a particular learning pathway that should give learners the opportunity to access more complex knowledge over time, promoting a good learning experience.

This study uses a semantic wave to illustrate how to sequence a lesson incorporating a GIS. Having identified the pedagogical value of a GIS, the aim was to locate where on a semantic wave different lesson steps can be located and locate where a GIS can be used. Thus, the semantic wave were used to describe the journey the teacher and the learners can take during the lesson. The aim was to explain how concepts can be explained by “moving from abstract concepts towards concrete, everyday life examples (‘unpacking’), but also on the ability to move knowledge from concrete real life situations towards abstract theorization (‘repacking’)” (Hassan, 2017, p. 101).

The following section discusses the conceptual framework that were used to respond to the research questions.

Conceptual Framework

While the conversational framework describes the 12 activities that come into play during the interaction between the teacher and the learner, there is a need to measure the pedagogical value that the GIS affordances bring to the understanding of concepts. It is for that reason that the conceptual framework in Figure 2.3 was used to answer the research questions.

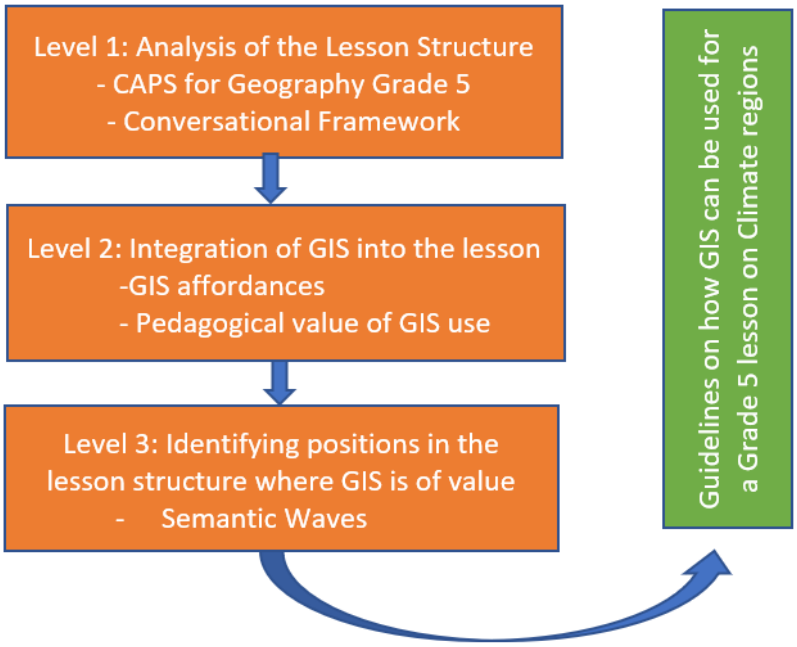


Figure 2.3: The conceptual framework

The conceptual framework in Figure 2.3 begins with Level 1 in which the conventional lesson structure is analysed and unpacked in terms of the conversational framework. Level 2 describes the GIS affordances that can be used during the lesson and the pedagogical value it could bring to the lesson. Level 3 describes the way each lesson step can be located on a semantic wave. All the levels work collaboratively to demonstrate and describe particular guidelines for using a GIS in a mapwork lesson.

Thus, this study used the theoretical frameworks discussed in this chapter and the conceptual framework to illustrate and recommend how using a GIS in Geography can allow learners to engage in a meaningful learning experience that allows them to acquire terminology and a thorough understanding of the concepts.

Chapter 3: Research Design and Methods

The aim of this research was to investigate the role of a GIS in Geography and to demonstrate how it can be implemented to teach concepts in a way that can enhance the learning experience. The research design for this study adopted a conceptual research approach to answer the research questions.

For this specific research, a conceptual design was used. This type of design involves understanding and analysing already present information about the research topic. Thus, "concept analysis is associated with the research design of philosophical inquiry" (Botes, 2002, p. 24), and "the purpose of philosophical inquiry is to perform research using intellectual analysis to clarify meaning" (Botes, 2002, p. 24). This specific type of research design does not use practical experiments or observations. A conceptual research design allows the researcher to systemically provide explanations and accounts pertaining to a particular phenomenon based on knowledge obtained from other research with the intent to build a theoretical model. Because the research was purely conceptual, it involved clarifying ideas and arguments concerning concepts and ideas, which in this case focused on a relationship between GIS and how it can be used to teach specific concepts in Geography. Thus, a conceptual framework is important when conducting this research.

The conceptual framework in Figure 2.3 demonstrates how information was gathered to show how a GIS can be used to enhance the learning experience in a particular lesson.

Research Method

An outline of a lesson plan in which the use of technology is not evident were developed to describe the steps a Grade 5 Geography teacher could take using a GIS to teach learners particular concepts. This study focused on using this model of the lesson plan alongside the conceptual framework to illustrate and demonstrate ways in which a GIS can be used to teach concepts. This helped answer the research question: How can the use of a GIS enhance the learning and teaching of vegetation regions in South Africa in the Geography classroom?

The analysis of a Geography lesson

Level 1: It is important to identify the lesson steps from the lesson plan example that is aligned to CAPS that is used to teach vegetation regions in South Africa in Grade 5 without the use of

technology. Figure 3.1 presents the sequencing of the lesson steps adapted from an Intermediate Phase Teacher's Guide from the Western Cape, South Africa (Western Cape Education Department, n.d.).

The semantic wave was used to make sense of what exactly the teacher and the learners do in each step.

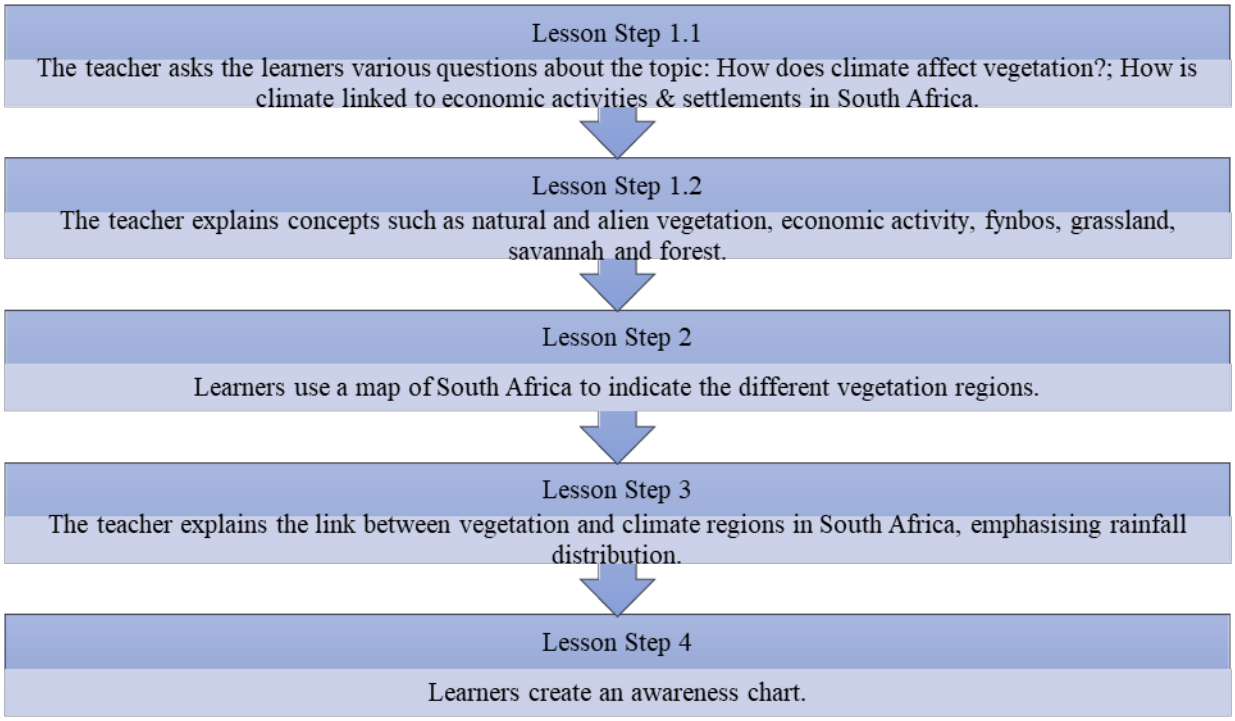


Figure 3.1: The proposed lesson steps for the Geography lesson (adapted from Western Cape Education Department, n.d., p. 17)

Level 2: Identify the features and affordances of a GIS that could be used during this lesson. Ndlovu's (2015) analytical framework were used to help determine what is of pedagogical value in the use of ICTs. It is important to locate the learning activities the teacher and learners will engage in during this lesson (Laurillard, 2002). This informs the way in which a GIS could be implemented for specific activities to enhance these activities between the teacher and learners.

Level 3: Identify the possibilities of using a GIS in each step based on its features and affordances, which were derived from Level 2. Once the learning activities were established, the semantic wave were used to possibly locate where the learning activities can take place. LCT were used to locate the possibilities of using a GIS as part of the learning activities and demonstrate how it could be used based on the semantic wave. Using the descriptions of the

semantic wave informed the way learning activities can unfold when using a GIS during particular learning activities.

Table 3.1 was used with its colours to locate the value of a GIS in the Grade 5 lesson presentation. The colours were used to locate the pedagogical value a GIS brings to the lesson.

Table 3.1: Analytical tool to determine what is of pedagogical value in the use of a GIS, with colour codes (Ndlovu, 2015, p. 106)

Media Forms	Affordances	Evidence	What Pedagogical Value Does It Add
Narrative	Non-linear	Multimodality	Apprehending structure/connections
Interactive	Immediacy	Immediate feedback	Exploration: Misconceptions amended
Communicative	Collaborative	Discussion: Class/group	Re-descriptions of concepts
Adaptive	Diversity	Reproduction: Experiment/role play	Concretising theory: Practice
Productive	Articulation	Product: Amination/model	Knowledge construction

Figure 3.2 illustrates how the value of a GIS can be located once the semantic wave of the lesson presented above has been established.

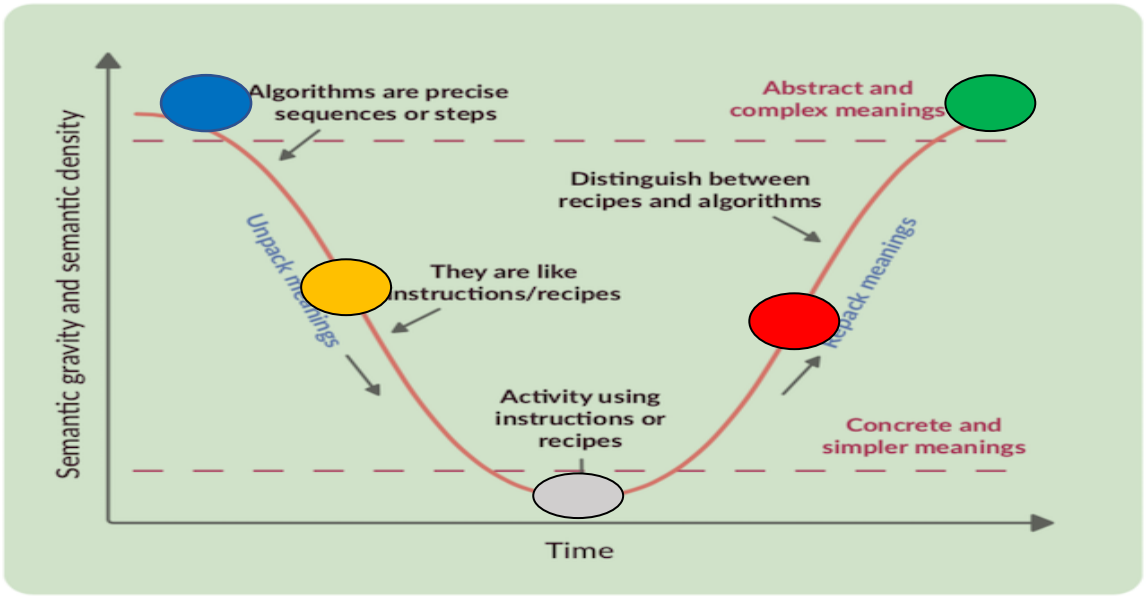


Figure 3.2: The pedagogic value of a GIS is placed on the semantic wave (Raspberry Pi, n.d., p. 2)

Figure 3.2 of a semantic wave is an example of how the value of GIS affordances was located during a learning experience. The affordances mentioned are associated with the use of a GIS. The framework informed how a GIS can be used throughout a lesson and allowed the

researcher to be in a position to recommend and demonstrate ways a GIS, as part of ICT integration, for Grade 5 Geography can be used effectively to teach particular concepts in Geography as per the CAPS document.

The use of the concepts of the semantic wave and the affordances were used to map out a model of a semantic wave to illustrate how a teacher can teach a particular concept in Geography with a GIS.

Ethical Considerations

This study is conceptual and document based and was therefore not subject to ethics protocols, except in terms of obtaining a waiver of the ethical clearance from the University of the Witwatersrand School of Education Ethics Committee.

Chapter 4: What Is a GIS?

According to Zerger et al. (2002, p. 67), "a geographic information system (GIS) is a computer-based system for managing, storing, analysing, modelling, and visualising spatial information". The aim of a GIS is to allow individuals to better understand spatial patterns and relationships in relation to the earth's surface. A GIS has a variety of tools and approaches that can be used to understand and analyse the world we operate in. It has been praised as an invention that "has transformed the way we describe and study the earth" (Kidman & Palmer, 2006, p. 290).

GIS is not a new invention. The concept of a GIS emerged in the early 1960s, and the first devices were commissioned by the Canadian government. Over the years, a number of researchers contributed to the development of the GIS. The implementation of 'computer map-making software' and a focus on spatial analysis emerged, generating great interest in this system. In early 1981, more tools and methods were developed that could be used abroad. This led to the first commercial GIS. Over time the GIS shifted from being a concept to a science. Today, the GIS is used in many disciplinary spaces, with a special focus on data sharing and collaboration. There is no doubt that the GIS will continue to evolve, especially with the progression of computers and technology because "today, hundreds of thousands of organizations are sharing their work and creating billions of maps every day to tell stories and reveal patterns, trends, and relationships about everything" (University of Washington, 2020, para. 7).

A GIS produces electronic maps in which data is produced in the form of symbols, lines, polygons and points. Spatial data plays a crucial role in a GIS as this type of data is linked to a particular location and coordinates is used to locate the area. The most common geo-referencing system used to locate a particular area is the lines of latitude and longitude. On a map, spatial data is represented by points, lines and polygons (Figure 4.1), known as vector data. In terms of vector data, "using points, lines or polygons all depends on which features of the map you want to represent with greater detail" (Pieters, n.d., p. 8).

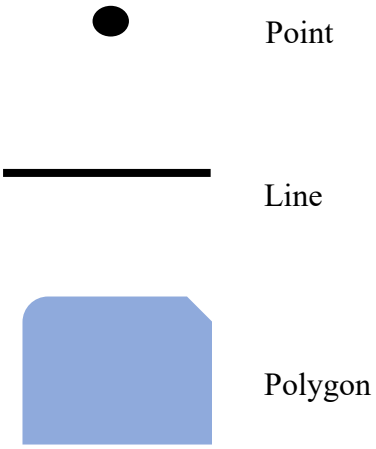


Figure 4.1: Vector data

The point is often used to discretely represent a specific location on a map. The line is commonly used to represent boundaries, such as provincial and national borders, as well as to represent rivers, streams and transportation routes, such as roads. The user can use the polygon to represent particular objects or areas, such as a building, a vegetation patch or dams.

Raster data is also used in a GIS and uses pixels to define a particular feature in a particular location. Evidently, "because raster data represent square areas, they describe interiors [the interiors of the feature] rather than boundaries [the shape of or surface of a feature] as in the case with vector data" (Pieters, n.d., p. 9). Vector data and raster data represent the same features but in different ways, and each format will best suit the type of information that needs to be represented. Vector data is useful for storing data, whereas raster data works to store specific coordinates of a particular location or feature. Figure 4.2 illustrates the differences between vector and raster data.

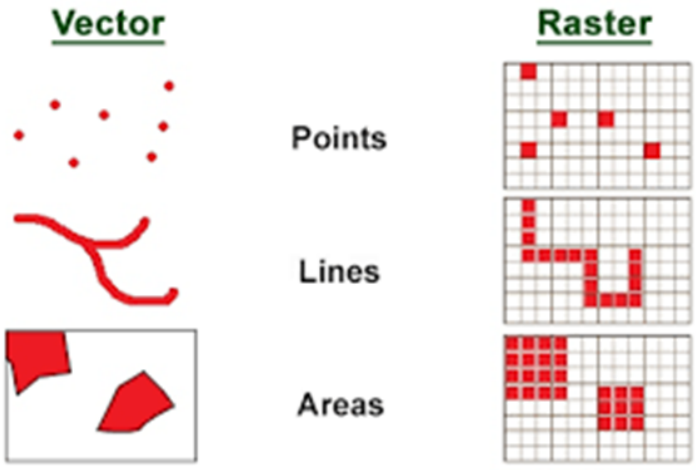


Figure 4.2: Comparing vector and raster data (Yusuf, 2016)

There are an array of tools and applications that can be used in a GIS, and for this study these features and their affordances were closely analysed to get the best from the software.

"Research initially focused on teaching about GIS" (Goldsmith, 2016, p. 9) and has since "moved on to consider teaching with GIS" (Goldsmith, 2016, p. 9). The CAPS document recommends using a GIS in Geography lessons is to give learners the opportunity to develop map competencies and spatial literacy (Department of Education, 2011). This recommendation came because a "GIS supports a number of educational goals, such as promoting inquiry processes in science and social studies, advancing problem-solving in real-world contexts, and facilitating learning transfer across school subjects" (Jadallah et al., 2017, p. 2). It is therefore important to unpack the affordances and pedagogical value a GIS has and the role it can play in adding value to the teaching and learning process.

What Affordances and Pedagogical Values Do a GIS Have?

Before answering this question, it is important to identify and explain the terminology are used. According to Laurillard et al. (2000), "affordances is a word now in common currency in describing characteristics of the learning process" (p. 3).This means that the affordances of technologies are the opportunities they present to the individual or their environments, which can be used beneficially for particular situations and scenarios. In this case, the affordances of technology can be used to stimulate and enhance the teaching and learning process in the schooling environment. ICT Pedagogical value can be described as the advantage of using technology to enhance the learning process, and thus, a GIS is analysed to see in what ways it can add value to the Geography lesson. Thus it is important to identify the affordances a GIS has and the pedagogical value it can bring to the Geography lesson. According to Conole and Dyke (2004, p. 122), "by making the affordances explicit in the form of a taxonomy it will be possible for practitioners to make more informed choices about the ways in which different technologies can be used". Table 3.1 is used to describe the affordances and pedagogical value that a GIS has.

A media form describes the type of features that can be used, and in this case the features are from the GIS. The feature has particular affordances associated with it, and so to understand what features and their affordances can be used for the learning process in the Geography lesson, it is important to unpack the different media forms.

Adaptive media form

The adaptive media form, as coined by Laurillard (2002), is the first media form analysed in relation to a GIS. The affordance the adaptive media form promotes is diversity. It gives individuals the opportunity to concretise theory and practice. The crucial underpinning definition of diversity is giving individuals the opportunity to engage with an array of opinions and information other than their own and use it to establish their own well-informed understanding. In addition, its ability to present information in different representations optimises the learning experience. South African classrooms have a diverse population of learners. Thus, it is important to promote and engage with different information through diverse views and opinions and "provide a means for individuals to understand the point of view other than their own" (Driscoll, 2005, p. 397).

The adaptive media form refers to computer programs that have capabilities "to accept input from the user, transform the state of the model, and display the resulting output" (Laurillard, 2002, p. 126). This means that the computer should have the capability of storing information from the user, process the information and display the results of that action. The GIS can do this, as indicated when discussing its features. The display result is not a stagnant output but rather a dynamic output. This means that the results can be viewed and displayed in many different, 'diverse' ways, and the user can access these different forms by using the GIS.

Models

An important element in a GIS is the use of models as representations of the world, which give individuals "an important toolbox that can help to improve [the individuals] understanding of the world" (Huisman & De By, 2009, p. 49). In terms of a GIS, a model is a form of representation of the real world and its phenomena. This representation "will have certain characteristics in common with the real word" (Huisman & De By, 2009, p. 49). In a GIS there are different models that come in different flavours in which real-world phenomena can be presented (Huisman & De By, 2009). This is the diversity ICT affordance that gives individuals access to different ways to understand and represent the real world.

Map

According to Huisman and De By (2009), "in the GIS environment, the most familiar model is that of a map" (p.49), which is used to represent real-world phenomena. Maps have been

used for thousands of years to depict and display various information about the world. Paper maps have always been used, but over the years, digital maps emerged, transforming the way maps are used. Paper maps present common challenges as they can only display two-dimensional static representations and represent information on a fixed scale without giving the whole picture(Huisman & de By, 2009, p. 51). Digital maps allow the user a view of different aspects of an area as they adapt it to suit their needs, and all this can happen on one screen and be saved for future use (Figure 4.3).

With new technology revolutionising maps, “the dominance of paper maps is eroding in today’s increasingly ‘digital world’” (Huisman & De By, 2009, p. 51). Digital maps, as found on a GIS, allow for more user flexibility, which means maps can be far more easily arranged and adapted depending on its purpose. In fact, “they allow animations and simulations to be carried out by the computer system” (Huisman & De By, 2009, p. 49).

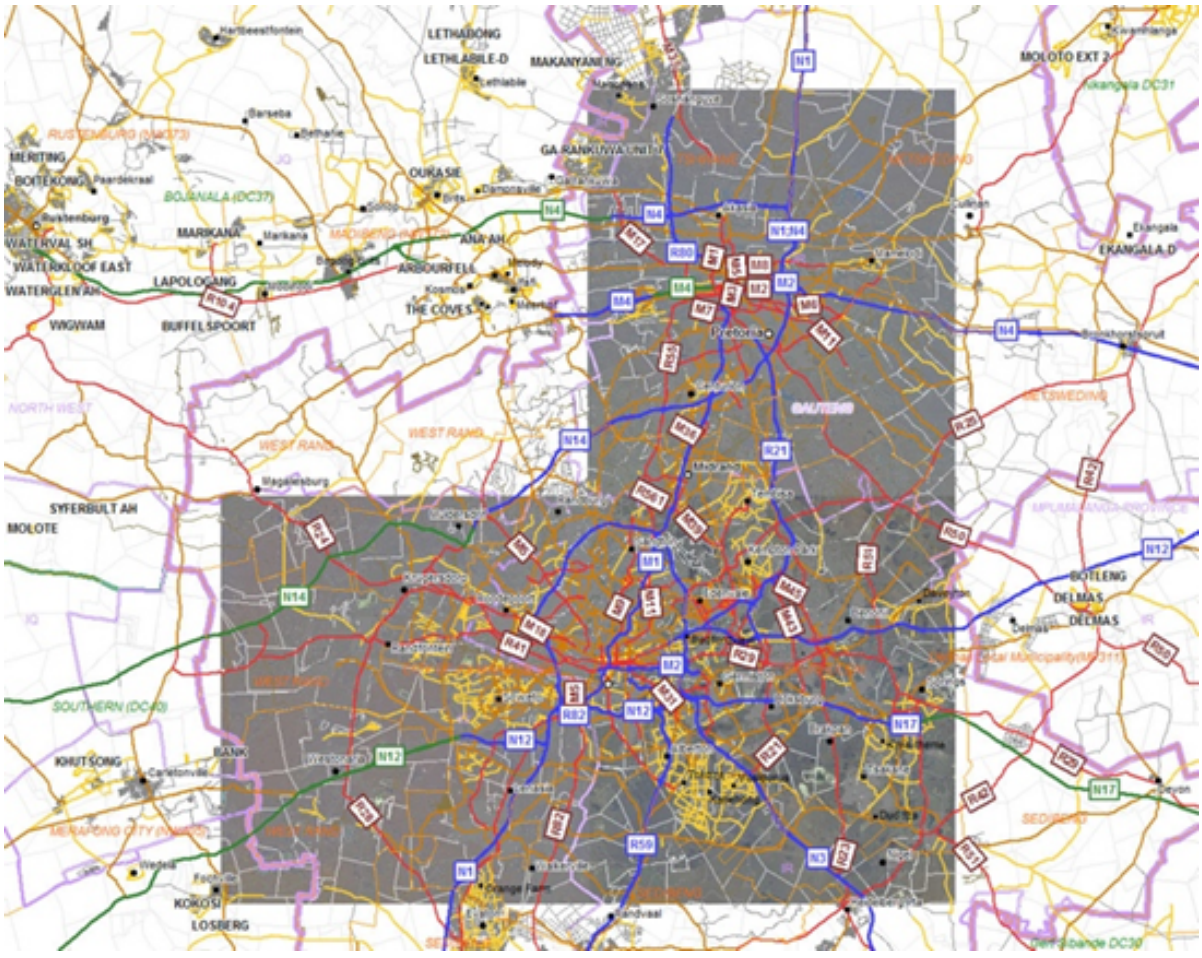
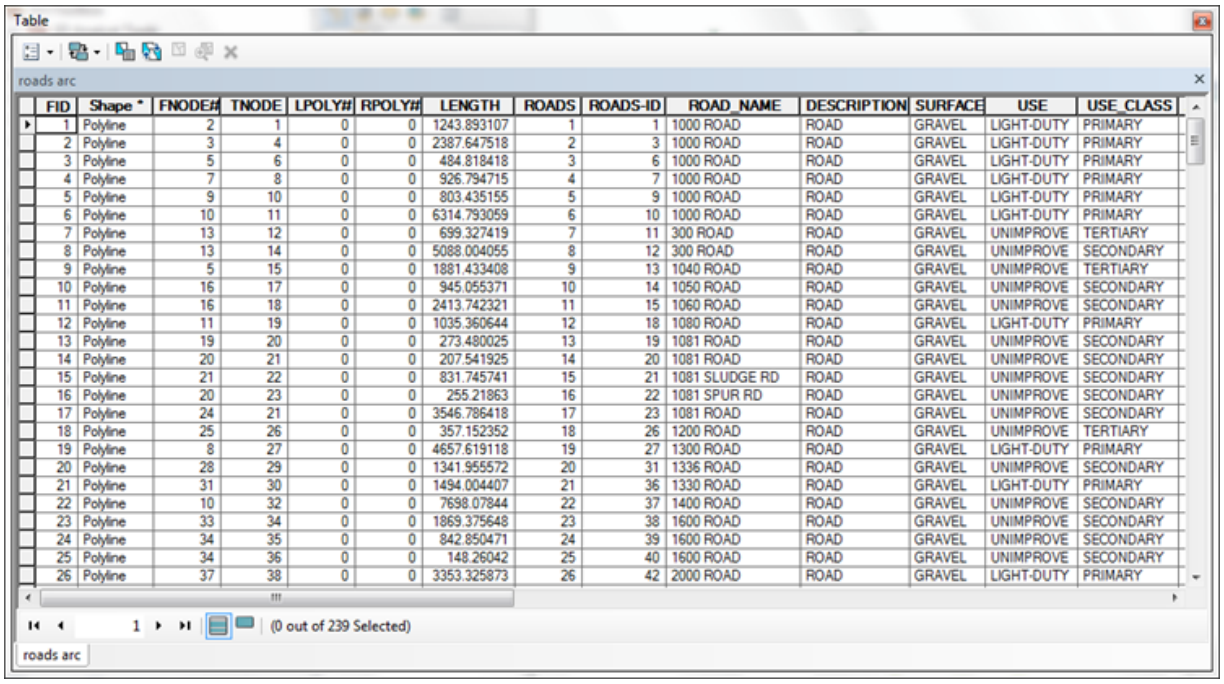


Figure 4.3: An electronic orthophoto map of an area in Gauteng, South Africa (Planet GIS, n.d.)

Database

Although the most popular way to represent information about the world is by using a map, using a database as a medium to store data is often preferred. Similar to a map, a database is "a repository for storing large amounts of data" (Huisman & De By, 2009, p. 53), and one of its advantages is that it can store data of any nature. Often modern databases display data in a tabular format that can later be used in a spreadsheet. The benefit a database is that it enables concurrent use, which means that multiple individuals can access the database at the same time. "Tabular information can be stored as tables in folders or databases, text files, queries on databases and so on" (What is GIS?, n.d., para. 4), and an attribute table is commonly used in a GIS to store data, shown in Figure 4.4. An example of a database in a GIS is an attribute table presented in Figure 4.4.


Table

roads arc

FID	Shape *	FNODE#	TNODE	LPOLY#	RPOLY#	LENGTH	ROADS	ROADS-ID	ROAD_NAME	DESCRIPTION	SURFACE	USE	USE_CLASS
1	Polyline	2	1	0	0	1243.893107	1	1	1000 ROAD	ROAD	GRAVEL	LIGHT-DUTY	PRIMARY
2	Polyline	3	4	0	0	2387.647518	2	3	1000 ROAD	ROAD	GRAVEL	LIGHT-DUTY	PRIMARY
3	Polyline	5	6	0	0	484.818418	3	6	1000 ROAD	ROAD	GRAVEL	LIGHT-DUTY	PRIMARY
4	Polyline	7	8	0	0	926.794715	4	7	1000 ROAD	ROAD	GRAVEL	LIGHT-DUTY	PRIMARY
5	Polyline	9	10	0	0	803.435155	5	9	1000 ROAD	ROAD	GRAVEL	LIGHT-DUTY	PRIMARY
6	Polyline	10	11	0	0	6314.793059	6	10	1000 ROAD	ROAD	GRAVEL	LIGHT-DUTY	PRIMARY
7	Polyline	13	12	0	0	699.327419	7	11	300 ROAD	ROAD	GRAVEL	UNIMPROVE	TERTIARY
8	Polyline	13	14	0	0	5088.004055	8	12	300 ROAD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
9	Polyline	5	15	0	0	1881.433408	9	13	1040 ROAD	ROAD	GRAVEL	UNIMPROVE	TERTIARY
10	Polyline	16	17	0	0	945.055371	10	14	1050 ROAD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
11	Polyline	16	18	0	0	2413.742321	11	15	1060 ROAD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
12	Polyline	11	19	0	0	1035.360644	12	18	1080 ROAD	ROAD	GRAVEL	LIGHT-DUTY	PRIMARY
13	Polyline	19	20	0	0	273.480025	13	19	1081 ROAD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
14	Polyline	20	21	0	0	207.541925	14	20	1081 ROAD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
15	Polyline	21	22	0	0	831.745741	15	21	1081 SLUDGE RD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
16	Polyline	20	23	0	0	255.21863	16	22	1081 SPUR RD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
17	Polyline	24	21	0	0	3546.786418	17	23	1081 ROAD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
18	Polyline	25	26	0	0	357.152352	18	26	1200 ROAD	ROAD	GRAVEL	UNIMPROVE	TERTIARY
19	Polyline	8	27	0	0	4657.619118	19	27	1300 ROAD	ROAD	GRAVEL	LIGHT-DUTY	PRIMARY
20	Polyline	28	29	0	0	1341.955572	20	31	1336 ROAD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
21	Polyline	31	30	0	0	1494.004407	21	36	1330 ROAD	ROAD	GRAVEL	LIGHT-DUTY	PRIMARY
22	Polyline	10	32	0	0	7698.07844	22	37	1400 ROAD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
23	Polyline	33	34	0	0	1869.375648	23	38	1600 ROAD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
24	Polyline	34	35	0	0	842.850471	24	39	1600 ROAD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
25	Polyline	34	36	0	0	148.26042	25	40	1600 ROAD	ROAD	GRAVEL	UNIMPROVE	SECONDARY
26	Polyline	37	38	0	0	3353.325873	26	42	2000 ROAD	ROAD	GRAVEL	LIGHT-DUTY	PRIMARY

1 (0 out of 239 Selected)

roads arc

Figure 4.4: An attribute table representing a database of different roads (University of Washington, 2013)

An important component in the success of a GIS is the attribute data that provides information on a feature and so "expresses a number of qualities and characteristics of the vector data and raster data" (Pieters, n.d., p. 13). Often attribute data is displayed in a tabular format, but this data is shown on a map with symbols, labels or graduate colours. An attribute table constitutes a particular layer "of spatial information in the GIS" (Pieters, n.d., p. 14). The attribute table consists of fields located vertically and is used to organise data according to the feature.

Horizontally, the table has rows that indicate the attributes of a particular entity (Pieters, n.d., p. 14). An attribute table is a functional way to store, capture and anaylse spatial information of a particular feature or location.

Images

A GIS uses various illustrations, such as graphs and images, to represent particular phenomena of the world. These types of illustrations are linked to spatial data captured on a database, such as an attribute table. It gives individuals using a GIS the opportunity to explore different models of data and represent data in different formats.



Figure 4.5: An image of an area in Gauteng, South Africa (Planet GIS, n.d.)

Figure 4.3 and Figure 4.5 are both illustrations of the same area, depicting the same data but in different formats. Thus, data can be stored and accessed in various ways, demonstrating its diversity. Although Figure 4.4 illustrates data on an attribute table of roads, it is also a different way of representing spatial data. These illustrations show that the “forms of representation

adopted by a discipline embody both a way of looking at the world and a description of it from that perspective" (Laurillard, 2002, p. 48).

Although it is evident that a GIS can promote the ICT affordance of representational diversity that enables the user to depict information using different models, we need to know how this brings about pedagogical value in a South African classroom.

The capability of a GIS to store and display information about the world in a number of ways gives individuals in the classroom the opportunity to "swiftly and dynamically represent the world and its issues from a variety of spatial perspectives" (Goldsmith, 2016, p. 10). Learners can represent the findings of the world from their own perspective, share it with their peers and acknowledge the diverse interpretations of the phenomena of the world; this promotes collaboration and productivity. An array of representations of data gives teachers the opportunity to "generate exercises for students in exploring the relationship between the three forms of representation, progressing to generating their own versions to describe a similar situation" (Laurillard, 2002, p. 51).

In terms of the diversity ICT affordance, a GIS "facilitates the integration of content matter and expertise from varied core subjects" (Liu & Laxman, 2009, p. 21). This means that a GIS incorporates interdisciplinary subjects, allowing learners to draw skills and knowledge from other subjects. Therefore, a "GIS thus has the capability to support cross-disciplinary curricular emphasis" (Liu & Laxman, 2009, p. 22), broadening the use of knowledge and skills and not isolating them to a particular subject domain. Depending on the pedagogical preference of the teacher, teamwork can be promoted and achieved by using a GIS. Although this particular point are unpacked further in the upcoming media forms, collaboration gives learners the opportunity to engage with different perspectives. Therefore, "the sharing of ideas and learning from one another, students become tolerant of perspectives that might be opposed to their own and appreciate the eclectic diversity of different world views on issues of mutual concern" (Liu & Laxman, 2009, p. 22), and re-descriptions occur as a result of collaboration.

Narrative Media Form

When one talks about technology affording the possibility of individuals accessing information in a non-linear way, the emphasis is on ensuring that all learners have access to content in an array of formats. Interactive multimedia such as videos, images, audio and texts are popular ways in which information can be depicted in different ways. A fundamental advantage is that

learners can access many sources of information about the same topic, subsequently allowing learners to "construct knowledge from a number of angles to improve their efficiency of information transfer and the depth of understanding" (Jianhong, 2010, p. 1980), thus, promoting productive and adaptive processes.

An affordance that emerges from the use of a GIS is the "main principle of data organisation applied in GIS system … that of a spatial data layer" (Huisman & De By, 2009, p. 124). A spatial layer is a representation of a collection of objects that normally have the same characteristics. For example, all main roads can be represented in a layer while all main roads can be located in another layer. Figure 4.6 shows the spatial data that different layers can represent. Often layers are analysed in isolation, but it is possible to integrate the different layers to form one representation of the world. A feature of a GIS is that the layers can be overlaid (Huisman & De By, 2009, p. 124), allowing individuals to analyse and study geographic phenomena in isolation as well as study the relationship between geographic phenomena.

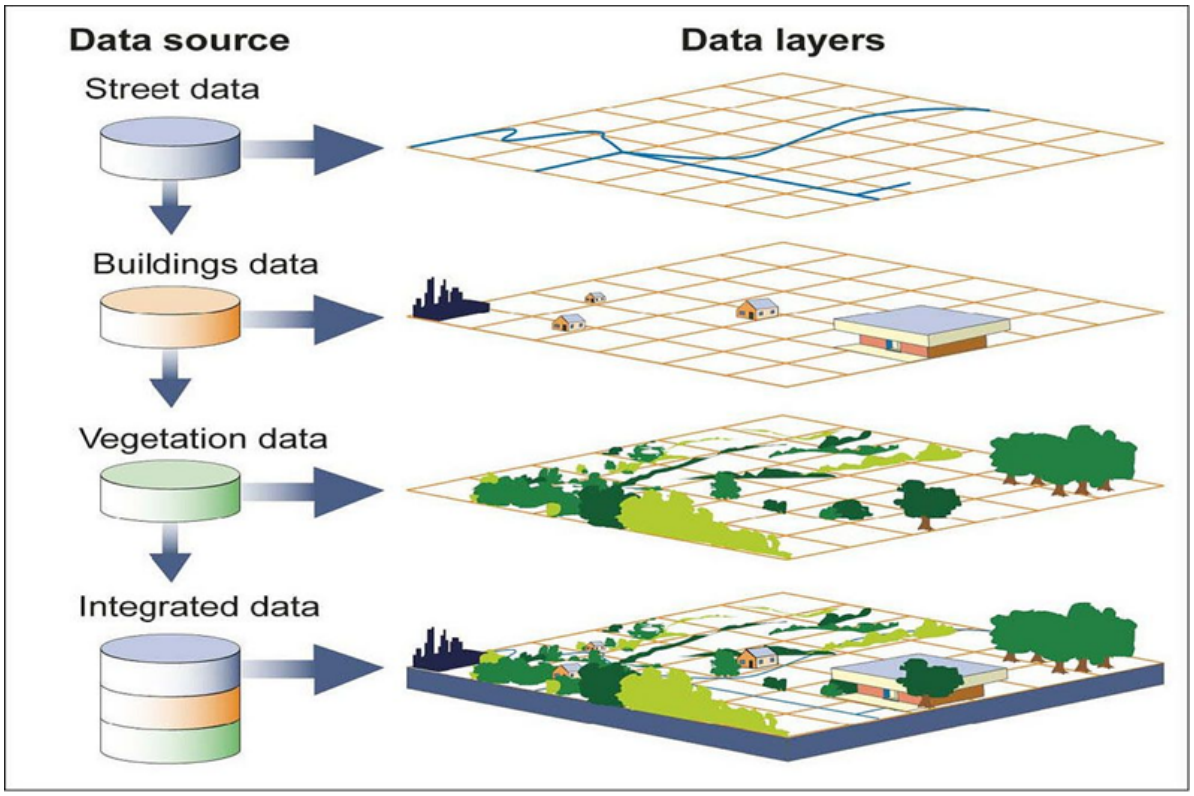


Figure 4.6: Data layers in a GIS (National Geographic, Resource Library)

According to Pieters (n.d., p. 17), "the power of a GIS comes from the ability to relate different information in a spatial context and to reach a conclusion about this relationship". A GIS allows

individuals to integrate various forms of data to develop particular information about a location or feature. A GIS "can be used for mapping and studying the spatial distributions of various social phenomena including events, placements and organisational services" (Pieters, n.d., p. 22). Thus, the advantage of a GIS is the affordance of linking unrelated data through which a new set of information can be developed for a spatial point. "Environmental studies, geography, geology, planning, business marketing, and other disciplines have benefited from GIS tools and methods" (Pieters, n.d., p. 32), and thus it is important to investigate how a GIS can be used in a disciplinary space such as education.

For this study, the capability of non-linearity by a GIS is important because learners are able to isolate layers to analyse vegetation regions, climate regions and rainfall distribution in South Africa. The layers can then be overlaid, giving learners the opportunity to determine, analyse and display the connections between concepts. This allows learners to apprehend structures and connections. Learners are given the chance to construct links between layers of geographic phenomena, allowing them to use different layers to engage with different information to understand the real world. However, Laurillard (2002, p. 55) states that "these apparently direct experiences of the world are mediated by the teacher, contextualised within the course, and encountered within the way the subject is being taught"

Not only do the different layers of data afford the representation of data in various ways, but the affordance of visual presentations in terms of colour schemes and colour gradient further gives learners an opportunity to engage with multiple sources of information depicted in various forms, acknowledging ICT affordances such as diversity and non-linearity.

Productive Media Form

An important part of any learning process is having learners articulate the learnt content so that the teacher can identify that learning has occurred. This involves ensuring that pedagogy incorporates knowledge construction.

The term 'productive' emphasises engaging in a process of production. As already mentioned during the adaptive media form, a database is a model used in a GIS to store and analyse data for a particular location. Although learners can represent data with the different models used in a GIS, a "Microsoft interface [can be used] to access and integrate different data types, including geographic database, raster, spreadsheets and images" (Astroth, 2008, p. 114). The data from attribute tables can be exported to Microsoft applications such as Excel. This means

that data captured on maps and databases from a GIS can be represented and exported to other applications. In terms of the affordance articulation and promoting knowledge construction, learners have the opportunity to construct knowledge using the different models in a GIS. Learners can produce a product of the data collected in a spreadsheet, text document and images such as tables or pie charts by selecting particular data from the table and only exporting the selected data (Figure 4.7). Furthermore, "online maps can be exported as PDF files and used in printed or digital reports and PowerPoint presentations" (Esri, 2002, p. 4).

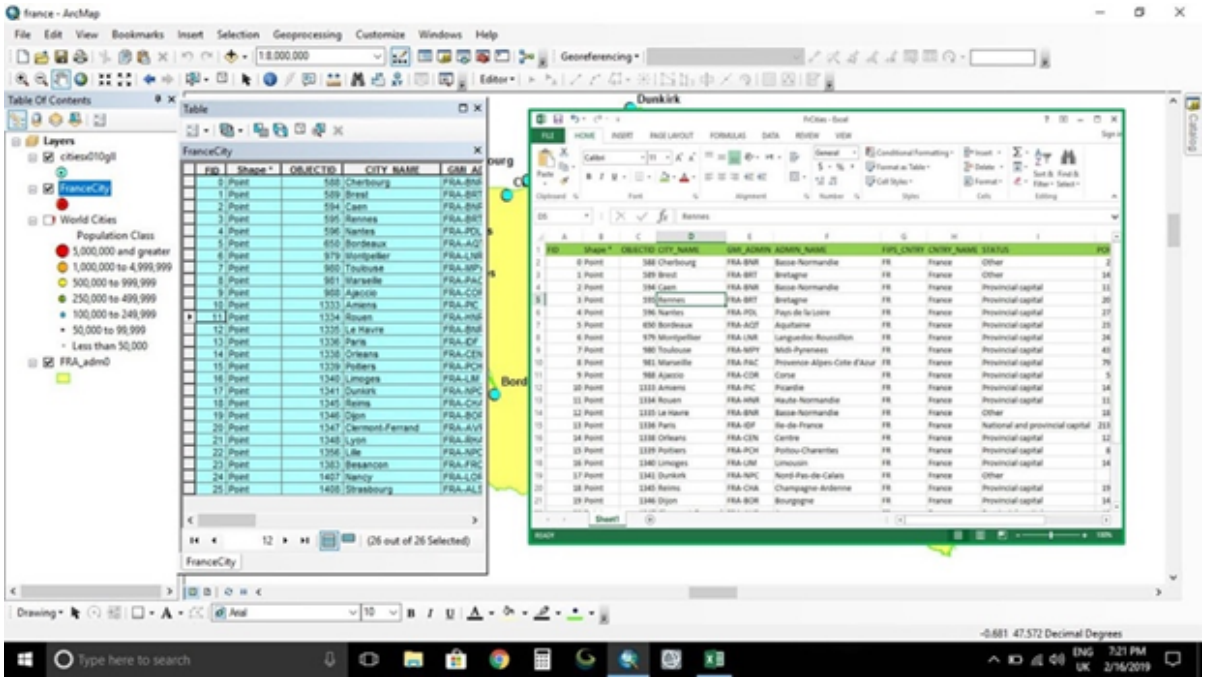


Figure 4.7: An attribute table being exported to a Microsoft spreadsheet (Made 4 Geek, 2019)

This is important because it gives learners the opportunity to engage with applications that "deal with geographic data creation, import and editing, data integration and management, data manipulation and organisation, and data analysis, mapping and reporting" (Maguire, 2008, p. 26). Learners can use these options to articulate their understanding of the world or the particular concepts engaged with during a lesson. Furthermore, a GIS gives learners the opportunity to display spatial data (see Figure 4.8) in a complete figure with headings and keys.

Figure 4.8 shows how learners can present a complete document of spatial data. Learners can insert headings, keys (which represent different layers of data), a scale and a compass. Therefore, when learners have successfully identified the data for vegetation regions, climate regions and rainfall distribution in South Africa, they will be able to successfully articulate their findings in the format illustrated in Figure 4.8. Learners can export such an illustration to

any Microsoft application such as Word or PowerPoint. This means that the ICT affordance of articulation enables learners to use a GIS to produce and represent their understanding of concepts in particular ways. As already mentioned, the GIS paves the way for data to be represented and accessed in several ways and thus promotes productivity.

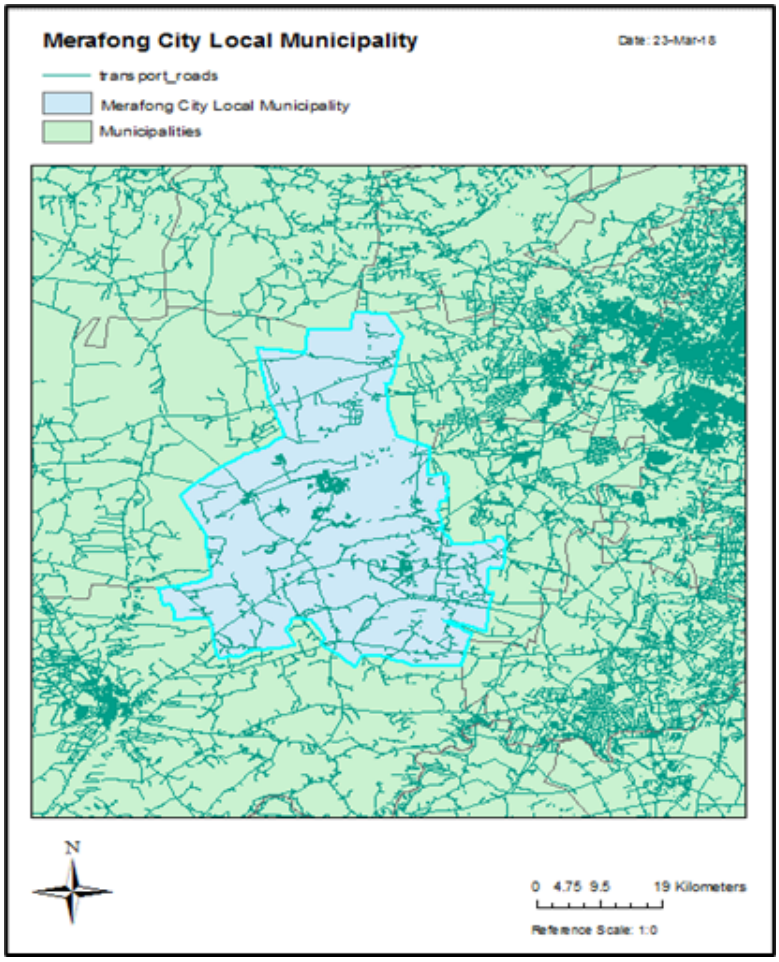


Figure 4.8: An illustration of spatial data

Communicative Media Form

Collaborative learning environments have increasingly become a popular way of learning, and knowledge is acquired in the process. This type of learning environment has been greeted with pleasure by many because "the collaboration approach allows participants to work in different places or at different times" (Jing et al., 2019, p. 1). The communicative media form thus unpacks the collaboration ICT affordance. Collaboration gives pedagogical value through the re-descriptions of concepts to the learning experience.

With the revolution of digital technologies, 'communities of practice' have been supported by the affordances that various technologies have. A community of practice is often associated with individuals forming a group with similar beliefs or shared ideas that can be discussed. Wenger (1998) described a community of practice as "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (p. 2), and so "they have conceived of communication as a representation of shared belief" (Driscoll, 2005, p. 397). The potential for individuals to share ideas and work together to access knowledge has been deemed necessary where "the cognitive demands of modern work which makes the collaboration and networking of different expertise necessary for successful problem-solving" (Lehtinen et al., 1999, p. 5). It is suggested that promoting community of practice "may also encompass meaningful relationships and respect for diversity" (Veletsianos, 2016, p. 245).

A GIS exhibits "the anywhere-anytime characteristic and its potential to support interactive group learning" (Kreijns et al., 2002, p. 9) and makes for a popular approach to education. Individuals can access a GIS at any time from any device that has an internet connection, such as a smartphone, computer or tablet. This enables data to be shared among individuals and organisations. Many researchers prefer a GIS for having the ability to foster collaborative learning environments (Liu & Laxman, 2009, p. 22). This promotes a learner-centred environment, giving learners an opportunity to discuss and work together. The affordance of collaboration means individuals can co-construct knowledge as a community.

"Team-based engagement with GIS-enabled problem-solving tasks" (Liu & Laxman, 2009, p. 22) means that learners work together and they "engage in discursive dialogues and constructive argumentation to tap the expertise and knowledge of their fellow students to model consensual problem solving approaches" (Liu & Laxman, 2009, p. 22). Learners can conceptualise concepts in order to identify problem-solving strategies. An important part of this process of collaboration is the ability for learners to work together in order to describe and redescribe concepts. Working together or 'team-based engagement' encourages individuals to engage with one another. Driscoll (2005) stated that "collaboration in learning environments is to provide a means for individuals to understand a point of view other than their own" (p. 397). Therefore, individuals discuss various perspectives (promoting diversity), as suggested during the discursive process of the conversational framework (2002), allowing for continuous re-description of concepts.

Interactive Media Form

It is important that during the teaching and learning process there is room for continuous reflection for both the teacher and learners, because "as we learn about the world through acting on it, there is continual feedback of some kind" (Laurillard, 2002, p. 55). The ICT affordance immediacy, as mentioned by Conole and Dyke (2004), promotes just that, engaging with effective feedback and allowing individuals to explore concepts and amend misconceptions.

Liu and Laxman (2009, p. 17) acknowledged that learning has been successfully achieved and improved by the immediate feedback learners tend to receive when working with a GIS. Dangermond (2009) also applauded the GIS as it affords the possibility of providing "instantaneous feedback in the form of maps, charts, and statistics and enables rapid testing of multiple design services" (para. 9). According to Laurillard (2002, p. 55), "intrinsic feedback is that which is given as a natural consequence of the action". An example of this in terms of a GIS is that learners will experience feedback when they "adjust the movement [of the mouse] to its manifestation on the screen" (Laurillard, 2002, p. 55). This could involve using maps, databases or isolating layers of spatial data. On the other hand, feedback in terms of the teacher providing guidelines that operate at the level of descriptions of actions is known as 'extrinsic' feedback (Laurillard, 2002, p. 55). This type of feedback is about giving learners appropriate information on how to adapt their performance or actions.

A fundamental feature that is lacking in a GIS is that the software does not support "reflective wizards to provide directed feedback" (National Research Council, 2006, p. 182). This means that when using a GIS in the classroom, it is important that the teacher "devise situated actions that elicit meaningful intrinsic feedback for the student, or redescribe the student's description in a way that gives meaningful intrinsic feedback to the student" (Laurillard, 2002, p. 58).

It is evident that a GIS affords various teaching and learning possibilities that bring pedagogical value to the classroom experience. All of Ndlovu's (2015) five affordances were identified in this analysis as having the potential to enhance the teaching and learning of mapwork with a GIS. The next step for this study is to identify positions in the lesson structure where the use of a GIS can be of value. This means locating areas in the lesson structure using the conversational framework and a semantic wave where a GIS can be used to enhance the teaching and learning process.

Chapter 5: Integrating a GIS into the Lesson

The lesson that is the focus for this research is a Grade 5 lesson on vegetation regions in South Africa. According to the CAPS document, this lesson is taught in term three (Department of Education, 2011). It is important to note that according to the CAPS document, learners would have already engaged with the concepts of rainfall distribution and climate regions before this lesson and the concepts of vegetation regions is the part of the lesson that is integrated with GIS (Department of Education, 2011).

The aim of this lesson is to introduce to learners the nature of vegetation regions and form links between the concepts engaged with previously, such as climate regions and rainfall distribution. It is important to note that the responses included are merely anticipated responses from learners. For this study, it is important that the lesson is broken down into different lesson steps that can be analysed. The duration of this lesson is approximately 3 hours, as according to the CAPS document (Department of Education, 2011), and so will need to be completed over a number of sequenced lessons, which should be decided by the teacher. Teachers are given a proposed way to deliver this lesson, indicated in Figure 3.1, and this chapter demonstrates how GIS can be integrated into its delivery.

In order to provide a thorough analysis of the selected lesson, each lesson step will be analysed using the conceptual framework illustrated in Figure 2.3. The conceptual framework is used as a step-by-step guide to analyse this particular lesson. The intent of this chapter is to unpack the lesson to provide suggestions on which phase each lesson step is situated in the conversational framework (2002), as indicated in Figure 2.1. The use of the conversational framework allows the role of GIS to be located to enhance the teaching and learning process. Suggestions are made for which GIS feature or media form should be used, and the affordance and pedagogical value it bring to each lesson step is demonstrated. To conclude, the nature of the semantic wave produced by each lesson's structure is illustrated.

Lesson Step 1.1

This lesson step presents the educator using questions and answers to introduce the topic of vegetation regions. The questions that could be posed to the learners lay a sound foundation for understanding a) how climate affects vegetation and b) how climate links to economic activities and settlements in South Africa.

According to the conversational framework (Laurillard, 2002), in this first step of the lesson both the teacher and the learners engage in the discursive process. According to Laurillard (2002), this meant that there needs to be a "a continuing iterative dialogue between teacher and student, which reveals the participants' conceptions, and the variations between them, and these in turn will determine the focus for the further dialogue" (p. 71).

The discursive process does not only entail a question-and-answer dialogue between the teacher and learners, but this process also entails agreeing on the learning goals for the topic (Laurillard, 2002). The dialogue between the teacher and learners promotes continuous access to the conceptions of the topic as they interact with one another (Laurillard, 2002), and the discussion of the topic goal is arranged so that "students can generate and receive feedback on descriptions appropriate to the topic goal" (Laurillard, 2002, p. 78). This is illustrated in Figure 5.1.

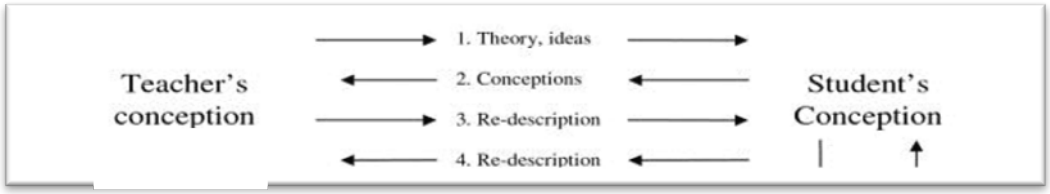


Figure 5.1: The discursive process (Ndlovu, 2015, p. 28)

This learning activity is situated "at the conceptual level", in which "the teacher explains something orally and the individual student or peers asks a question or generates an articulation of his/her own conceptualisation" (Holmberg, 2016, p. 5). So, in this discussion between the teacher and the learners "the teacher can then answer the question and give feedback on the articulations" (Holmberg, 2016, p. 5). This feedback from the teacher prompts the learners to alter their descriptions and establish the correct re-description of the concepts. This process "is represented as a series of activities by the teacher and student at the level of descriptions of the topic goal" (Ndlovu, 2015, p. 29), which in this case is the understanding the vegetation regions.

In the context of this study, the teacher should 1) explain the concepts, 2) explain vegetation regions, and 3) form links between climate regions and rainfall distribution, which are terms that are used throughout the lesson (Department of Education, 2011). In the process, learners get an opportunity to share their own conceptions of the concepts while the teacher guides and

enriches this experience using GIS features. The steps attempt to mimic a real classroom lesson and therefore includes both the teacher's and the learners' interaction.

To make the teacher aware, there are particular hardware specifications needed for the lesson, such an interactive whiteboard, speakers, and a projector.

Introduction

The teacher may initiate the conversation by asking an introductory question aimed at linking knowledge from experience to "stimulate learning interest to accept new lesson[s] and focus their attention on the lesson" (Widodo, 2020 pg. 124). This is aimed at preparing learners for the video they will watch and to give them a feel of the topic they will cover. The conversation may go as follows:

Teacher: Has anyone heard of the Kruger National Park? And if so, what do you know about it?

Learners' responses may be:

Learner 1: It is a place where you can find many wild animals.

Teacher: That is correct, but is that all?

Learner 2: There are different kinds of trees and plants; a lot of them.

Teacher: That is good. I know that not all of you have been to the Kruger National Park, and I have prepared a video that should help all of us have the same experience so we can engage with today's topic from the same level of understanding.

As you watch the video, I would like you to focus on the types of plants, known as vegetation, and trees found in this area and think about the type of climate that would promote it.

The teacher plays the 5 minute video created from a GIS displayed on the interactive board.

The video player is integrated into the GIS (see Annexure A) by collecting ground features on a map, such as topographies in the Kruger National Park, compiling the information and displaying it as a video to the learners. This feature on GIS gives the teacher an opportunity to pause, fast forward, zoom in or out and replay a video with the intent to later identify and explain features found on the map as the teacher elaborates on the concepts.

The video played from the GIS at this stage is used as a narrative media form aimed at giving learners a description of the type of vegetation they can use to link or connect with the ideal climate. The teacher needs to point out specific aspects of the video and narrate where needed as the video plays.

The following is an example of a discussion the teacher and learners may have after viewing the video:

Teacher: Can you add anything to what was said earlier about the vegetation in the Kruger National Park?

Learner 1: There are similar types of plants in this area.

Teacher: Indeed. This is a place where specific types of animals and plants are often found. Did you know that the Kruger National Park is just one example of a vegetation region found in South Africa? Can anyone tell me what they think a vegetation region is?

Learner: Maybe it has something to do with plants in different places.

Teacher: Yes, it can have something to do with plants, but more specifically where and why particular plants, known as vegetation, grow in specific areas or regions in South Africa.

The teacher can then refer back to the video and ask learners what they saw during the video, such as what plants did they see in the video, and if learners do not know their names yet, it can be a good opportunity to get learners to describe them. A key question during this conversation might be: Why do these types of plants grow in the Kruger National Park? This interaction between the teacher and the learners probes for concepts to be explored.

Incorporating a GIS at this point of the lesson can mean that the teacher provides visuals that make explicit the connections between vegetation and climate as other regions and their climates are explored. This is a non-linear way of using the images and the information from the video as part of the discussion. The video in this instance constitutes a narrative media form and intends to display content in a structured way (Ndlovu, 2015, p. 30). The video does not intend to promote interactivity, but it provokes a discussion, which aligns with the discursive process. The use of the GIS enables the learners to apprehend structures (characteristics of vegetation regions) and connections between the regions and the climates. The video is not only used to introduce the concepts, but once the discussion has taken place, the video is used as a point of reference to reinforce what is discussed as the topic is developed.

It is recommended that after this interchange, the teacher gives learners a short exercise where they match the covered vegetation regions and climates on their tablets. Software like Mentimeter can be installed on their tablets so they can take the quiz for the teacher to determine if they understood the lesson. Misunderstandings can be tightened in the next lesson step.

Conclusion

In this first step, the teacher used GIS as a narrative media for its multimedia affordances by using the video and images to understand vegetation regions and how they relate to different climates, and in doing so concretised their understanding. It is therefore used as an adaptive media as learners get to see and experience the structure and connections. When a GIS is used to create content, the teacher uses it as a productive media to introduce the topic. The interaction happens as the teacher and learners help in the re-description of misconceptions that may exist. In this case, the communication media form is used and enhanced by the use of a GIS to extend the basic understanding (relationship between a vegetation region and climate from the Kruger National Park example) to the other regions and climates. This is enhanced by the visuals that help the learners establish their understanding of the concepts.

Lesson Step 1.2

To extend learners' understanding about the topic, the educator is expected to explain the concepts that are associated with the topic for this lesson step. These are natural and alien vegetation, economic activity, fynbos, grassland, savannah, and forest.

As per the conversational framework (2002), similar to the lesson step 1.1, the teacher and the learners engage in the discursive process depicted in Figure 5.1. There is still continuous engagement and conversation between the teacher and the learners at a conceptual level, where conceptions are shared between the teacher and the learners.

Introduction

At this point of the lesson the learners can engage with images on the GIS, which aims to provide some information about the different types of vegetation found in particular regions and to engage with the terminology associated with the lesson. Similar to step 1.1, the teacher and learners engage in a dialogue based on the images used, which are aimed at identifying and unpacking descriptions of their world.

The teacher can use images on the GIS of the different concepts to be unpacked. The teacher begins by asking the learners to summarise what it is that they saw in the image that are displayed on the whiteboard. Learners can summarise the images displayed by verbally providing descriptions of the image, and the teacher can guide learners on what aspects to focus on. For example, the teacher can use the GIS to map out where indigenous vegetation and alien vegetation are found in South Africa. The map from the GIS is at this stage used as a narrative media form to give learners a description of how vegetation can be classified. Figure 5.2 shows one map displaying indigenous regions and another map displaying alien vegetation regions in South Africa.

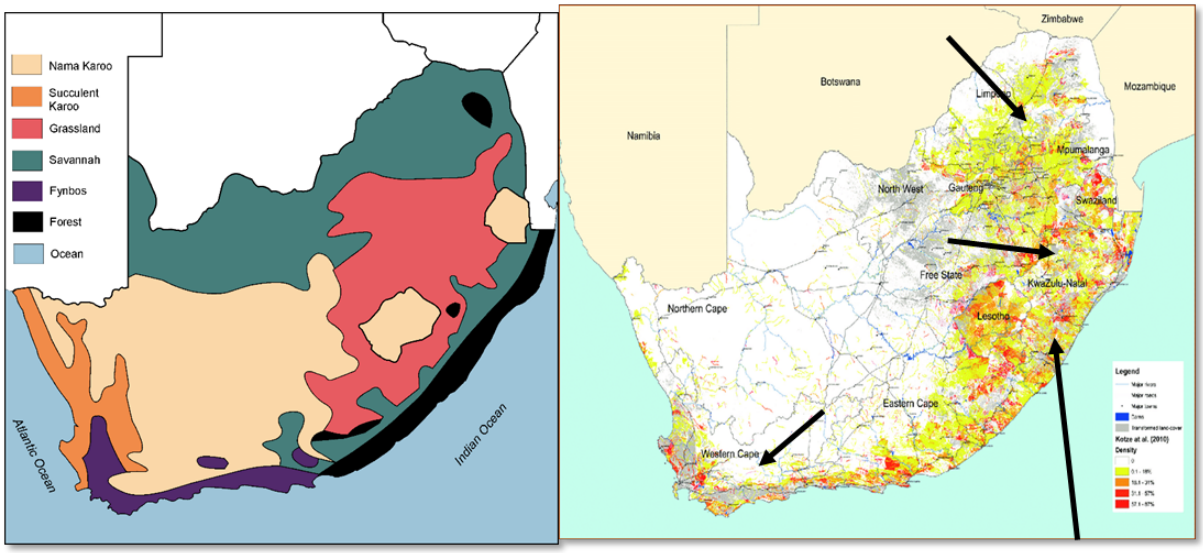


Figure 5.2: Indigenous vegetation vs alien vegetation in South Africa (Daniel Williamson, OpenStax cnx, Rice; Giordano, Thierry & Blignaut, James & Marais, C, 2012)

The teacher can begin the following dialogue to elaborate on indigenous and alien vegetation:

Teacher (using arrows on the map to indicate where the regions can be found): There is what is called indigenous and alien vegetation in some regions in South Africa. Does anyone know what indigenous vegetation means?

Learner 2: Indigenous vegetation is the plants that are known to grow in an area, and alien vegetation are plants that do not grow in an area naturally.

The teacher can extend learner understanding by saying the following:.

Teacher: Indigenous vegetation is known to grow in specific regions and so originates from a particular place. For example, Rooibos is a plant that originates in South Africa. This means that this plant is commonly found

in South Africa and nowhere else in the world. This is why many places in the world might not offer you Rooibos tea.

Alien vegetation is plants that do not naturally grow in South Africa and were brought to South Africa from other countries. *(The teacher can refer to the images displayed by showing learners where some alien vegetation is found and can extend this by providing more examples of bluebottle trees, spider gum trees and mistflower).*

After this, the teacher can give learners a quiz, using any quiz tool, where they match vegetation and where they are found and determine whether they are alien or indigenous.

The teacher may continue the dialogue by presenting more terminology to the learners, such as economic activity where the teacher can use another map to display the different economic activities in South Africa because of the different types of vegetation. In groups learners can figure out what economic activities would take place in specific vegetation areas using a map as in Figure 5.3 from the GIS.

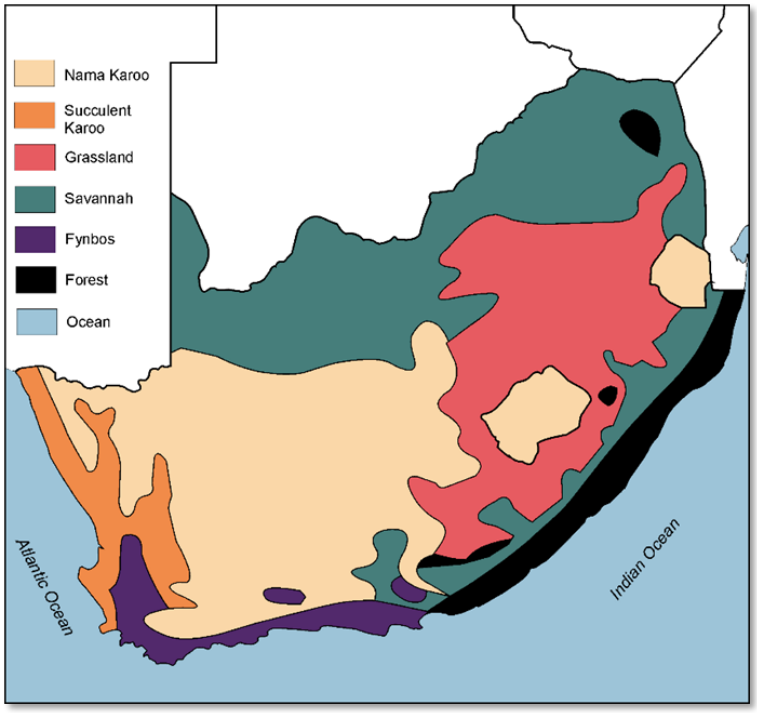


Figure 5.3: Using a GIS to isolate vegetation regions in South Africa (Daniel Williamson, OpenStax cnx, Rice)

With the guidance of the teacher the class can discuss concepts that can be described and elaborated on by the learners in which the "learner is able to expose his or her interpretations

of given descriptions" (Ndlovu, 2015, p. 28). There can be continuous back and forth articulation and re-articulation of the concepts and ideas between the teacher and the learners. Eventually the learners "demonstrate the same or similar 'descriptions of the world' as that of the teacher" (Ndlovu, 2015, p. 28).

After the teacher isolated the vegetation regions in South Africa using a map on the GIS (Figure 5.3), the teacher can begin to pose questions to learners about what is on the map. The teacher goes through each vegetation region briefly using the key located on the map. Here the teacher elaborates briefly on concepts such as the different plants, climate aspects and economic activities associated with the vegetation region. The teacher will go into more detail about each vegetation region in the next lesson step.

Conclusion

The GIS affords the possibility of enhancing the lesson by giving learners the opportunity to explore the concepts using visuals such as images and maps. This means that the teacher used the GIS in this lesson step as a narrative media. The images were used to introduce terminology, such as indigenous and alien vegetation, and the different vegetation regions and to spark discussions in groups and as a class with the intent to concretise their understanding. Similarly to step 1.1, the GIS was used as an adaptive media form as learners started to experience and establish structures and connections.

Lesson Step 2

Since the previous lesson steps focused on understanding the concepts, this particular lesson step focuses on engaging learners with a task based on the concepts articulated and discussed in the discursive process. Learners are required to use a map of South Africa on a GIS to indicate and identify the different vegetation regions. For this particular lesson step, there is a combination of processes and activities that the teacher and learners can engage in. According to the conversational framework (2002), they engage in activities found within both the adaptive process and the interactive process.

First, activities in the adaptive process depicted in Figure 5.4 enables both the teacher and the learners to 'adapt' or adjust "their actions at task level in light of the discursive process at the description level" (Ndlovu, 2015, p. 29). Inevitably, "adaptation also occurs as a part of the process of reflecting on tasks, as a result of comparing the teachers' descriptions and the

students' understanding as it is applied to the task" (Lee, 2006, p. 14), which may also happen to a lesser extent in the earlier steps as the teacher establishes learner understanding as learning is developed.

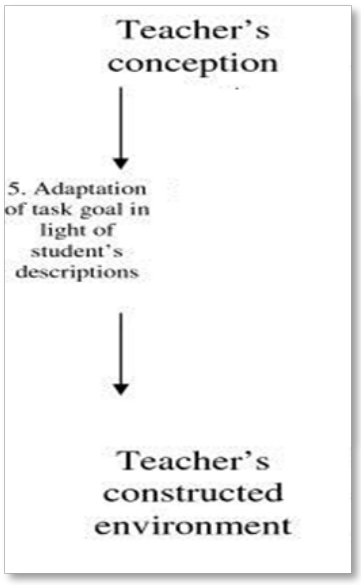


Figure 5.4: The adaptive process (Ndlovu, 2015, p. 28)

The intent is that the task will evoke a dialogue between the teacher and the learners, because at this stage of the adaptive process it is important that teachers adapt "both their delivery of theory and the task environment as apparent (mis)understandings become evident from learner actions/articulations" (Lee, 2006, p. 14). For example, if the learners struggle to locate the vegetation regions in South Africa, it is a cue for the teacher to adapt the task by providing scaffolding by using instructions or by illustrating an example of locating vegetation regions, giving learners a foundation to work with. The intent is to have learners locate vegetation regions so that each region can be unpacked and discussed.

The teacher and learners must engage in the interactive process during which feedback is appropriately generated and extended to the learners based on their actions when engaging with the task. At this point of the interactive process depicted in Figure 5.5, the learning environment promotes "setting and aiming to achieve the task goal, giving and acting on feedback" (Ndlovu, 2015, p. 29) in relation to the task. Particular actions and articulations are generated from their engagement with the task, and it is here where the teacher provides "meaningful intrinsic feedback" (Laurillard, 2002, p. 78) to the learners based on their actions. Therefore, the teacher and the learners engage in an active interactive process that allows the learners to achieve the

set goal. It is a conversation of constructive feedback that promotes the modification of learners' actions that allows learners to apply the theory to the task.

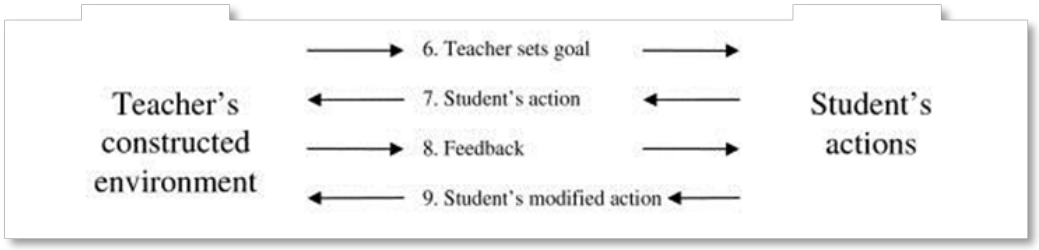


Figure 5.5: The interactive process (Ndlovu, 2015, p. 28)

Introduction

For step 2 learners engage with a map on a GIS based on the descriptions made during the discursive process. Learners are required to adjust and adapt their actions at the task level according to concepts realised at the conceptual level.

A GIS can be used during these processes when learners engage with the set task. The GIS affords the possibilities of using the layer function. This allows learners to isolate particular vegetation regions and display them. Before learners are given an opportunity to locate vegetation regions using GIS, the teacher goes through an example with them first, which may look as follows:

> *Teacher*: The Kruger National Park is known as a savannah region; just one of the many vegetation regions in South Africa. Characteristics of a savannah region are dry and rainy seasons. *(Images can be shown of these characteristics using the GIS)* So, in the winter it is quite dry, and in the summer there is a lot of rainfall in this region. All year round it has a warm climate, and in the summer it can become very hot. There are many different types of plants (vegetation), and one of the commonly known plants is the baobab tree. A variety of animals are also found in savannah regions, such as zebras, elephants and lions, to name a few. We can locate the savannah regions in South Africa using the GIS. Let's give it a try.

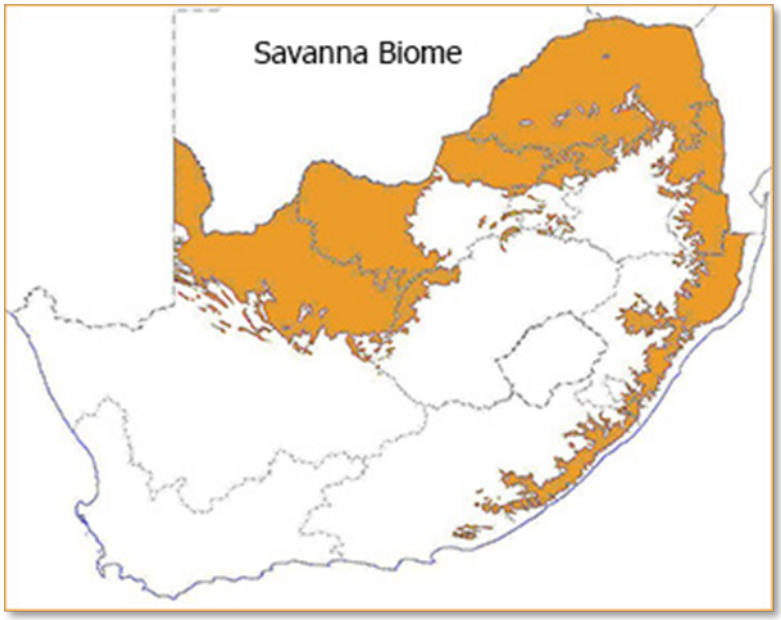


Figure 5.6: A map showing the savannah regions in South Africa (South African National Biodiversity Institute, 2010)

Figure 5.6 is an example of how the teacher and learners can use the GIS to isolate particular vegetation regions, such as the savannah regions, in South Africa. The learners can isolate the savannah regions, which allows them to focus on one specific region at a time. It can of course be effective to use a GIS to have learners locate particular images of the different vegetation regions as well as the vegetation and types of animals found within those regions.

It is recommended that the teacher uses images on the GIS to display to the learners the different vegetation regions and the vegetation associated with those regions. Learners can use applications like Microsoft Word where the teacher can give learners a table to fill in about each vegetation region, such as the name of the region, the vegetation found there, and the types of animals most likely to live there. This will give them information about each vegetation region that can be revisited later for study purposes.

Conclusion

In terms of the narrative media form, the images and maps used on the GIS give learners the opportunity to make connections between the concepts already described and discussed. As learners begin to use the GIS, it provides them with the opportunity to isolate different vegetation regions, taking note of where they are located in South Africa. The GIS can also be used to show learners particular images of the vegetation regions isolated, which can be

discussed among each other. It is here where the interactive media form can be mentioned as during this stage the GIS provides learners with feedback by displaying the maps isolated by the learners and the teacher also provides feedback to the learners to ensure any misconceptions are amended during this activity. For example, if learners are asked to locate a particular vegetation region and provide detail on it and their conceptions are incorrect, it is important that the teacher amends this and provide clarity if they cannot locate the areas on the GIS. This also allows mentioning the communicative media form because the GIS is used to enhance learner's understanding of the different vegetation regions.

Lesson Step 3

Once the task has been completed, this lesson step requires the educator to explain the link between vegetation and climate regions in South Africa with an emphasis on rainfall distribution. This lesson step incorporates some activities from the interactive process (Figure 5.5). The teacher and the learners can relate the concepts discussed in the discursive process to the task and identify the links between the concepts and their actions. This means that the teacher can "help the learner 'connect' a representation at the practice level with the concept that is to be learnt, thus supporting the learner's internal learning cycle" (Holmberg, 2016, p. 6).

Lastly, this lesson step uses activities located in the reflective process, as depicted in Figure 5.7. This means that the teacher and the learners reflect on the "interaction at the task level in order to redescribe their conceptions at the level of descriptions of the topic goal" (Ndlovu, 2015, p. 29). Once the learners have accomplished the interactive process and achieved the goal of indicating vegetation regions in South Africa, it is time to reflect on their findings.



Figure 5.7: The reflective process (Ndlovu, 2015, p. 28)

Introduction

This lesson step involves establishing the link between vegetation regions, climate regions and rainfall distribution. Of course it can be argued that the reflective process generally is associated with being at the end of the lesson, but it is important to engage with this process throughout the lesson because it "provides teachers with feedback on their teaching and whether students are learning what is intended" (Holmberg, 2016, p. 6).

The map layer function on the GIS gives the teacher and the learners the opportunity to isolate particular areas and then overlap the isolated maps so one map can be constructed, displaying all the concepts in one place. This is where the relationship between the different concepts can be displayed and established, paving the way for the teacher and learners to discuss this relationship. Therefore, the GIS affords the possibility of not only displaying concepts in isolation but also displaying the concepts simultaneously on one map, as illustrated in Figure 4.8, allowing for relationships between concepts to be established. The teacher and the learners can work together, each using their own maps, to display and describe the links between the concepts.

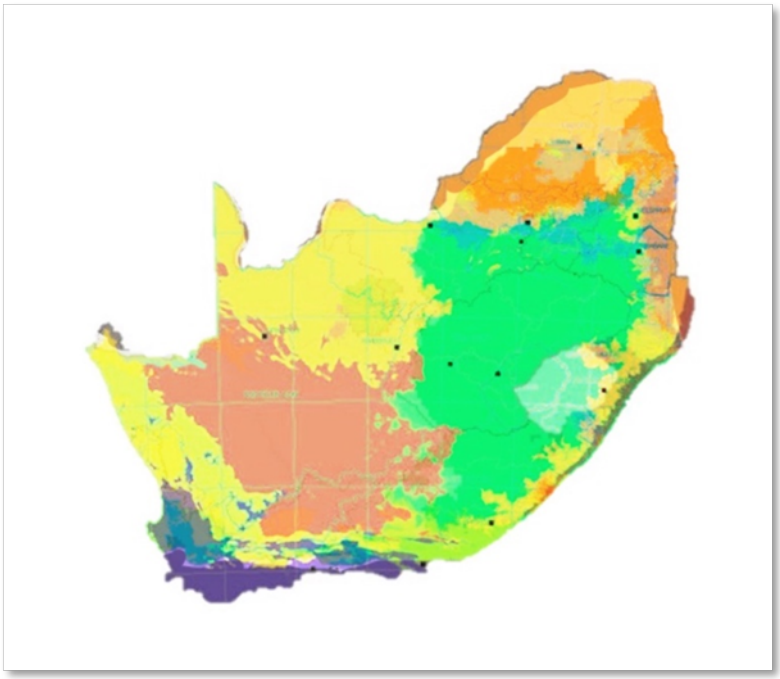


Figure 5.8: Integrating layers

The aim is for the GIS to allow learners to discuss why various vegetation regions may be established because of the climate of a specific region. The teacher also incorporates the rainfall distribution with the other two layers. This means that learners are presented with an integrated layer that shows data of vegetation regions, climate regions and rainfall distribution in South Africa, such as the map depicted in Figure 5.8. This means that the GIS gives learners the opportunity to establish the relationship between the two concepts.

Thus, the teacher gradually increases the number of layers integrated on the map, hence gradually increasing the number of concepts being analysed in relation to each other. As more concepts are explained and related to each other, it is evident that the concept meanings will become more complex, and the GIS is used to assist in understanding these meanings by visually displaying a relationship between concepts, which can be discussed between the teacher and the learners.

Conclusion

The integrated layer depicted as a map is used as a narrative media form that paves way for structures and connections to be established between the different concepts. Again, a GIS is used as an adaptive media by giving learners the opportunity to experience the structure and connections of concepts. As learners use the GIS to create and model different maps and isolate

various vegetation regions, it is being used as a productive media providing the basis for knowledge to be constructed. For example, this includes looking at the different factors and concepts that may cause vegetation to be found in different regions, and these concepts were discussed in the discursive process. As the teacher and learners interact with each other based on their findings, misconceptions can be amended and relationships established between vegetation regions, climate regions and rainfall distribution.

Lesson Step 4

The final step in this lesson involves having learners create an 'awareness chart' about vegetation regions in South Africa. According to the conversational framework (2002), in this final step both the teacher and the learners engage in activities located in the reflective process, as indicated in Figure 5.7.

By making an awareness chart, learners reflect on the concepts and descriptions that were derived throughout the lesson. The teacher uses this task as an opportunity to reflect on the learners' actions and to reflect on their teaching, giving them insight into possible improvements that can be made to their teaching activities. Furthermore, learners can reflect on their learning process and on the concepts learnt during this lesson, and so "reflection takes place for the student as a result of these experiences of application" (Lee, 2006, p. 14). Inevitably, this final lesson step allows both the teacher and the learners to reflect on whether the task goal was achieved successfully.

Introduction

In this lesson step learner use a GIS to compile an awareness chart using the different models featured in a GIS. Each learner can either be assigned to specific vegetation regions or they can have the freedom to choose their own and isolate that region on a map with reference to the climate region, rainfall distribution and economic activities in the region. The different models that they choose to represent the data with is at their discretion, giving learners the opportunity to articulate their awareness chart or data compiled in a variety of ways.

Using a GIS to create the awareness chart means that learners can express their articulation in different ways, promoting diversity. Learners can use maps, images and symbols to display the information, and learners can incorporate other applications like Microsoft Excel, which can be used to create their awareness chart. Therefore, the GIS gives learners an opportunity to

construct their own product of a vegetation region using dynamic maps, images and symbols to articulate their findings. Again, this is a hands-on activity and the GIS provides opportunities for learners to construct knowledge and express their understanding of the concepts discussed during the lesson in many ways. Figure 5.9 is merely an example of what learners can create when engaging with the activity.

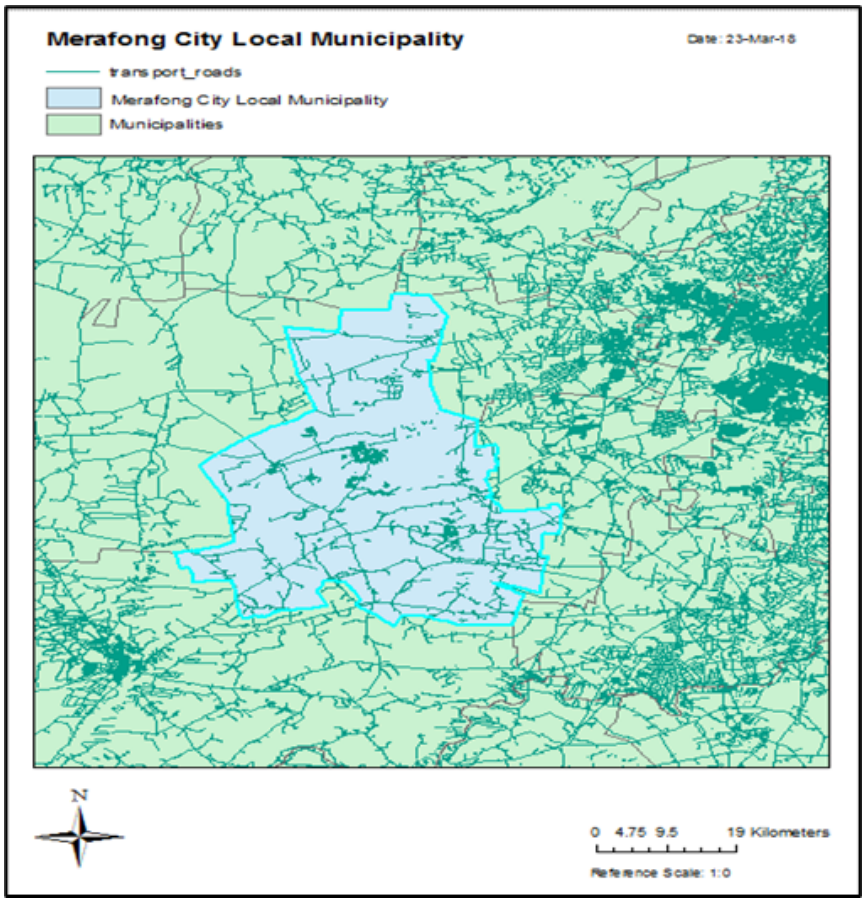


Figure 5.9: An example of a way to compile data using GIS

Figure 5.9 shows a municipality that has been isolated, depicting the transport roads for the municipality. This is to show that learners can assign headings, dates, a key, a scale and a compass based on the region they have chosen to investigate. For the context of this lesson, learners can isolate a particular vegetation region in South Africa and display the climate, rainfall distribution and economic activities associated with the region. Learners can then be given an opportunity to display and describe them to the rest of the class. Furthermore, the teacher can create an online portfolio where all the learners' awareness charts can be stored that can be accessed by everyone.

Learners can use Figure 5.9 as an example to create their own awareness chart that relates to vegetation regions in South Africa. Learners can also create videos using the GIS to articulate their understanding of the concepts. It may be necessary for learners to complete a write-up alongside their product produced on the GIS to articulate and describe the relationship of the spatial data displayed.

Thus, the aim of such an activity is to bring all the knowledge and concepts together, giving the learners an opportunity to express their understanding of and repack the complex concepts, and using the illustration created, learners can explain the concepts using the GIS.

Conclusion

The GIS affords the possibility of enhancing the lesson by giving learners the opportunity to create an awareness chart using different features and models. This means that the teacher and learners use the GIS in this lesson step as a narrative media for multimedia purposes. Learners use the GIS as a productive media form in which an awareness chart can be created to display their understanding of particular vegetation regions, paving way for concretising theory and practice. The GIS is used as a communicative media form to provide learners with the opportunity to expand their understanding of vegetation regions. The intent is to give learners an opportunity to present their final products to each other, during which interaction can be promoted by feedback given by the teacher and the rest of the learners in the class.

Lesson Conclusion

Teachers have to make important decisions when embarking on the quest to use ICTs such as a GIS in their classroom with the intent to teach mapwork. It is important to note that that there is not one correct way to integrate ICTs in education or in any particular lesson. It is a dynamic process that is continually changing and evolving from teacher to teacher, learner to learner, topic to topic and school to school. Based on the experience of this study, there are a number of things that need to be considered when using a GIS in a lesson.

The intent was to develop a prototype of a Grade 5 lesson that focused on vegetation regions in South Africa. The aim was to show how a GIS can be used in various parts of the lesson to unpack and discuss various concepts. It proved that the affordances of a GIS can promote pedagogical value for particular activities that unfold in the lesson.

Chapter 6: Discussion

This chapter discusses the patterns and connections. The conversational framework, the media forms, the affordances and the value they bring to the teaching and learning experience is discussed using the summaries for each lesson step. The semantic waves assist by tracking "how the pedagogic process plays out in terms of semantic gravity and semantic density over time. It also forces you to think about the two processes separately and together at the same time" (Hugo, 2017). The semantic wave in this study helps to depict where a GIS is useful to enhance learners' understanding of the topic.

Tables are used to present a summary of each step by making explicit what phase in the conversational framework the lesson step is operating from; the media forms and affordances engaged from GIS; and the pedagogical value the use of the GIS brings to the teaching and learning experience. To conclude each step, the semantic wave is described.

Table 6.1 highlights lesson step 1.1.

Table 6.1: Summary of lesson step 1.1

Conversational Framework	**GIS Media Forms & Affordances**	**Pedagogical Value**
Discursive Question & answer Video used as a stimulus or point of reference for the discussion. Question & answer	*Narrative:* Video use in introduction (GIS) *Interactive:* Question and answer/quiz for immediate feedback using Mentimeter or Google Forms on tablets *Adaptive:* Video-teacher explaining (GIS) *Productive:* Creation of a video by the teacher (GIS)	Structure & connections Exploring knowledge Concretising basic understanding of vegetation regions Knowledge construction for the teacher

In this lesson step, the teacher uses a GIS as a narrative, adaptive and productive media form. Although a GIS has an interactive media form that can be used to elicit feedback between the teacher and the learners, it is not adequate, and as a result an external tool (e.g. Mentimeter) is used for immediate feedback during the lesson.

In terms of the semantic wave, the teacher begins this lesson step relatively low on the semantic wave because they start the lesson by referring to an everyday experience that all learners are exposed to by using the video on the GIS. This GIS affordance levels the ground for all learners and helps them operate at semantic gravity (SG+) that is high and a semantic density (SD-) that is low. The teacher uses the video to elicit a conversation about vegetation regions and posing

questions to learners, and by so doing, strengthens the SG+ and weakens the SD- (Hassan, 2017). The teacher uses the discussion of the concepts to gradually strengthen the SD+ as the images available on the GIS expands their understanding of the topic goal. The semantic density will later increase as more technical language is introduced, such as terms like economic activity, rainfall distribution, indigenous vegetation.

The aim of using an example to initiate the development of the lesson is to promote meaning that is dependent on its context so that learners are given concrete examples they can work with (Maton, 2020). This helps when technical concepts are discussed later. Therefore, instead of working with generalisations, learners are able to engage with local particulars of a specific case (Maton, 2020), helping them develop their understanding of the concept.

Table 6.2 highlights lesson step 1.2, which is an extension of step 1.1, in which the GIS is used to introduce basic terminology.

Table 6.2: Summary of lesson step 1.2

Conversational Framework	**GIS Media Forms & Affordances**	**Pedagogical Value**
Discursive Images and maps used as a stimulus or point of reference for the discussions of concepts. Question & Answer	*Narrative:* Images used to introduce terminology (GIS) *Interactive:* Question & answer and quiz on an online tool *Adaptive:* Images explained by teacher (GIS)	Structure & connections Exploring knowledge Concretising basic understanding of classifying vegetation and the different vegetation regions

The discursive phase is important because during it the teacher and learners discuss and unpack their own descriptions of the concepts introduced. This paves the way for the teacher to redescribe concepts so that learners begin to develop concepts based off of the teacher's perspective. This is an important stage because the descriptions made at this level pave the way for action tasks to be developed. It also provides the basis from which learners will start to develop their conceptions of the concepts, which will be used throughout the lesson.

As mentioned in the previous lesson step, a GIS is used as a narrative and adaptive media form. The teacher uses the GIS as a narrative media form by using images and maps to introduce terminology to learners. The onus is on the teacher to produce the images and maps so that they can be used as a stimulus or point of reference for the discussions. Again, an external tool is used as a GIS as an interactive media form is not adequate on its own.

Similar to the previous lesson step, this lesson is situated relatively low on the semantic wave, but learners progress upwards on the semantic wave as new, abstract concepts are being brought forward and unpacked by the teacher and the learners. This means that the semantic density will increase as more abstract concepts are being unpacked and more technical language comes into the conversation, and so the semantic gravity begins to decrease. This means that less generalised examples and experiences are being used, and instead there is a focus on addressing the complexities of the concepts being discussed. Of course, examples will be mentioned and so it depends on how many examples, such as Rooibos, the teacher introduces and discusses as this will affect the semantic gravity and semantic density. However, there should be a slow progression up the semantic wave during this lesson step compared to the previous lesson step.

Table 6.3 highlights lesson step 2, and its purpose is to show how a GIS can be incorporated as learners engage with a task that are on concepts and their descriptions realised at the beginning of the lesson.

Table 6.3: Summary of lesson step 2

Conversational Framework	**GIS Media Forms & Affordances**	**Pedagogical Value**
Adaptive Task goal: Locating vegetation regions on a map (GIS) Interactive Providing feedback to learners based on their actions	*Narrative:* Images and maps used to locate various vegetation regions (GIS) *Interactive:* Feedback from the teacher (question & answer) and completion of the table *Adaptive:* Maps and images, and learners experimenting (GIS)	Structure & connections Exploring knowledge Experimenting and concretising learners' understanding of different vegetation regions

Lesson step 2 incorporates the narrative and adaptive media form. Learners use external applications such as Microsoft Word to engage with an activity alongside the GIS as an interactive media form.

When the teacher constructs the learning environment, it is important that the task goal is adapted according to the articulations made by the learners at the conceptual level. In this case it is important that the descriptions from the discursive process can be tested at the practice level, and so the teacher needs to adapt the task goal accordingly. It is counterproductive to have a task goal set for learners that does not correspond to the descriptions made during the discursive process. For example, the teacher and the learners have agreed on the descriptions of vegetation regions in the first two lesson steps, and so the task goal is to locate the different

vegetation regions found in South Africa. It is here that the "teacher has the responsibility to use the relationship between their own and student's conception to determine the task focus of the continuing dialogue" (Laurillard, 2002, p. 78).

It is important that the teacher adjusts the learning process according to the articulations made by the learners so that misconceptions can be amended. Through the continuous conversations between the teacher and the learners, a shift between abstract and everyday concepts can be used.

In terms of the semantic wave, the teacher should begin the descent back down the semantic wave, moving towards "more grounded and less complex meanings" (Maton, 2020, p. 73), and move from "generalised ideas towards concrete and delimited cases" (Maton, 2020, p. 63). This means that the teacher has moved on the semantic scale "from highly condensed and decontextualised ideas (SG−, SD+) towards simpler, more concrete understandings, often including examples from everyday life (SG+, SD−)" (Maton, 2013, p. 14).

Table 6.4 highlights lesson step 3 that focuses on showing how a GIS can be used to establish links between various concepts.

Table 6.4: Summary of lesson step 3

Conversational Framework	**GIS Media Forms & Affordances**	**Pedagogical Value**
Reflective Establishing a link between the concepts	*Narrative:* Using map layer function to visually display the different concepts (GIS) *Interactive:* Feedback from the teacher by linking the concepts together. *Adaptive:* Map layer function, and learners experimenting (GIS) *Productive: T*eacher and learners create a layer map displaying multiple concepts (GIS)	Structure & connections Exploring knowledge Re-description of concepts Experimenting and concretising learners' understanding of the relationship between vegetation regions, climate and rainfall distribution Knowledge construction for the learners

The GIS is used as narrative, interactive, adaptive and productive media form during this lesson step. The intent is to reflect on how each concept discussed is linked so that its relationship can be acknowledged and understood by displaying the concepts together on a single map produced by the teacher and learners.

This lesson step is a particularly important part in the lesson because it brings together all the concepts discussed in this lesson as well as the lessons completed previously. It gives the

teacher and the learners an opportunity to establish relationships between the concepts, and by using a GIS these relationships can be visually displayed and explored, promoting knowledge construction. The various colours on the maps make establishing relationships between concepts possible and more distinct than merely talking about the relationships.

In terms of the semantic wave, the learning process in this step should start progressing upwards on the semantic wave, and so semantic density increases, which suggests that the practice will be more complex (Maton, 2020, p. 63). The aim of this lesson step is to move towards understanding the link between the concepts previously learnt, such as climate regions, and rainfall distribution. The teacher starts to explain the relationship between the concepts using the integrated layer feature on the GIS.

Table 6.5 highlights lesson step 4, and the focus is on describing how a GIS can be used as learners produce an awareness chart as their final activity for the lesson.

Table 6.5: Summary of lesson step 4

Conversational Framework	**GIS Media Forms & Affordances**	**Pedagogical Value**
Reflective Learners create an awareness chart	*Narrative:* Images, maps and features are used to display concepts (GIS) *Interactive:* Feedback from teacher and learners when presenting the awareness chart *Adaptive:* Map layer function; maps, images and different GIS features; learners experimenting (GIS) *Productive:* Learners create an awareness chart (GIS)	Exploring knowledge Re-description of concepts Experimenting and concretising learners' understanding of the concepts covered during the lesson Knowledge construction for the learners by producing an awareness chart.

The final activity completed during this lesson step is important because it paves the way for the teacher and learners to reflect on their journey in the lesson. The GIS is used as a narrative, interactive, adaptive and productive media form. Using the GIS during this lesson step is a great way for learners to articulate their understanding of the concepts and gives them the opportunity to be creative in the different ways their articulations can be produced.

In terms of the semantic wave, as the lesson continues to progress towards a high profile on the semantic scale, it is important that learners are given the opportunity to provide descriptions of the concepts using more technical terminology, strengthening semantic density. As the

lesson comes to an end, semantic density increases and semantic gravity decreases as learners begin to construct their awareness charts using technical language and abstract concepts.

Proposed Semantic Wave

After completing this lesson, Figure 6.1 shows the proposed semantic wave, indicating the position on the lesson where GIS media is used to enhance concepts in the lesson steps.

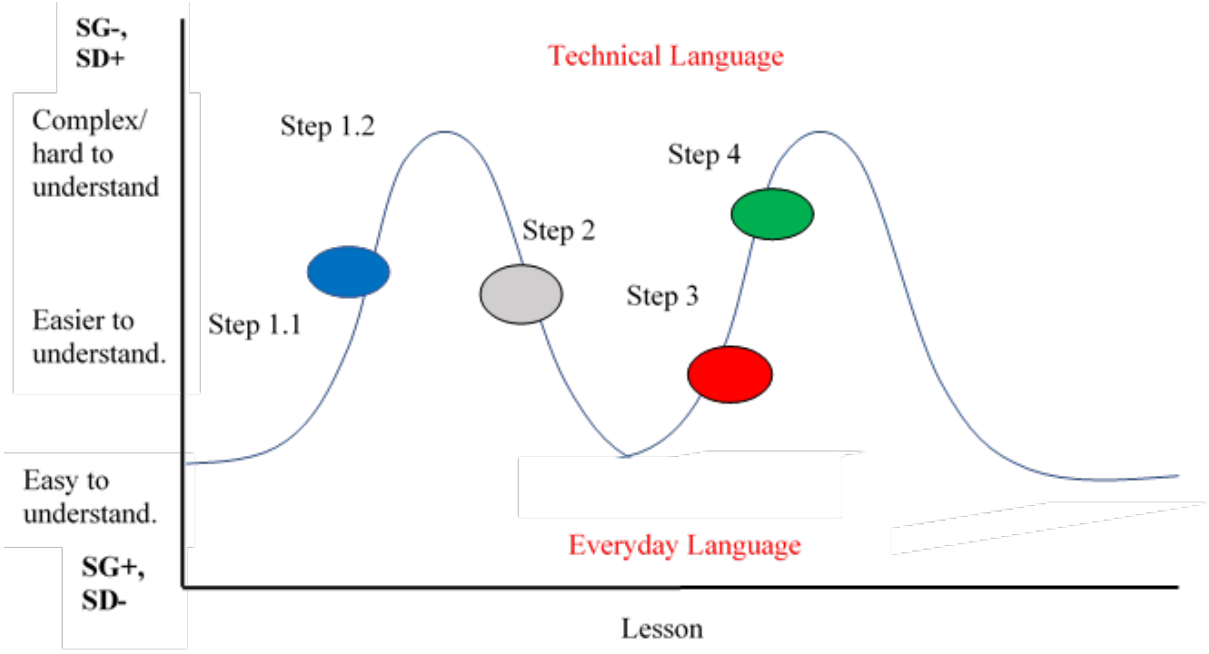


Figure 6.1: A semantic wave for teaching vegetation regions in South Africa

As seen in Figure 6.1, in general the GIS as a narrative media form (blue dot) is used as a way to display images and maps to learners so that concepts can be identified and discussed from those particular images. It therefore helps present structure and connections as the concepts are introduced. The GIS as interactive media (grey dot) is used to provide feedback to learners throughout the lesson that is often completed by verbal interaction between the teacher and the learners. It became evident that the GIS alone was not adequate as an interactive media form, and thus external tools like Mentimeter, quizzes and Microsoft Word were needed. The GIS as an adaptive media form (red dot) was evident in terms of the various ways concepts could be represented and displayed to learners to help them concretise technical language; for example, concepts should be displayed as a map or image. Lastly, the GIS as a productive media form (green dot) was evident in terms of the teacher and learners producing and articulating concepts in the form of maps and awareness charts. The GIS as a communicative media form was not evident in the lesson.

Teachers do not need to follow this semantic wave exactly, but it is a guide on how best to ensure there is a shift between abstract concepts and everyday concepts. It will become evident that the teacher can begin the lesson either at a low semantic scale, which was indicated, or on a high semantic scale. It depends on the teacher and the approach they would like to take with the lesson structure.

For this particular lesson, the teacher started the lesson low on the semantic wave and shifted between abstract, technical concepts and everyday concepts and experiences (as indicated in Figure 6.1). It is important to ensure that these shifts occur to give learners the opportunity to engage with both the abstract concepts and every day examples, and by so doing, promote cumulative knowledge building. It is important to note that the movement between the semantic gravity and semantic density is a slow movement, and especially for Grade 5 these types of movements should be evident but not extreme.

In the essence of this study, the use of GIS can enable the creation of "learning environments where both the teacher and the learners use these interchanges to develop learning or concept understanding" (Ndlovu, 2015, p. 29). The GIS were showed to be of great value for the visual representations it provides to learners in which data can be analysed and relationships established between data, to help make abstract concepts more concrete, and to provide learners with hands-on activities. The GIS can help the teacher with the explanations of locating vegetation regions in South Africa and provide images and videos of those specific areas that can be discussed.

This lesson focuses on what would happen in the classroom if the GIS is not used as a communicative tool. That does not mean it cannot be used as such. For instance, when the teacher communicates information that they may send to learners' tablets and they do the same for clarity, this can help in the re-descriptions of concepts. Learners can use the software to work on a project where they discuss from their homes as they work towards understanding a concept that may lead to the production of an accurate representation illustrating aspects about vegetation.

Therefore, understanding the value of ICTs and integrating them in the classroom can depict where and how these activities can be transformed, and where the use of a GIS can be of value and assist both the teacher and learners when unpacking and discussing concepts.

Chapter 7: Conclusion and Recommendations

In this era, it is no longer of whether ICTs can be used in education; instead it should be acknowledged that ICTs have a significant role in the educational domain, and so the question that should be asked is how ICTs can be effectively integrated into the classroom. According to Hardman et al. (2018, p. 156), "unfortunately, the misconception in South Africa is that knowing how to use technology is the same as knowing how to teach with technology" Although it is important for teachers to develop their technical skills to operate a GIS, emphasis should be placed on "assisting teachers to develop their pedagogical practices to include optimal use of ICTs as learning and teaching tools" (Hardman et al., 2018, p. 156).

This study primarily focused on a Grade 5 lesson about vegetation regions in South Africa and how a GIS can be used throughout the lesson structure to enhance the learning process. According to the CAPS document, the "Social Sciences curriculum [which incorporates both History and Geography] aims to provide opportunities for learners to look at their own worlds with fresh critical eyes and perhaps more importantly, it aims to introduce learners to a world beyond their everyday realities" (Department of Education, 2011, p. 8). The document recommends using a GIS in Geography to provide learners with the opportunity to engage with the world in a new and exciting way.

The aim of this study was to provide a prototype of a Grade 5 lesson that uses a GIS in which guidelines could be formulated to assist teachers wanting to use a GIS in their classroom. The research questions were answered throughout the discussion of this study. The conventional way a Grade 5 Geography lesson about vegetation regions are taught are illustrated in Figure 3.1, which is a guideline of steps teachers should follow when teaching in the conventional manner. The descriptions in the figure provide guidance on developing a semantic wave of the lesson, which entails particular steps to be carried out throughout the lesson. The affordances of a GIS were unpacked and discussed, providing insight on the potential a GIS holds to enhance the teaching and learning process for the Geography lesson. A prototype of the Grade 5 Geography lesson using a GIS was demonstrated, with reference to the affordances of a GIS and the conversational framework (2002).

The remarks discussed in the following sections were derived from this study.

Conversational Framework

Laurillard (2002) defined ICTs as having the potential to provide new and different ways in which the exchange of knowledge can be enhanced, and a GIS provides the means for learners to engage in successful meaning making. In this study, it became evident that a GIS can be used in a variety of ways as different media forms are used for the benefit of learner understanding. Their pedagogical characteristics and the affordances of a GIS made valuable contributions to particular steps in the lesson, which made way for the affordances of a GIS to be identified as per the research question. Laurillard's conversational framework (2002) focuses on teaching, which should deliberately promote the way individuals interact with their world. The CAPS document acknowledges that "it is important to bring the world into the Social Sciences classroom" (Department of Education, 2011, p. 9), and the use of a GIS paves the way for this to be accomplished. The GIS should be used to represent real data about various spatial points using interactive, dynamic 3D maps, which enhances the understanding of particular concepts that is realised through conversations and discussions.

Semantic Wave

The semantic wave played a vital role in identifying a possible learning experience that both the teacher and the learners can embark on. The use of the semantic wave made the lesson structure and its steps more evident, showing which steps can help teachers develop a prototype lesson. This allowed for the identification of possible positions in the lesson where the use of a GIS could be of value. The use of a semantic wave made visible the pedagogical value of GIS as a teaching technology in the classroom as it paved the way for a continuous shift between abstract concepts and everyday experiences.

GIS

By making use of the functions of a GIS, such as the map layer function, learners are given the opportunity to form relationships between different spatial data. It can be said that "the power of GIS resides not only in the clarity of the visual representations of the data but also in the manner in which the mapping process encourages our thinking about the relations between the data sets, and the factors that encourage or inhibit their mutual relations" (Kidman & Palmer, 2006, p. 290). It is important to use a GIS so that learners can start to connect concepts to real-

world experiences and because it gives learners the opportunity to acquire knowledge through the linking of concepts in a systematic way.

Making Decisions About the Learning Pathway

Teachers must ensure that they make decisions on the intended learning pathway that will be used for a particular lesson. Although most teachers use a lesson plan, in order to identify where in a lesson a GIS can be used the teacher needs to have some idea of how the lesson is to be structured and sequenced. The previous chapter highlighted how a semantic wave can be used to sequence particular lesson steps appropriately. Once the teacher has identified the particular learning experience or learning pathway, the teacher can then identify areas in the learning experience where a GIS can be of use. Once the learning pathway has been established, the tools that can be used to deliver the content can be negotiated. In this case, the GIS was used to introduce abstract concepts and to concretise concepts and create content as well as give learners the opportunity to engage with real-world phenomena.

The type of learning pathway the teacher selects determine the tools needed for that particular learning experience. The semantic wave has become popular in many discourses with the intent on establishing the appropriate learning pathway for teachers and learners to embark on because "power resides in semantic waves that weave together and transform knowledge" (Maton, 2020, p. 81). The semantic wave for the lesson on vegetation regions in South Africa is an example of how teachers and learners can sequence the lesson in a meaningful and constructive manner to promote the cumulative building of knowledge. It shows that "both upward and downward shifts are required for cumulative knowledge-building" (Maton, 2013, p. 19). It is important to emphasise that there is no universally good semantic wave or one standard semantic wave. Rather, it depends on who you are teaching and what you are teaching, which affects the sequencing of events.

Being Aware of ICT Affordances

It is important for teachers to be aware of the affordances of a GIS. This will allow teachers to make appropriate decisions on which GIS features to use, such as using map layers to represent different spatial data or using an attribute table to collect data about a particular location. If teachers are not aware of the capabilities of a GIS, similarly to any other software, it will be rather difficult for teachers to capitalise on its capabilities. When teachers can acknowledge the affordances of a GIS, it becomes easier for them to identify areas in a lesson where the use of

a GIS can be beneficial. It is not merely using a GIS in the lesson that will enhance it but also how it is used that will affect the learning process.

Continuous teacher development

According to Chikumba and Chisakasa (2017), "a GIS needs adequate resources including people with required knowledge and skills" (p. 129). Thus, teachers need to have some sort of training or experience using a GIS so that they can identify particular functions and affordances to be used in a lesson. The UNESCO ICT Competency Framework (2018) has been used all over the world to categorise teacher competency levels based on digital competencies. Based on this particular framework, it is important that teachers acquire the 'knowledge acquisition' competency and completed or will acquire the 'knowledge deepening' competency. This constitutes teachers having a thorough foundation of ICT competencies, which means they acquired the necessary skills and knowledge to use and implement technology.

"Education and knowledge of the GIS can only be obtained through ongoing learning exercises" (Meaden, 2013, p. 82), which means that teachers need to engage with continuous and ongoing training to develop GIS skills. This is often a challenging task because often "teachers do not have the time to devote to developing their GIS skills" (Kidman & Palmer, 2006, p. 293). It is paramount that teachers are first exposed to a GIS and have the opportunities and means to acquire and develop the necessary skills, which will allow them to use a GIS and implement it in their classroom.

Of course, the success of implementing a GIS or any technological device or software is dependent on the teachers' knowledge and skills, and this is an important factor to consider when deciding on the type of ICT to be used. Once teachers are aware of the affordances and capabilities of a GIS, they can assert their knowledge by identifying where in the lesson it is appropriate use to give learners the opportunity to achieve particular learning outcomes. It is important that teachers know what needs to be accomplished and what it is learners need to learn or acquire. Appropriate decisions can then be made on what type of features from a GIS will best enhance the learning process and provide learners with opportunities to engage with that process.

Future Recommendations

As this study focused on conceptually developing a prototype Grade 5 lesson about vegetation regions in South Africa, it will be beneficial for someone to take this lesson prototype and apply it empirically. It would be insightful to investigate if this lesson as depicted could work in a real-life context.

Conclusion

"The teacher enhances learning by not just teaching with ICTs, but through integrating it into his or her teaching—that which already exists" (Ndlovu, 2015, p. 292), and so it is evident that the use of a GIS or any ICT requires training and guidance on how to use it effectively. This study provided a demonstration on how a Geography concept in Grade 5 can be enhanced using a GIS and promotes that a GIS "helps students think critically, use real data, and connects them to their community" (Kerski, 2018, para. 3). Of course, the use of a GIS will vary depending on the concept and the context in which the learning is happening. This study highlighted that understanding how a GIS functions and its affordances give teachers great insight into its capabilities. This means that the affordances can be aligned to ICT taxonomies and various media forms, and so can be used to elicit a dialogue between teachers and learners in the classroom. Although educational policies and senior management have a role to play in the successful integration of ICTs in the classroom, "you, the teacher, are the critical factor in determining the success of a technology-integrated environment" (Hardman et al., 2018, p. 81).

Reference List

Astroth, J. (2008). Computer environment for GIS and CAD. In S. Shekhar, & H. Xiong (Eds.), *Encyclopaedia of GIS* (pp. 1–1370). Springer.

Bodner, G. M. (1986). Constructivism: A theory of knowledge. *Journal of Chemical Education, 63*(10), 873–878.

Botes, A. (2002). Concept analysis: Some limitations and some possible solutions. *Curationis, 25*(3), 23–27. https://doi.org/10.4102/curationis.v25i3.779

Chikumba, P. A., & Chisakasa, G. (2017). GIS implementation for health management in Malawi: Opportunities to share knowledge between implementers and users. *American Journal of Geographic Information System, 6*(4), 129–140. https://doi.org/10.5923/j.ajgis.20170604.01

Conole, G., & Dyke, M. (2004). What are the affordances of information and communication technologies?. *Research in Learning Technology, 12*(2), 113–124. https://doi.org/10.1080/0968776042000216183.

Curzon, P. (2020, May 20). *Learning to learn (to program).* Teaching London Computing. https://teachinglondoncomputing.org/learning-to-learn-to-program/

Dangermond, J. (2009). *GIS, design, and evolving technology*. Esri. https://www.esri.com/news/arcnews/fall09articles/gis-design-and.html

Driscoll, M. P. (2005). *Psychology of learning for instruction.* Pearson.

Made 4 Geek. (2019, February 16). *How to copy attribute table data from ArcGIS to MS Excel* [Video]. YouTube. https://www.youtube.com/watch?v=oJ2CFWiiZHE

Goldsmith, C. (2016). *How, and to what extent do Geographical Information Systems (GIS) contribute to student engagement with service learning projects?* [Master's thesis]. University of Oxford.

Hardman, J., Dlamini, R., Dumas, C., Lewis, A., Lilley, W., Madhav, N., Molotsi, A., & Mnisi, S. S. (2018). *Teaching with information and communication (ICT)*. Oxford University Press.

Hassan, S. L. (2017). Tutors' role in tutorials: 'Unpacking' and 'repacking' during the semantic journey. *South African Journal of Higher Education, 31*(3), 99–115.

Holmberg, J. (2016). Applying a conceptual design framework to study teachers' use of educational technology. *Educational Information Technology, 22*, 2333–2349. https://doi.org/10.1007/s10639-016-9536-3

Hugo, W. (2017). Editorial Issue 67. *Journal of Education, 67,* 1–12.

Huisman, O., & De By, R. A. (2009). *Principles of geographic information system. An introductory textbook*. ITC Educational Textbook Series.

Jadallah, M., Hund, A. M., Thayn, J. B., Studebaker, J. G., Roman, Z. J., & Kirby, E. (2017). Integrating geospatial technologies in Fifth Grade curriculum: Impact on spatial ability and map analysis skills. *Journal of Geography, 116*(4), 139–151. https://doi.org/10.1080/00221341.2017.1285339

Jianhong, P. (2010). The application of hypermedia instruction and its improvement. In *Proceedings of the 7th International Conference on Innovation & Management, School of Politics and Administration, Wuhan University of Technology, China* (pp. 1979–1982). https://www.pucsp.br/icim/ingles/downloads/papers_2010/part_9/30_The%20Application%20of%20Hypermedia%20Instruction%20and%20Its%20Improvement.pdf

Jing, C., Zhu, Y., Fu, J., & Dong, M. (2019). A lightweight collaborative GIS data editing approach to support urban planning. *Sustainability, 11*, 1–17.

Kerski, J. J. (2018, June 8). *Why GIS in education matters*. Geospatial World https://www.geospatialworld.net/blogs/why-gis-in-education-matters/

Kidman, G. C., & Palmer, G. (2006). GIS: The technology is there but the teaching is yet to catch up. *International Research in Geographical and Environmental Education, 15(*3), 289–296.

Kreijns, K., Kirschner, P. A., & Jochems, W. (2002). The sociability of computer-supported collaborative learning environments. *Educational Technology & Society, 5(*1), 8–22.

Laurillard, D. (2002). *Rethinking University Teaching* (2nd ed.). Routledge Falmer.

Laurillard, D., Stratfold, M., Luckin, R., Plowman, L., & Taylor, J. (2000). Affordances for learning in a non-linear narrative medium. *Journal of Interactive Media in Education, 2*, 1–19. http://doi.org/10.5334/2000-2

Lee, N. (2006). Design as learning cycle: A conversational experience. *Studies in Learning Evaluation Innovation and Development, 3*(2), 12–22.

Lehtinen, E., Hakkarainen, K., Lipponen, L., Rahikainen, M., & Muukkonen, H. (1999). *Computer supported collaborative learning: A review of research and development.* CL-Net Project.

Liu, Y., & Laxman, K. (2009). GIS enabled PBL pedagogy: The effects on students' learning in the classroom. *I-manager's Journal on School Education Technology, 5*(2), 15–27.

Maguire, D. J. (2008). ArcGIS: General purpose GIS software system. In S. Shekhar, & H. Xiong (Eds.), *Encyclopaedia of GIS* (pp. 1–1370). Springer.

Maton, K. (2013). Making semantic waves: A key to cumulative knowledge-building. *Linguistics and Education, 24*(1), 8–22. https://doi.org/10.1016/j.linged.2012.11.005

Maton, K. (2020). Semantic waves: Context, complexity and academic discourse. In J. R. Martin, K. Maton, & Y. R. Dovan (Eds.), *Assessing Academic Discourse*: *SFL and LCT*. Routledge.

Maton, K., Hood, S., & Shay, S. (2016). *Knowledge-building: Educational studies in Legitimation Code Theory.* Routledge.

Meaden, G. J. (2013). Implementation of GIS. In G. J. Meaden, & J. Aguilar-Manjarrez (Eds.), *Advances in geographic information systems and remote sensing for fisheries and aquaculture.* FAO.

Mphaphuli, S. E., & Luneta, K. (1996). Geography and mathematics: Issues in Southern Africa. *Social Education*. http://www.socialstudies.org/sites/default/files/publications/se/6107/610707.html

National Research Council. (2006). *Learning to think spatially*. The National Academies Press.

Ndlovu, N. S. (2015). *The pedagogical integration of ICTs by seven South African township secondary school teachers* [PhD Thesis]. The University of the Witwatersrand.

Pieters, H. (n.d.). GIS for people like me.

Raspberry Pi. (n.d.). *Pedagogy quick reads. Improving explanations and learning activities in computing using semantic waves.* National Centre for Computing Education. https://raspberrypi-education.s3-eu-west-1.amazonaws.com/Quick+Reads/Pedagogy+Quick+Read+6+-+Semantic+Waves.pdf

Department of Basic Education. (2011). *Curriculum and assessment policy statement Grades 4–6. Social Science*. Department of Basic Education.

Resnick, M. (2001). *Revolutionizing learning in the digital age*. Educause. https://library.educause.edu/resources/2001/1/revolutionizing-learning-in-the-digital-age

Planet GIS. (n.d.). *South African GIS Data*. Retrieved August 16, 2020, from https://planetgis.org/data.php?int

ESRI. (2020, May). *Teach with GIS for Classrooms*. https://www.esri.com/content/dam/esrisites/en-us/media/pdf/teach-with-gis/implementation-guide-classroom.pdf

University of Washington. (2013, August 4). *ESRM 250: Introduction to Geographic Information Systems in Forest Resources*. Retrieved August 16, 2020, from https://courses.washington.edu/gis250/lessons/arcmap_basics/exercise/index.html

Van der Merwe, C. D. (2016). Map literacy and spatial cognition challenges for student Geography teachers in South Africa. *Perspectives in Education, 34*(2), 20–138.

Veletsianos, G. (2016). Digital learning environments. In N. Rushby, & D. Surry (Eds.), *Handbook of learning technologies* (pp. 242–260). Wiley.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity*. Cambridge University Press.

Western Cape Education Department. (n.d.). *Intermediate Phase Teacher's Guide Grade 5, Social Science.* Retrieved on May 15 2020 from http://www.wcedcurriculum.westerncape.gov.za/images/GET_WorkSchedules/124131939_ss-gr5-tg.pdf.

What is GIS? (n.d.). Retrieved August 10, 2020, from https://www.esri.com/en-us/what-is-gis/overview

Widodo, H. (2020). Application of guided question and answer method to improve Pai learning achievement of state junior high school. *Sei Rampah. Jurnal Tarbiyah, 27*(1).

Yusuf, U. (2016, May 17). Working with vector and raster data in Python. Retrieved November 17, 2020, from https://umar-yusuf.blogspot.com/2016/05/working-with-vector-and-raster-data-in.html

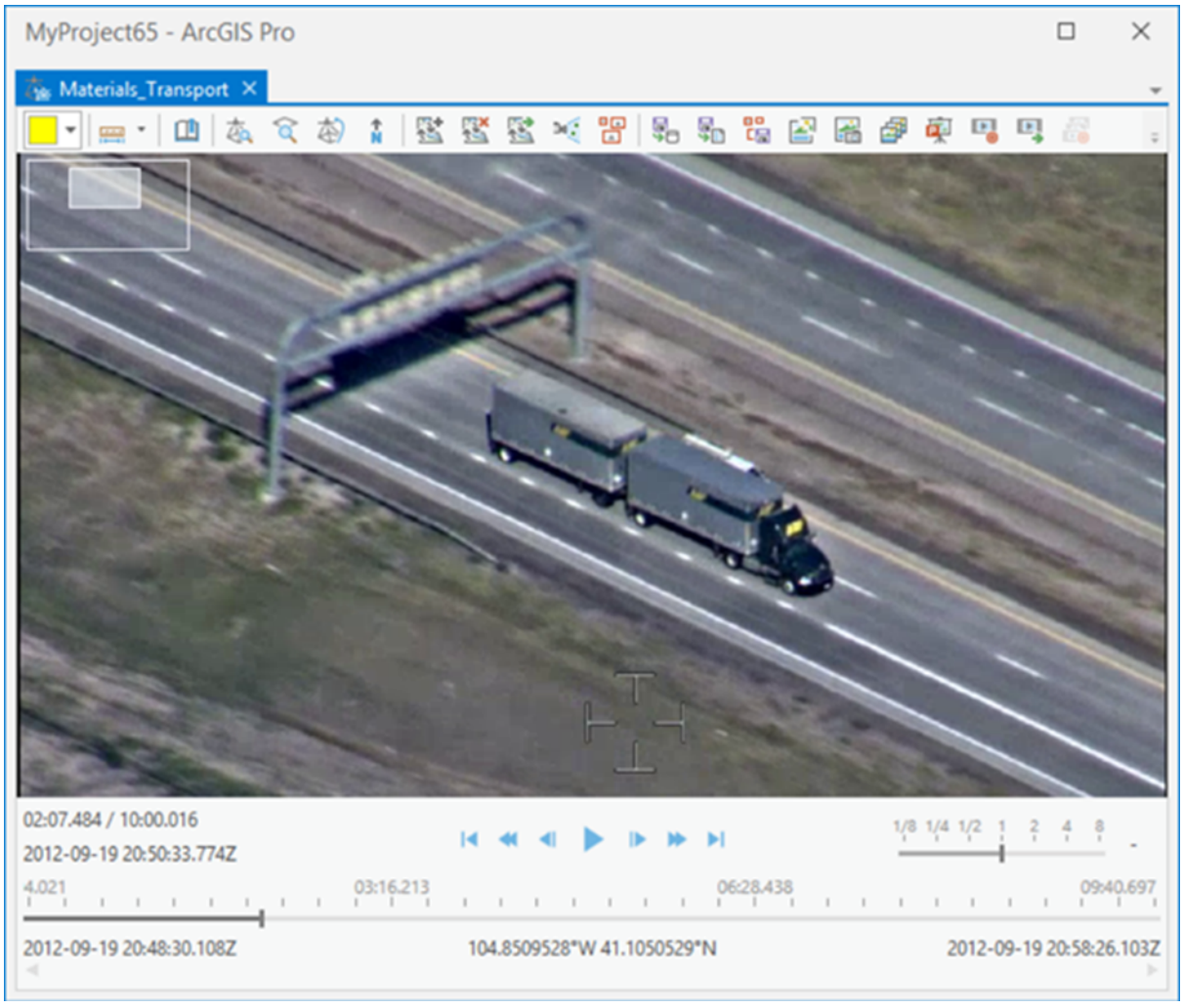
Zerger, A., Bishop, I. D., Escobar, F., & Hunter, G. J. (2002). A self-learning multimedia approach for enriching GIS education. *Journal of Geography in Higher Education, 26*(1), 67–80.

Zwartjes, L. (2014). The need for a learning line for spatial thinking using GIS in education. In R. De Miguel Gonzalez & K. Donert (Eds.), *Innovative learning Geography in Europe: New challenges for the 21st century*. Cambridge Scholars.

Appendices

Appendix A: Video Player

The video player is called a digital video recorder (DVR) and has a familiar look and feel to a common DVR. The video player includes standard video controls such as play, fast forward, rewind, step forward, step backward, jump to the beginning, or jump to the end of the video. You can zoom in to and roam a video while it is in play mode or in pause mode. The size and position of the zoomed view within the video frame are indicated in the overview window.



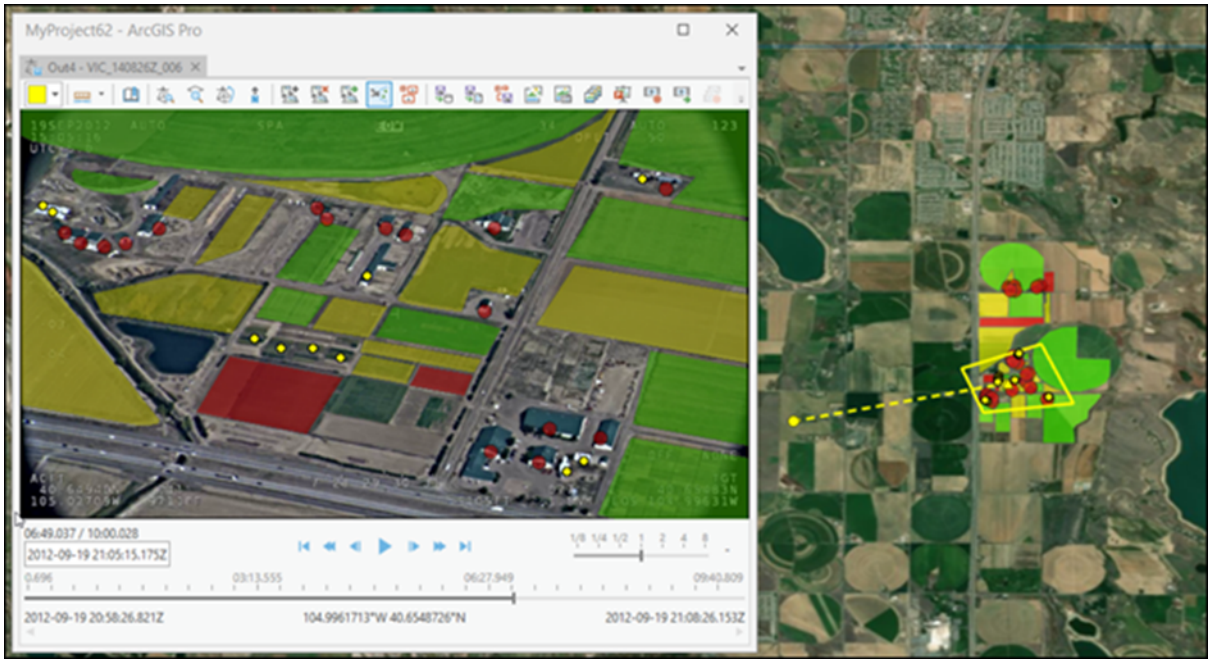




Additional tools include capturing, annotating, and saving video bookmarks; capturing single video frames as images; and exporting video clips.

Add graphics

You can collect ground features of interest that are visible in the video player by marking them with a feature, which is also displayed on the map. Conversely, you can mark ground features in the map view, and the features are also displayed in the video player. These points can be saved as a feature class and fully used later for further analysis.



Source: (ESRI, 2020). Retrieved August 4, 2020, from https://www.esri.com/content/dam/esrisites/en-us/media/pdf/teach-with-gis/implementation-guide-classroom.pdf

Appendix B: Language Editing Certificate

WORDPLAY EDITING
Copy Editor and Proofreader
Email: karien.hurter@gmail.com
Tel: 071 104 9484
Website: http://wordplayediting.net/

12 August 2021

To Whom It May Concern:

This letter is to confirm that *Enhancing a South African Grade 5 mapwork lesson with a geographic information system (GIS)* by Dominique Steggink was edited by a professional language practitioner.

Regards,



Karien Hurter