INAUGRAL LECTURE

Problem-based learning to foster self-directed learning in geography education

by

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In this inaugural lecturer, my central argument, is for the effective implementation of problem-based learning in geography teacher education, to help foster student teachers' self-directed learning skills.

1. THE THEORETICAL DISCOURSE

In this section I will discuss self-directed learning (SDL), problem-based learning (PBL), the influence of PBL on students' SDL, as well as providing an example of how to implement PBL in BEd. Geography modules.

2.1 Self-directed learning

The definition of SDL varies throughout the literature, and Ainoda, Onishi, and Yasuda (2005) point out that the term is often used interchangeably with educational concepts such as lifelong learning, active or independent learning, and student-centered or learner-centered education. The most common definition is that of Knowles (1975), who defines self-directed learning as "*a process in which individuals take the initiative, with or without the help of others, to diagnose their learning needs, formulate learning goals, identify human and material resources for learning, choose and implement appropriate learning strategies, and evaluate learning outcomes.*" A basic tenet of SDL is that students have the ability to identify and achieve learning goals through the effective use of learning strategies, to understand, monitor, manage, evaluate, and reflect on their own learning and locate appropriate resources (Francom, 2010). All these SDL abilities of students should benefit our future society and environment via an SDL process (Kwan, 2003).

The successful introduction of SDL into curricula requires adequate lecturer and student preparation; the challenge for educators involved in teacher training to promote SDL is to create learning environments and spaces in which it can be developed (Levett-Jones, 2005). Students as well as lecturers must possess a clear understanding of the concept of SDL and lecturers must select the appropriate teaching and learning strategies to facilitate and enhance learners' abilities in becoming self-directed. Although, a student can become a self-directed learner without explicit instruction and development of these traits, but it is more likely to occur when lecturers. teachers, and administrators understand and foster SDL in educational settings (Levett-Jones, 2005).

To facilitate students' SDL, it is critical to assess students' readiness for SDL. Kwan (2003) pointed out that readiness for SDL exists along a continuum and is, to some extent, present in all individuals. SDL readiness is defined as "the degree [to which] the individual possesses the attitudes, abilities and personality characteristics necessary for self-directed learning" (Wiley, 1983, p. 182). The instrument most widely used in educational research to measure SDL readiness, is Guglielmino's (1978) Self-Directed Learning Readiness Scale (SDLRS) (Merriam, Caffarella, & Baumgartner, 2007).

The challenge for lecturers interested in promoting SDL in higher education institutions is to create learning environments in which it can be developed. Using active learning strategies allows the practice of SDL by combining subject content with the application thereof in learning activities (Francom, 2010). In the literature, Golightly and Guglielmino (2015), Bao et al. (2010), and De Simone (2014) pointed out that PBL have all the attributes to assist in fostering SDL.

2.2 Problem-based learning

2.2.1 Introduction

PBL has a social constructivist view of learning (Barrett, 2005). PBL is thus student-centred and uses the solving of real-world ill-structured problems to initiate learning. It is defined by its founders as "*the learning that results from the process of working toward the understanding or resolution of a problem. The problem is encountered first in the learning process and serves as a focus for the application of problem solving or reasoning skills, as well as for the search for or study of information or knowledge needed to understand the mechanisms responsible for the problem and how it might be resolved"* (Barrows & Tamblyn, 1980:18).

Since the development of PBL in the field of medicine at the McMaster University in Canada in 1965, the successes recorded led to the widespread application of this teaching and learning strategy in other fields, including law, engineering, business, economics, nursing and social work (Rakhudu, 2011:81). From the literature PBL is increasingly finding favour in higher education because it offers a way to enhance student-learning by providing constructive and transformative learning experiences (Sproken-Smith, 2005). Interestingly, PBL has had little impact on teacher education and relatively little research has been published on PBL in teacher education settings (Kwan, 2008).

It is necessary for me to highlight that problem-based learning is a teaching and learning strategy by which students are encouraged to take responsibility for their own learning. In the

teaching profession, the ability to direct and regulate one's own learning experience is crucial to success. PBL facilitates not only the acquisition and organisation of knowledge, but also the development of several other 21st century skills such as problem-solving s, critical thinking, self-directed learning, communication skills, teamwork, sharing of information and identification of personal strengths and weaknesses (Schmidt, Rotgans & Yew, 2011: 798).

Fundamental problems may arise when Geography teachers are expected to teach within the social constructivist paradigm, using a learner-centred approach, if they did not receive the necessary training in preparation thereof. During their formative school years, most potential Geography teachers are confronted only with the traditional behaviourist teaching approach (Rambuda & Fraser 2004). Consequently, their beliefs and perceptions of the nature of teaching and learning do not support the very essence of the social constructivist paradigm. Among various constructivist approaches, PBL has been advocated as exemplary because it promotes a learner-centred approach that shifts the classroom focus from teaching to learning (Burch, 2001).

2.2.2 The learning process of PBL

Although there may be several ways of implementing the learning process of PBL, the following discussion includes a general PBL process. The PBL process is anchored by an ill-structured real-world problem, in other words, there is more than one solution to the stated problem (Pilgrim, 2014: 216). The students in their various groups actively collaborate to describe and demarcate the problem, research it and formulate learning issues that will guide further studies. The group members are then involved in self-directed research guided by the set learning issues, whereafter they must identify relevant sources that contain the theoretical or practical information needed. In tutorial sessions, group members come back with new information to share with the group and apply their knowledge to solve the problem by presenting multiple solutions. Lastly, the different groups must submit a final PBL report and present their solutions for the stated problem to the other PBL groups (Woods, 2006).

2.2.3 Role of the lecturers and students in PBL environments

PBL places the student at the centre of teaching-learning events, which contrasts with traditional teacher-centred models based on lectures. As such, PBL approaches require a different kind of educator – or at least a change in teaching practice. The self-directed approach of PBL suggests changes on the part of the lecturer from the conveyor of information and knowledge to the facilitator and guide of students' self-directed learning and collaboration with group members during the learning process (Van der Vleuten & Schuwirth, 2019). For the effective implementation of PBL, the availability of expert facilitators to guide students through the challenges of learning in PBL is important (Doering & Veletsianos, 2007). The facilitator

or tutor stimulates the discussion, provides students with relevant content information if needed, evaluates the progress, and monitors the extent to which each group member contributes to the group's work. Facilitators should engage actively in didactic conversations with the learners and provide appropriate scaffolds (Schmidt, Van der Molen, Te Winkel, & Wijnen, 2009). Moreover, facilitators are responsible for continuously giving formative feedback to the PBL groups (Koh et al., 2019). It is also the facilitator's responsibility to design and plan the PBL activity and create a problem scenario that is aligned with the outcomes of the subject module (Woods, 2006). The facilitator should be able to plan and design various types of problems for PBL activities, including decision-making problems, trouble-shooting problems, case studies and dilemmas (Jonassen 2011: 96). However, Pedersen and Lui (2002) also warn that a facilitator who is overly directive can deny group members the opportunity to discuss, argue, collaborate and engage in self-directed study, thus undermining the major goals of PBL.

With reference to the role of the students in PBL environments, the students also fulfil new roles. In most instances in PBL the students are organised into small tutorial groups where the students function as members of a team and learn collaboratively by sharing their newly acquired knowledge (Dolmans, Wolfhagen, Van der Vleuten, & Wijnen, 2001). Taylor and Hamdy (2013) highlight the importance of collaboration among group members for them to learn from one another's experiences, sort and refine ideas, consolidate what they know and rehearse the arguments that will serve them well in solving the stated problem. A common method is for students to actively work with reality-based situations or problems and then to formulate learning issues that will guide further studies. Using library resources, textbooks, maps and databases, as well as laboratories, field studies tools, techniques and procedures, they argue and debate to find answers to and perspectives on their problems and learning needs. The social negotiation of meaning is an important part of the learning process. The students begin to work on the problem and reconceptualise their problem into more specific learning issues (Järvelä, 2006). These learning issues are conceptualised into different learning tasks and delegated to different team members who must complete the tasks in their own time. In the next tutorial, everyone comes back with new information to share, and concentrate on peer teaching and working together on the problem (Lam, 2009). After the students have discussed and analysed the problem in their tutorial groups, they gather and apply their knowledge to solve the problem by presenting one or multiple solutions (Tick, 2007). At the end of the PBL process students are involved in peer and self-assessment.

2.2.4 PBL models

Many variations of PBL models are practised in educational settings. A *pure* PBL model requires students to use a full degree of SDL and solve highly ill-structured problems and is likely to result in better development of SDL skills when compared to other PBL models where there are more assistance and guidance from facilitators or tutors (Lee, Mann, & Frank, 2010). In an *integrated* or *embedded* PBL model, pure PBL is integrated in a traditional teaching curriculum for a period of time (Kivela & Kivela, 2005). In the *hybrid* PBL model, steps have been taken to assist the student in the transition from "content push by the lecturer" to "content pull by the student" as the problem-solver, guided and supported by the facilitator or tutor. Therefore, in hybrid PBL curricula a range of planned teaching strategies is incorporated, such as lectures, demonstrations, and conferences, along with the implementation of small group PBL tutorial sessions (Kivela & Kivela 2005).

Traditionally, PBL is usually conducted in classrooms, involving in-person, face-to-face interaction. As online learning is embraced in higher education, the development of online technologies can be used to supplement, or even replace, face-to-face PBL (Ryan *et al.* 2009). In the online PBL model, all meetings take place electronically, using the telephone, text-based chat or audio or video conferencing, or asynchronously, using discussion forums or email. The production of reports or presentations on their approach and solution is a common element of PBL activities. Tools such as wikis or Google Docs offer ways for students in different locations to create reports and presentations collaboratively on the same document (Glover 2014).

2.2.5 Use of scaffolds in PBL

A highlighted issue for PBL in connection to SDL is that of less mature students, who tend to have difficulty engaging with self-direction and require a higher degree of external scaffolding and structuring of their work (Hmelo-Silver, 2004; Knowles, 1980). Hmelo-Silver et al. (2007) argue that with the implementation of PBL, student support and guidance through scaffolding are essential. Scaffolding can be described as the assisted learning process in which students are supported by educators and fellow students (Powell & Kalina, 2009). By using scaffolds in PBL, facilitators can improve students' autonomy, competence and relatedness for enhancing their intrinsic motivation (Belland et al., 2013).

In PBL environments, group members are confronted with many different types of challenges, mostly brought on by deficiencies in knowledge or skills (Dolmans & Gijbels, 2013) that may negatively affect their learning (Wijnia et al., 2015). The facilitator must develop and implement various scaffolds that make the PBL activity more manageable and accessible for students to successfully attain their learning goals through solving problems (Ertmer & Glazewski, 2015). Ertmer and Glazewski (2019, p. 337) state that "scaffolds should be designed

and activated with intentionality, based on a detailed understanding of the learners and context in which they are used". Providing appropriate levels of scaffolding and support in PBL will enhance students' engagement, higher-order thinking skills and motivation (Belland, 2014) and improve their deep content knowledge. Yeung (2010) highlights that scaffolds enable students to deal with the complexities of a PBL activity and help to develop students' self-directed learning skills. In this regard, Schmidt et al. (2011) point out that once group members can complete the required PBL activity successfully, scaffolding can be gradually removed in the following PBL activities.

Scaffolding must be shaped to fit the specific learning context and, therefore, may take multiple forms (Simons & Klein, 2007), but most scaffolds can be classified as either soft or hard (Saye & Brush, 2002; Schmidt et al., 2011). In general, soft scaffolds refer to the facilitator's actions in response to the group members' efforts when there is a specific need (Choo, 2012). In this regard, Schmidt et al. (2011) explain that soft scaffolds offer timely and dynamic support, assistance and guidance, such as conversations or dialogue between facilitator and group members, and among group members themselves. Thereby soft scaffolds provide new information (Choo, 2012), give feedback on the group's performance, provide question prompts that encourage elaborative learning, provide hints, clues or suggestions to help group members solve the problem (Preus, 2012) and provide expert modelling of how experts perform a given task (Van de Pol et al., 2010) that help group members organise their thinking during the PBL process.

Hard scaffolds are static support structures or tools to assist in dealing with expected difficulties and challenges that may occur during the PBL process and are mostly developed before the implementation of the PBL activity (Choo, 2012). Hard scaffolds in PBL may include strategies or tools, such as student guides, videos, hints, resources, worksheets and assessment rubrics, that are developed in advance to guide group members during the PBL process (Choi et al., 2015; Choo, 2012; Schmidt et al. 2011; Yeung, 2010). The group members may refer to the hard scaffolds while they are working on the PBL activity and use them throughout the problem-solving process.

However, in geography and geography education, only a few researchers specifically refer to the use and impact of scaffolds in PBL in different learning contexts (Caesar et al., 2016; Golightly, 2020; Quain, 2014; Tonts, 2011). These researchers mostly use the following scaffolds in PBL activities: training videos and workshops (Golightly, 2016); learning and reading materials and assessment rubrics (Golightly & Muniz, 2013; Tonts, 2011); team-based learning strategies (Keeling, 2008); collaboration among group members (Caesar et al., 2016);

class-based discussion sessions (Keeling, 2008; Tonts, 2011); group meetings focusing on PBL and group processes; the provision of online learning resources, reflective diaries by tutor and students, feedback and comments by the facilitator or tutors (Golightly & Muniz, 2013; Mandić et al., 2016); argumentation (McGhee, 2015); PowerPoint presentations (Caesar et al., 2016); modelling (Tonts, 2011); online learning technologies, such as Google Docs, to facilitate the exploration and solving of complex and realistic problems (Golightly & Van der Westhuizen, 2018); and the use of multi-scaffolding for online learning, such as situated movies, screen-capture videos, conversational agents and collaboration zones (Doering & Veletsianos, 2007).

2.2.6 Assessment in PBL

Assessment in PBL is an essential part of the PBL process, as "learning and assessment are mutually dependent because both students and facilitator tend to pay greater attention to learning objectives that are assessed" (Van Aalst, 2013: 280). Assessment in PBL environments is driven by the need for constructive alignment between intentions of PBL and the assessment implemented during the PBL process (Van der Vleuten & Schuwirth, 2019: 904). Constructive alignment according to Norcini, Brownell Anderson, Bollela et al. (2018: 1103) is best achieved through an integrative approach to assessment using assessment *of, for* and *as* learning and moving away from the traditional assessment *of* learning or the summative assessment approach.

Assessment *of* learning is also often referred to as "summative assessment" and involves reporting on learning at the end of the PBL activity. It is built on strategies to motivate students and to provide information about students' performance, achievement and progress in PBL activities by giving them a mark or a grade for their performance (Bennett, 2011: 7). Grading students' performance or achievement in PBL can offer challenges because students are working collaboratively and interactively to solve the stated problems. It is difficult and complex to assess students' higher-order thinking skills that are promoted by PBL (Albanese & Hinman, 2019: 389). The facilitator therefore needs to assess students' performance using a scoring assessment rubric for identifying core competencies and essential skills, including attitude and punctuality, preparedness, participation, knowledge, group skills, problem-solving skills, critical thinking and the relevance of resources (Ibrahim & Al-Shahrani, 2018: 84).

In the development of students' 21st century skills through PBL activities, assessment *for* learning (also referred to as "formative assessment") in the form of continuous feedback on a regular basis during the learning process is essential (Albanese & Hinman, 2019: 392). Assessment for learning in PBL can be defined as the process of seeking and interpreting evidence for use by facilitators to decide where the group members are in their learning, where

they need to go and how best to get there (Assessment Reform Group, 2002: 1–2). In another definition by Schuwirth and Van der Vleuten (2011: 478), assessment *for* learning is described as an approach in which the assessment process is inextricably embedded within the PBL process, which is information rich and which serves to steer and foster the learning of each group member to the maximum of his/her ability.

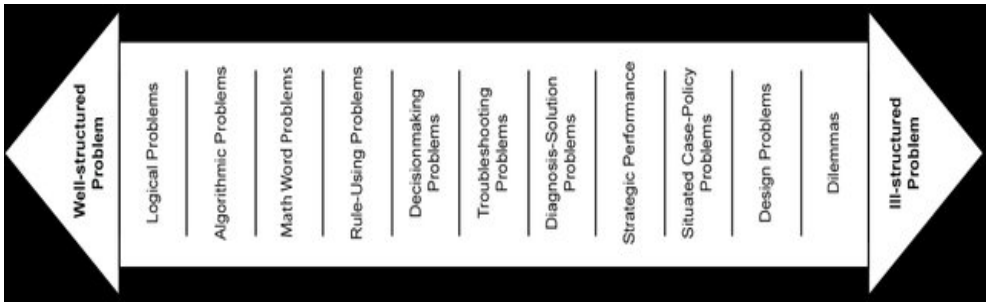
Assessment *as* learning reinforces and extends the role of assessment for learning as group members are involved in assessing their own and their fellow group members' contributions and progress in the PBL activity (Siarova et al., 2017: 40), rather than focusing only on the facilitator's assessment. However, it is necessary to point out that self-assessment in PBL can be shaped by a group member's prior learning experiences, motivations, emotions, and cognitive and metacognitive capabilities (To & Panadero, 2019: 922). The facilitator must keep this in mind when involving group members in self- and peer assessment.

When a facilitator involves group members in the assessment process, he or she promotes and develops the group members' self-directed learning skills (Koh et al., 2019: 19), giving them the tools to take responsibility for their own learning (Rodriguez-Gomes & Ibarra-Saiz, 2015: 2) and challenging them to become realistic monitors of their own performance and contributions, which ultimately leads toward the effectiveness of PBL (Gijbels, Dochy, Van den Bossche & Segers, 2005). With self-assessment, the focus is on the development of group members' capacity to assess their own work against criteria "to revise, modify, and redirect their efforts; and to take initiative in monitoring their own progress" (Koh et al., 2019: 19). The involvement of group members in self-assessment in the PBL process will, according to Saavreda and Opfer (2012: 13), support them to master content and improve their metacognitive skills.

2.2.7 Different type of problems

There are various types of problems that can be applied in PBL experiences. In this regard Jonassen (2000) collected hundreds of problems through a literature study. A cognitive task analysis of those problems was conducted to identify attributes of those problems, where after, based on their characteristics, distinguished 11 different types of problems were distinguished (See figure 1). The well-structured problems focus on correct, efficient solutions, while the ill-structured problems focus more on decision articulation and argumentation. In the geography PBL activities the use of ill-structured problems such as decision-making problems and dilemmas were used (Golightly 2018).

Figure 1 Different types of problems



Jonassen 2000

2.2.8 Self-directed learning in problem-based learning

In problem-based learning, self-direction is often seen as a critical component, as both an advantageous learning outcome of the teaching and learning strategy and as a specific goal (de Graaff & Kolmos, 2003). Hmelo and Lin (2000) argued that specific PBL features support the development of students' self-directed learning skills. The student-centred nature of PBL, the fact that students start working on a problem before they have received other curriculum inputs, the identification of their knowledge deficits, the generation of their own learning issues, students' self-directed research and individual study, the critical evaluation of the literature resources, the application of the new knowledge to the problem, and the critical and collaborative reflection on their SDL skills are all crucial features that foster SDL.

With respect to the *learning process* in PBL, students need to assess their learning issues based on the analysis of the problem discussed in the tutorial group. These learning issues, formulated as questions, comprise what needs to be research in the literature and subsequently be studied, to gain a better understanding of the stated geography problem. Given their prior knowledge of the study topic, students must decide independently how detailed and extensive their self-study should be. Essentially, "students are free to pursue whatever literature resources they deem interesting in light of the problem" (Schmidt &Moust, 2000, p. 243). Especially with respect to the independent literature search, students can develop their information-seeking skills, which prepares them to become flexible and adaptive learners. This reflection on students' SDL skills happens individually when a student notices that his or her study activities were insufficient and collaboratively when students, after hearing each other's input in tutorial meetings, realize that their literature resources do not (fully) cover the subject to be studied (Hmelo & Lin, 2000).

In PBL students collaborate with group members to help solve the problem. Collaborative learning has been found to promote the development of competencies needed to ask good questions and give explanatory feedback (Hmelo & Lin, 2000). It is no surprise that students in PBL environments have been found to attain more deep-level learning, stray further from

their teachers' authoritative guidance when seeking information and become continuously more self-reliant throughout their studies (Loyens et al., 2008). However, these advantages have also been found to be contingent upon the students' developing better self-directed learning (SDL) skills, such as information seeking, personal learning strategies, handling of group discussions and reflecting on their learning (Evensen et al., 2001). Therefore, self-directed learning skills have long been seen as one of the most central learning goals for PBL institutions, essentially an antecedent for many of the other advantages, as well as one of the most significant benefits.

They found, among other things, that students in PBL environments applied a more comprehensive range of resources and information relating to their learning goals than their peers in traditional programs (Loyens et al., 2008). Schmidt et al (2011) found that during the span of their education, PBL students become continuously more self-reliant, depending less on lectures but increasingly on group discussions. Results that to some extent mirror these are those of Kivela and Kivela who studied students during an implementation of PBL in Hong Kong. They found that the students relied on the teachers' guidance to a lesser extent after having been subject to PBL. In their first semester they tended to rely on their fellow students, but this tendency seemed to have lessened in their second year, where they seemed to have developed self-direction and autonomy to some extent (Kivela & Kivela, 2005).

2.2.9 Problem-based learning to foster self-directed learning

Savery (2015:8) highlights the development of SDL when employing PBL as strategy. As PBL is a learner-centred approach, learners should engage with the problem and develop responsibility for their own learning. It is necessary to point that many variations of PBL models are practised in educational settings.

A pure PBL model is likely to result in better development of SDL skills when compared to other PBL models where there are more assistance and guidance from facilitators or tutors (Lee, Mann, & Frank, 2010). Therefore, most of the evidence supporting PBL in fostering SDL has been reported by higher institutions with pure PBL curricula (Bao et al., 2010; Koh et al., 2019).

In contrast, the evidence from the integrated PBL model on SDL is rather inconsistent. Walker and Lofton (2003) reported a decrease in SDLR scores of PBL students in the first 16 weeks of their pharmacy studies. Golightly and Guglielmino (2015), as well as Aziz, Zain, Samsudin, and Saleh (2014), reported an improvement in students' perceived readiness in SDL after the implementation of integrated PBL experience. More evidence is required to understand whether the implementation of an integrated PBL model over a longer period of time actually leads to students becoming better self-directed learners.

Although I published various international and national articles dealing with PBL (See list 1) I have decided to focus on how PBL was implemented in BEd geography modules, as well as the influence of an integrated pure PBL model on geography students' perceptions of their self-directedness in learning in a longitudinal case study.

2.10 The implementation of PBL in BEd geography modules to foster SDL: An example

In my opinion it is important to show university lecturers and schoolteachers how PBL can be implemented in various modules in a programme during an academic year.

2.10.1 Planning and implementation of the PBL activities

In this example all B.Ed. geography modules in the first to third year at the North-West University (Potchefstroom campus), as indicated in Figure 2, were selected for the implementation of the six-week (three weeks per module) integrated PBL experiences per year. The facilitators developed geography problems, which were aligned with one of the module outcomes for each module during the three years (see Table 1). During three weeks per module in the first and second year, the students attended the twelve scheduled face-to-face PBL tutorial meetings (each tutorial was 90 minutes in duration) to present solutions to the stated real-world geography problems.

The on-campus fourth-year geography education students acted as student tutors for the first- and second-year geography student groups during the "face-to-face" PBL tutorials. The student tutors' involvement in the PBL tutorial sessions gave the student tutors exposure to applying theory in practice (Golightly, 2016) and form part of the didactic module in geography where they must plan and facilitate learner-centred geography school lessons. Additional to this, the fourth-year geography student tutors also received training in the form of a three-hour workshop about the role of tutors in PBL tutorials.

It was decided that in the third year the geography students had to complete the integrated PBL activities in google docs online. The online PBL groups worked collaboratively in Efundi, the Learning Management System of the university, to complete the PBL activities on Wiki. The geography lecturers responsible for the two third-year geography modules, have acted as online tutors during the six-week online PBL experiences.

Year Level	Semester 1 (10 weeks)	Semester 2 (10 weeks)
Fourth-year geography modules (GEOD411/ LASD421)	Fourth-year students act as tutors	Fourth-year students act as tutors
Third-year geography modules (GEOE311 & GEOE321)	---------- (M5) PBL**	PBL** (M6) ----------
Second-year geography modules (GEOE211 & GEOE221)	---------- (M3) PBL*	PBL* (M4) ----------
First-year geography modules (GEOE111 & GEOE121)	---------- (M1) PBL*	PBL* (M2) ----------

*– Implementation of face-to-face integrated PBL activities (3 weeks per semester/ 6 weeks per year) (M1-M2; M3-M4)
**– Implementation of the integrated online PBL activities (3 weeks per semester / 6 weeks per year) (M5-M6)
---------- – Normal classes
M1 to M6 – Measuring students' perceptions of their readiness in SDL before and after each PBL intervention

Figure 2. The implementation of PBL activities in the geography modules

Preparation of the geography student teachers before the PBL intervention in the first year included an orientation session in the form of a two-hour workshop, which included additional notes before the implementation of PBL in the different modules.

Table 1. PBL activities integrated in the different geography modules in the B.Ed. programme

Year	First semester	Second semester
First year	**GEOE111 Introduction to Africa and South Africa** **Theme: Water usage in urban areas** Municipalities in South Africa have been hit by service delivery protest over water shortages. A few people were killed allegedly at the hands of police (News24). Water supply by municipalities in South Africa is a basic service that must be provided to urban residents. Municipalities country-wide experience problems to properly render this basic service. Provide possible strategies and guidelines to municipalities and households in using water more wisely.	**GEOE121 Planetary Geography and Climatology** **Theme: Learner-centred instruction of Planetary Geography themes** The social constructivist approach to learning has implications for teaching geography topics, such as insolation differences on earth, origin of seasons, time differences and calculations of time on earth to first-year students. Assist the geography lecturer in planning learner-centred activities for the abovementioned topics.
Second year	**GEOE211 Settlement and Economic Geography** **Theme – Rural settlements: Land reform in South Africa** **Land reform:** Two and a half centuries of conquest and settlement by European colonialists in South Africa deprived Africans of most of their land. Since the election of a new government for South Africa in 1994, there has been no real progress with land reform. Assist the South African government in developing a plan and strategies to secure more agricultural land for black farmers.	**GEOE221 Environmental Geography** **Theme: Water quality** South Africa is a water-scarce country and we need to manage water properly. To encourage the different municipalities to improve the quality of drinking-water and water sources, the Department of Water Affairs annually awards Blue and Green Drop status to municipalities for the effective treatment and monitoring of drinking water, as well as the management of responsible water consumption and maintenance of services. The Tlokwe municipality (Potchefstroom) has for the past few years received the Blue as well as the Green Drop award. However, the question still remains as to the quality of the water in the Mooi River in Potchefstroom. The local newspaper asks you, as geography students, to determine the water quality of the river by using miniSass and, if necessary, to make recommendations to the local government on how to improve the river's water quality.
Third year	**GEOE311 Population Geography and Urban Geography** **Theme: Poor health in low-income urban areas** As beginner geography teachers in a school situated in a low-income informal settlement in Ikageng, Potchefstroom, you become aware that the geography learners in your class are absent on a regular basis. In discussions with the principal, teachers, as well as the clinic sisters at the nearby medical clinic, the poor health conditions in the low-income dwelling areas are highlighted as the main reason. The government body of the school ask you to provide possible solutions to the	**GEOE321 Climatology and Geomorphology** **Theme: Climate change in South Africa** Global warming and modern climate change are considered a serious problem world-wide and, according to scientists, this threatens the future existence of man on earth. In South Africa there is great concern about the impact that climate change (global warming) will have on our country's people and environment. The Department of Agriculture Conservation and Environmental Affairs requests a report from the geography students with reference to the presence of climate change in South Africa, as well as possible measures which the SA government could implement to, firstly, help manage this

	poor health problems of learners and residents in the area.	problem and, secondly, to combat it drastically. The Department also wishes to know what can be done by individuals and households to make a meaningful contribution.

(Golightly, 2018)

A case study approach was used for this research and involved the collection and analysis of quantitative and qualitative data (Creswell, 2009). In this case study, the longitudinal equivalent time samples design (Leedy & Ormrod, 2001, p. 241) consisted of making a series of observations over a three-year period in measuring the influence of the implementation of PBL in the different geography modules on B.Ed. students' perceptions of their self-directedness of learning.

The quantitative data were collected, using the Self-Directed Learning Readiness Scale (SDLRS), developed by Guglielmino (1978), before and after the implementation of PBL experiences over a three-year period (see Table 2). The SDLRS is a 58-item, five-point Likert scale instrument, which measures a total score for SDL readiness. The SDLRS questionnaire asks respondents to rate how important or relevant to their current learning they perceive each item to be. Students were asked to rate each item on a five-item scale (1 = almost never true of me; 2 = not often true of me; 3 = sometimes true of me, 4= usually true of me; 5= almost always true of me). Students' responses to questions are analysed and a score is computed indicating the readiness of a specific student for SDL. A high score implies that a student requires less guidance in learning than a student with a lower score. The range of the instrument is between 58 and 290, with the mean score for adults at 214.00 + 25.59. The levels of readiness for SDL are as follows: < 176 – low; 177 to 201 – below average; 202 to 226 – average; 227 to 251 – above average; 252 to 290 – high (Guglielmino, 1978). Guglielmino's (1978) dissertation research found the reliability coefficient for the SDLRS as 0.87. The reliability of the SDLRS of the geography students in another study at the same faculty, as measured by Cronbach alpha reliability coefficient, was 0.91 (Golightly & Guglielmino, 2015).

Out of the 66 B.Ed. Geography students enrolled for geography, 45 students (18 male and 27 female students) have completed the SDLRS questionnaire at various intervals over the three-year period.

After the analysis of the quantitative data, the researcher collected qualitative data by semi-structured focus group interviews with geography students (two groups of four students each) at the end of the PBL experiences in their third year (Leedy & Ormrod, 2001). The focus group interviews were conducted to gather deeper exploratory data from participants, and to gain a

wider range of responses regarding results found with the quantitative approach (De Vos, Strydom, Fouche, & Delport, 2005). The data, consisting of transcribed semi-structured focus group interviews, were analysed using a thematic analysis (Creswell & Plano Clark, 2007).

2.10.2 Results and discussions

First, the geography students' perceptions of their readiness in SDL with the implementation of PBL will be highlighted. Thereafter the influence of an integrated PBL on students' perceptions, with different levels of readiness in SDL as well as gender differences, will be discussed. The qualitative data were used to help interpret the quantitative data and, therefore, refer to the same themes as discussed below.

2.10.2.1 *The influence of PBL on geography students' perceptions of their readiness in SDL*

The geography students' perceptions of their readiness for SDL with the implementation of the integrated PBL model in the B.Ed. geography curriculum over a three-year period are indicated in Table 2 and Figure 2. The mean SDL scores of the geography students at the beginning of PBL intervention in the first year was 210.6, while their mean SDL scores at the end of the PBL intervention in the third year increased to 220.4. A statistically significant increase ($p = 0.0009$), as well as a medium practically significant increase ($d = 0.66$), with the implementation of the integrated PBL model in the geography modules and students' perception of their readiness for self-directedness in learning have occurred over the three years.

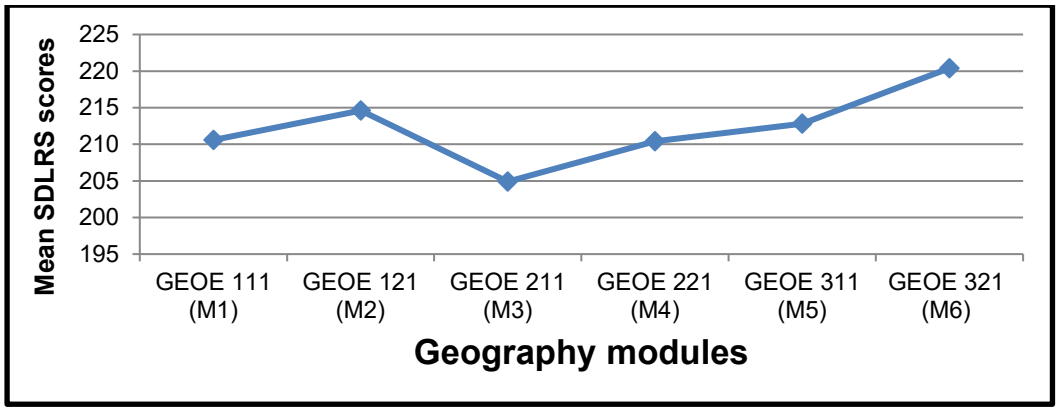


Figure 2. Geography students' perceptions of their readiness in SDL with the implementation of PBL

In Table 2 it is clear from the students' mean SDL scores that increases occurred after PBL interventions in the geography modules. These increases in students' mean SDL scores have medium practical significance ($d = 0.37$ and 0.52) with two PBL interventions (refer to M3-M4 and M5-M6 in Table 2). Interestingly, the highest increase in students' mean SDL scores, from

212.8 to 220.4, occurred in the third-year online PBL intervention (M5-M6), with a medium practically significant increase (d = 0.52). However, a high decrease in geography students' perceptions of their readiness in SDL occurred in the period between the PBL intervention of the first year and the PBL intervention of the second year (refer to M2-M3), with a medium practically significant difference (d = 0.66).

Table 2. Mean SDL scores, statistically and practically significant differences (effect size) of students' perceptions of their readiness in SDL with the implementation of PBL

Modules	$\bar{X}$	**MSE**	**p-value**	**d-value**					
				GEOE111 (M1)	GEOE121 (M2)	GEOE211 (M3)	GEOE221 (M4)	GEOE311 (M5)	GEOE321 (M6)
GEOE111 (M1)	210.6	217.7	0.00009	-	0.27	0.39*	0.01	0.14	0.66*
GEOE121 (M2)	214.6				-	0.66*	0.28	0.13	0.39
GEOE211 (M3)	204.9					-	0.37	0.53*	1.05**
GEOE221 (M4)	210.4						-	0.16	0.68*
GEOE311 (M5)	212.8							-	0.52*
GEOE321 (M6)	220.4								-

(d-value: small effect: d ≈ 0.2; medium effect: d ≈ 0.5* = medium effect; and d ≈ 0.8** large effect)

The average level of readiness for SDL among first-year geography students at the beginning of the study was lower when compared to other studies in other disciplines using the same SDLRS questionnaire (Premkumbar et al., 2014; Walker & Lofton, 2003). A possible reason for the lower readiness of SDL of geography students in a South African context can be attributed to the fact that most of the students had been exposed to teacher-centred instruction as learners in most South African classrooms (Warnich & Meyer, 2013).

In general, the implementation of the integrated PBL model in the geography curriculum had positive influences on students' perceptions of their readiness in SDL over time. This study concurs with other longitudinal studies from other disciplines where PBL was implemented over longer periods of time and where students' SDL scores increased (Bao et al., 2010; Chakravarthi & Vijayan, 2010; Rezaee & Mosalanejad, 2015). The findings of this study support the view of Polyzois, Claffey, and Mattheos (2010) that PBL could be more effective in shorter interventions within a traditional curriculum than at the whole curriculum level.

Possible reasons for the increase of students' perceptions of their self-directedness in learning with the implementation of integrated PBL experiences in this study can be ascribed to the important role that student tutors and group members have played in supporting and assisting geography students in the PBL environment. These findings support Williams, Alwis, and Rotgans (2011), who stated that students benefit from being facilitated by student tutors because of cognitive and social congruence. The important role of group members in fostering fellow group member's SDL skills during PBL activities was highlighted by the respondents. Hmelo-

Silver (2004) stated that students have the advantage of accessing the experiences of other group members to solve the stated problems. In this regard the findings of this study support Chakravarthi & Vijayan's (2010) recommendation that support and guidance must be provided to students early in a PBL environment and then facilitate increasing independence in the later years of the students' study.

Respondents highlighted the importance of using real-world geography problems in motivating them to do research to help solve these problems. These findings concur with Lambe's (2007) view that when students address real-life problems in teacher education, they are increasingly motivated to investigate such issues further. Van Berkel and Schmidt (2000) stated that the quality of the cases or problems affects the tutorial group functioning which in turn influences SDL in PBL. A respondent pointed out that to solve the real-world geography problems, they had to use information from other disciplines.

The geography students' involvement in the online PBL activities in the third-year geography modules encourages them to take responsibility for their own learning. This finding supports Sua and Beaumont's (2010) view that solving problems in wikis online promotes interaction, discussion, collaboration, reflection, co-creation, and the sharing of information, ideas and perceptions among group members. These are fundamental skills in promoting students' self-directedness in learning.

It is important to reflect on possible reasons for the geography students' drastic drop in average SDL scores at the beginning of the second year PBL experience. This contrasts with other studies where the decrease in students' SDL scores occurred at the end of the first PBL experience (Litzinger et al., 2003; Reio & Davis, 2005). In this study respondents mentioned that most of the students had been challenged by their involvement in a PBL environment in the first year, and therefore they were uncertain and nervous to be involved again in PBL activities in the second year, after a few months of traditional instruction. In this regard Lewis et al. (2009) pointed out that students who have no prior experience with SDL may initially express feelings of confusion and frustration with the lack of direction and information from the tutor. The steep decrease in students' SDL scores in this study can possibly be explained by Maung, Abas, and Abdullah (2007), who stated that students who entered university had a greater anticipation and expectation towards a new learning environment, such as PBL. After adaptation to the learning environment, the students faced a "honeymoon effect", meaning the self-directed behaviour would fade after a period of time. After passing the phase, students would enter an acceptance phase, in which they would reflect their learning process and get a deeper appreciation of SDL.

2.10.2.2 *The influence of PBL on geography students' perceptions with different levels of readiness in SDL*

With reference to the influence of the integrated PBL interventions on students' SDL scores, practically significant differences occurred. The students who held the perception of high levels of readiness in SDL, showed a steep decrease in SDL scores with the implementation of the PBL in their first year, after which there was an increase in the second and third year. Regarding the students with high mean SDL scores, a decrease was measured over the three years. This decrease in mean scores is of small practical significance (d = -.11) (refer to Table 3).

In contrast, the students who held perceptions of very low, low and average levels of readiness in SDL at the beginning of the study, had high increases in their mean SDL scores, with respectively high to medium practically significant differences (d-values of 0.93, 0.51 and 0.80) with the implementation of an integrated PBL model over the three years. It is interesting to note that the students who held perceptions of low and below average levels of their readiness in SDL had especially high increases in mean SDL scores after the first PBL intervention in the first year (M1 and M2), with high practically significant differences (d = 1.10 and 1.89) (refer to Table 3).

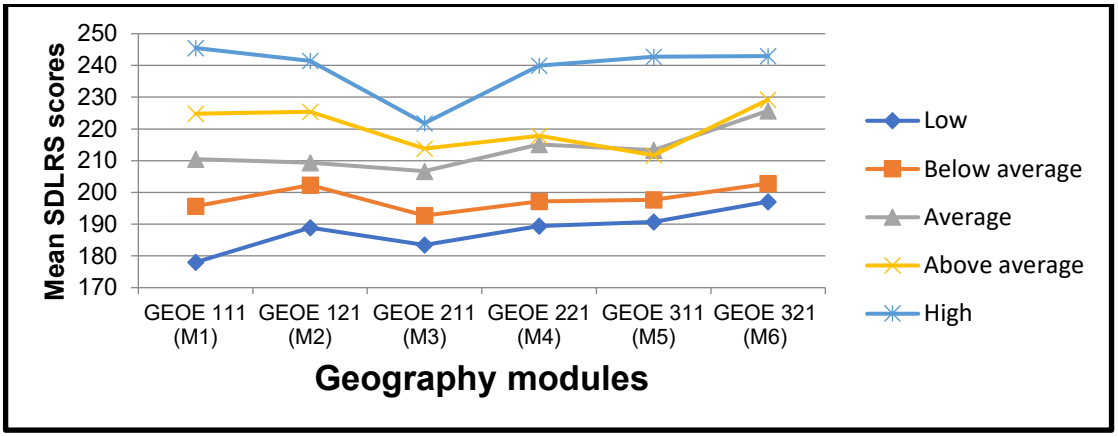


Figure 3. The influence of an integrated PBL model on students' perceptions of different levels of SDL scores

Table 3.Practically significant differences with the implementation of PBL on students' perceptions with different levels of readiness in SDL

LEVELS OF READINESS IN SDL	**Geography modules**	**Mean** $\overline{X}$	**N**	**SME**	**d-value**	
					In the different years	**From first year to third year**
Low	GEOE111 (M1)	178.0	15			
	GEOE121 (M2)	188.9	15		1.10**	

	GEOE211 (M3)	183.5	16			
	GEOE221 (M4)	189.4	16		0.42*	
	GEOE311 (M5)	190.7	13			
	GEOE321 (M6)	197.1	13		0.36*	0.93**
Below average	GEOE111 (M1)	195.7	14			
	GEOE121 (M2)	202.3	14		1.89**	
	GEOE211 (M3)	192.7	10			
	GEOE221 (M4)	197.2	10		0.31	
	GEOE311 (M5)	197.7	10			
	GEOE321 (M6)	202.8	10		0.33	0.51*
Average	GEOE111 (M1)	210.5	17			
	GEOE121 (M2)	209.4	17		-0.27	
	GEOE211 (M3)	206.7	14	208.0		
	GEOE221 (M4)	215.1	14		0.40*	
	GEOE311 (M5)	213.3	15			
	GEOE321 (M6)	225.7	15		0.48*	0.80**
Above average	GEOE111 (M1)	224.8	16			
	GEOE121 (M2)	225.4	16		0.15	
	GEOE211 (M3)	213.8	12			
	GEOE221 (M4)	217.8	12		0.20	
	GEOE311 (M5)	211.7	10			
	GEOE321 (M6)	229.2	10		0.72*	0.20
High	GEOE111 (M1)	245.5	10			
	GEOE121 (M2)	241.4	10		-0.32	
	GEOE211 (M3)	221.8	8			
	GEOE221 (M4)	239.9	8		0.73**	
	GEOE311 (M5)	242.8	8			
	GEOE321 (M6)	243.0	8		0.01	-0.11

(d-value: small effect: d ≈ 0.2; medium effect: d ≈ 0.5 *; and d ≈ 0.8** large effect)

Regarding the influence of PBL on students with different levels of self-directedness in learning, the students who had very high SDL scores at the beginning of the study showed a degree of decline over the three years. A possible reason can be that high academic performances in geography at school level can cause students to have misconceptions of their SDL abilities. Walker and Lofton (2003) believed the inflated perceptions of students' regarding their self-directedness in learning could be tamed over time with the implementation of PBL. It is necessary to clarify that some students already have the necessary SDL skills and, therefore, will not necessarily show an increase in the implementation of PBL over time.

What is insightful, is the fact that the geography student who had measured very low, low, and average SDL levels at the beginning of the study, showed an increase in SDL scores with the implementation of PBL over the three years. The implementation of PBL had a clear influence on the group of geography students' perceptions of their self-directedness in learning. The findings of this study can also be explained by referring to Biggs and Tang's (2011) two types of students who have different reasons for wanting a university degree, namely "academic Susan" and "non-academic Robert". In the context of this study, the students with high self-directedness in learning are compared to the "academic Susans", who are motivated to learn and who experience no real challenges to work on their own in PBL environments. Interestingly, the students with low self-directedness in learning – the "non-academic Roberts" – were challenged in the PBL environment to take, with time, responsibility to learn on their own.

2. Future research in PBL to foster SDL

I am currently involved in a Geography education project, where I want to explore the relationship between geography teachers' level of SDL, their involvement in self-directed professional development activities and the implementation of active teaching-learning strategies in the geography school curriculum.

With reference to my future research, I want to focus on the following:

3.1 *The implementation of PBL in the school geography curriculum*

In the geography literature no studies with the focus on the planning, designing and implementation of PBL activities in the school geography curriculum could be found. As the Charter of Geography Education recommended that PBL must be integrated in the school curriculum (Kolossov et al, 2016), it is therefore clear that geography teachers and preservice teachers need further professional development in the planning, designing and implementation of PBL in their geography classrooms. I support the view of other researchers who have pointed out that PBL also have all the attributes to assist geography teachers and preservice teachers in fostering their SDL skills (Pepper, 2009; Sproken-Smith, 2005) and help develop their PCK skills, with special reference to facilitating learners through investigative active learning strategies (Martin, 2017). The implementation of PBL in geography school curricula can also help develop 21st century skills of geography school learners.

The planning, design and implementation of PBL in the geography school curriculum will be a first encounter for most of the geography teachers and preservice teachers. In this research I plan to involve geography teachers and my preservice geography teachers in the design, planning and implementation of PBL tasks or activities in the geography curriculum. Geography teachers, who will act as mentors for the third-year preservice geography teachers during the WIL period, as well as the third preservice geography teachers will also be expected to plan, design and implement of PBL activities during the work-integrated learning period.

3.2 *The planning of meaningful geography PBL problems*

As a geography lecturer training future geography teacher, it is necessary to specifically focus on the planning and design of effective geography problems when planning the PBL activities that is aligned with the module outcomes of the specific module. Problems serve as a vehicle

to afford the content knowledge to be studied. It is no surprise that most PBL researchers agree that the design of problems could certainly influence the effectiveness of PBL activities (Ge & Chua, 2019). Against this background Hung (2006) proposed the 3C3R PBL problem design model, and then later developed the 2nd generation 3C3R model (Hung, 2019). I would like to use this framework to assist my geography students in planning and design geography problems to help foster SDL.

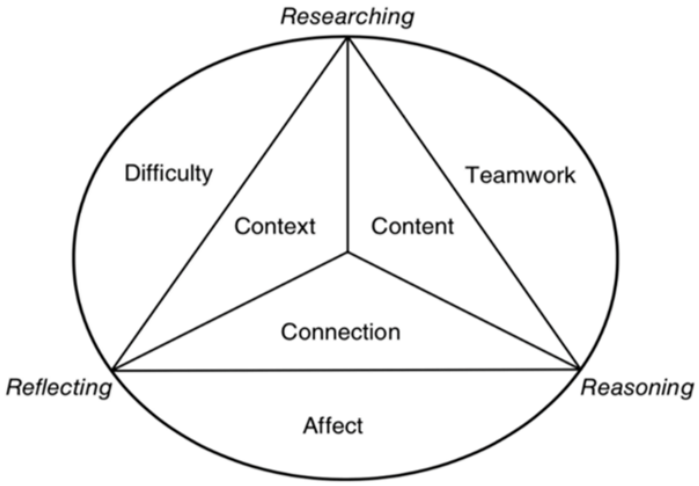


Figure 2: The 2nd generation of the 3C3R PBL problem design model (Hung, 2019: 251)

The ***core components*** of the 3C3R model consist of content, context and connection. The core components are concerned with students' acquiring the content knowledge, contextualizing domain knowledge, and building a conceptual framework around the topic under study (Hung, 2009).

The ***processing components*** include researching, reasoning, and reflecting, which deal with students' acquisition of content knowledge and the development of problem-solving skills and self-directed learning skills. These components direct students toward the intended learning outcome; adjust students' levels of cognitive readiness and address any challenges they may experience with PBL (Hung 2006).

The new set of components in the 2nd generation of the 3C3R model, which are the ***enhancing components***, include affective factors, problem difficulty, and teamwork functions. These components enhance the PBL problems to promote students' motivation and engagement, self-directed learning, and cooperative skills (Hung 2019).

In my opinion it is of utmost importance to develop a guiding template that can help and assist my geography students in including all the components as indicated by Hung's 2nd generation

of the 3C3R problem design model. I therefore plan to use my NRF funds to visit Prof Woei Hung at the University of Missouri-Columbia in North Dokota and to collaborate with him in designing a guiding template that schoolteachers and preservice teachers can use to plan meaningful problems.

3. Conclusion

The effective implementation of PBL in geography education can influence geography students' perceptions of their self-directedness in learning. For the best results to help foster geography students' self-directedness in learning, it is necessary to implement PBL experiences at regular intervals in the geography modules in the different academic years. The involvement of students in face-to-face PBL experiences makes it easier for them to be involved in on-line PBL experiences. The geography educator, who acts as facilitator in the PBL process, plays an important role in guiding the students in solving real-world geography problems. The training of geography facilitators and students to fulfil their new roles in face-to-face and online PBL environments is of the utmost importance. It is also necessary to provide geography students with assessment rubrics to assist them in solving the stated problem and compiling the PBL report.

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