PLAYING AN INDIGENOUS SOUTH AFRICAN GAME AS AN INDICATOR OF SUCCESS FOR LEARNING PROGRAMMING IN HIGHER EDUCATION INSTITUTIONS

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Abstract

This paper explores Morabaraba, a strategy-based African indigenous game, to develop problem-solving skills in computer programming students enrolled in higher education institutions in South Africa. This paper will not test any hypothesis or analyse any data collected, but rather explore the Morabaraba game play required to successfully solve programming problems. Morabaraba is a traditional South African game that has been passed down through generations of Africans which requires strategic and analytical thinking to win the game.

The result of the research identifies the critical thinking skills and abstract thoughts required for successful problem solving and correlates these to the skills that Morabaraba develops.

Introduction

Under South Africa's history of Apartheid, there were substantial disparities in the provision of schooling among the segregated population, with a disproportionate allocation of resources allocated to the minority white population (Sayed & Kanjee, 2013, p. 5). This resulted in many students who are enrolled to learn programming in higher education institutions in South Africa being non-English first language speakers, even though they have been taught and assessed in English at school (Barlow-Jones, 2019).

Many learners within the South African context experience difficult learning conditions and the problem being investigated is whether indigenous games could positively influence learning for programming, especially for learners from disadvantaged communities (Foko & Amory, 2008).

Barlow-Jones (2019) further explains that early foundational programming concepts which scaffold one on another are not easily grasped by students in the beginning stages of learning problem solving. Strategic indigenous games like Morabaraba could bridge the gap between language requirements and cognitive and social constructivism.

Problem Statement

The aim of this paper is to: (1) explore the potential of Morabaraba in programming courses in higher education to develop problem solving skills in students enrolled in Information and Communications Technology (ICT) courses; and (2) align the benefits of playing an indigenous African game to improve programming abilities.

Methodology

In this study, a qualitative approach was adopted using content analysis and comparisons. This was considered appropriate since the researchers required an in-depth exploration of Morabaraba games. The researchers relied on secondary data gathered from published journals, books, articles and websites. Various authors within South Africa have leveraged the role and learning affordance of different indigenous games, including Morabaraba. The following research questions will be answered:

- What cognitive capabilities are required for programming?
- Does Morabaraba contribute positively to the requirements for programming?

Theoretical Framework

Before drawing any conclusions about using an indigenous game to facilitate and improve learning for problem solving in computer programming, it is important to explore social constructivism as a learning theory .

Social Constructivism

Although there are many different learning theories and approaches to learning, the constructivist learning theories pursue to understand how learners create knowledge concepts and what these mean for understanding influences on thought processes.

Social constructivism was developed by a Russian psychologist Lev Vygotsky. According to Vygotsky (1978), cultural development is influenced by two factors: the social level and the personal level. Learning is viewed as a process of active knowledge construction with contributions from and within social forms and processes. Social constructivism emphases communication and social life in the forming of meaning and cognition (Boudourides, 2003), and the learner is considered a co-constructor of the knowledge (Taylor et al., 1997). Social constructivism has the most bearing in this paper because Morabaraba requires two players, which reinforces the active learning construction using social constructivism.

This paper frames its discussion based on the social constructivist theory that: 1) learners will develop problem-solving skills based on already existing social constructs to which they add new meaning; and 2) others have a role to play in the construction of an individual's knowledge.

Learning for Problem Solving and Computer Programming

Ben-Ari (1998) found that from his research that cognitive constructivism is the preferred learning theory for success in computer programming rather than passive learning where the learner sits back and learns theoretical content. Ben-Ari (1998) argues that learning problem solving and programming will be more successful using active learning. He concludes that computer programming students must create their own understanding of programming and problem solving from external factors and the guidance and feedback provided by their facilitators, lecturers, and peers.

Using games as a pedagogical tool for teaching and learning computer programming is not new (Lawhead et al., 2002). Pitiera & Haddad (2011) state that using games as a learning tool is advocated as games have the potential to positively contribute to successful learning.

Problem solving for computer programming has always been a challenging discipline for entry-level South African students in higher education. Students who struggle to understand key concepts and content can be left behind in the classroom, especially in subjects like problem solving and computer programming, where concepts build on each other (Barlow-Jones, 2019). Programmers need to have the ability to create the structure for programming logic using algorithms or pseudocode. Algorithms are defined as a set of precise rules determining how to provide a solution to a problem or to perform a task (Garner, 2006).

Background of Games

Juul (2003) proposed that games are formal systems based on rules with variable and quantifiable outcomes. Different outcomes are assigned values and players labour to influence the outcome, and in the process the player feels attached to the outcome. Ultimately, the consequences of the activity are optional and negotiable. Society views games as being recreational in many instances (Kovačević & Opić, 2013). It is understandable that play is defined as a form of human activity that is associated with early childhood and continues to follow them throughout their life (Kovačević & Opić, 2014).

Games, including indigenous games, stimulate psycho-motor, cognitive, emotional, and social development in children (Kovačević & Opić, 2013). Nxumalo and Mncube (2018) argue that indigenous games can be modified to fit contemporary needs. Teaching of programming concepts is such a need.

Strategic Board Games for Problem Solving

A strategy game or strategic game is where the players autonomously use their decision-making skills in determining the outcome. Almost all strategy games require internal decision tree-style thinking, and typically very high situational awareness (Karasimos & Zorbas, 2020). Chess has long been recognised as a game that develops critical thinking and analysis in the players, but there is very little research into indigenous South African (or African) games like Morabaraba.

What is Morabaraba?

The Morabaraba game is a two-player strategy board game based on tactically manoeuvring tokens, referred to as cows, around the board. The game is based on cows, which have historically represented the traditional African supreme symbol of wealth. Morabaraba was used to share cattle herding strategies in parts of Southern Africa including South Africa, Botswana, and Lesotho. Historically men and boys were responsible for hunting, protecting the tribe members and tending to the animals. Women and girls maintained the crops, cooked, cleaned and collected water (South African History Online, 2019). These traditional roles persist in the rural areas in South Africa, where many of the disadvantaged South Africans live.

Through Morabaraba, young boys were taught strategic and tactical skills when dealing with cattle (Russouw, 2002), and, even today, the playing pieces are known as “cows”. The game does not require special equipment as tokens can take any form, including stones or bottle tops, while the board can be drawn in the sand (Nkopodi & Mosimege, 2009).

The board (see Figure 1 below) is composed of three squares or levels with lines connecting the corners and the middle of the squares. Each square has eight junctions at which cows may be placed. Specific strategies and rules need to be employed at each level. The cows can be moved along the lines, including lines forming the squares. Each game starts with an empty game board and each player has twelve cows, a different colour from the opponent's cows, and may lose or gain these at different game stages (Mkhonto & Cloete, 2010).

The game involves three stages (Jama, 2000; Mosimege & Ismael, 2007; Nkopodi & Mosimege, 2009). The first stage involves each player, in turn, placing a cow on one of the empty intersections of the board, with the aim to get three cows of the same colour lined up to create a "mill". These mills can go in any direction, i.e., vertical, diagonal, or horizontal (Mosimege & Ismael, 2007).

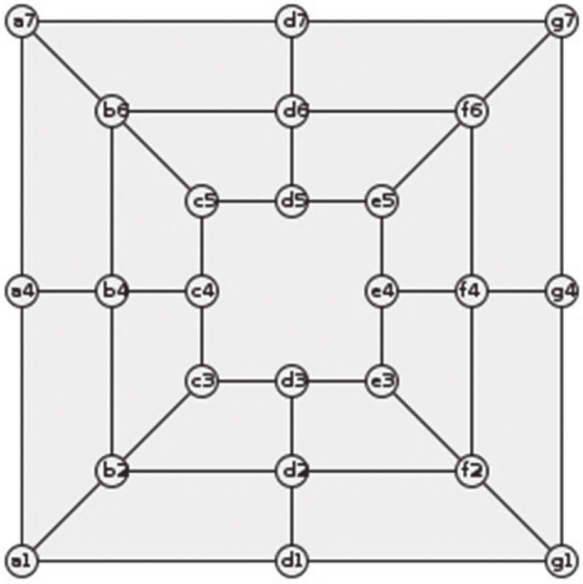
The second stage involves moving the cows in an adjacent empty space with the aim to create a mill. The opponent can try to block these moves by employing a countermove of repositioning their cows or creating a new mill (Mkhonto & Cloete, 2010). The player who successfully creates a mill can "shoot" one of his or her opponent's cows, which is then out of the game and removed from the Morabaraba board (Mkhonto & Cloete, 2010; Mosimege & Ismael, 2007). An exception to the rule is that a cow cannot be shot if it is in a mill itself unless all the player's cows are in mills, in which case they are all targets. When a cow has been shot, it is the end of the turn and the opponent's turn to move a cow to a free location to create a mill and thereby shoot an opponent's cow. Similar moves may be repeated in some cases.

When a player is left with only three cows, any one of the cows can be moved to any empty space on the board, regardless of "jumping" the lines (Mkhonto & Cloete, 2010; Mosimege & Ismael, 2007). Application of this rule signifies the final stages of the game.

There are two ways to win the game: firstly, if the opponent can't make a move, and secondly, if the opponent has only two cows left (Mkhonto & Cloete, 2010; Mosimege & Ismael, 2007). The rules also state that if each player only has three cows left and neither can shoot one of their opponent's cows in ten turns, then it is a draw.

Figure 1

Morabaraba Game Board



Note. Source of figure: https://www.researchgate.net/figure/Morabaraba-game-board-diagram_fig7_346308505

Cognitive Abilities Associated with Morabaraba and Problem Solving

The cognitive requirements for playing Morabaraba and Problem solving align closely as both require logical and abstract thinking to develop a strategy to provide a programming solution or to win the game.

Cognitive Abilities Associated with Morabaraba

Several researchers have concluded on the benefits of utilising Morabaraba in teaching and learning, specifically in enhancing mathematical skills (Mosimege, 2020; Tachie & Galawe, 2021). Various important skills are developed and learning principles imparted through the process and rules of the game (Bayeck, 2017). For instance, the rule that a player cannot capture more than one cow encourages empathy and compassion toward the opponent.

In addition, language acquisition and computational thinking skills are stimulated through utilising metaphors during the game in defining the action plans and movement of cows (Bayeck, 2017).Computational thinking can be defined as an abstract thinking process, based on an algorithm, for effectively and efficiently

defining and solving a problem such that the solution is reusable in different contexts (Shute et al., 2017). The fact that the game was a key strategic game brings attention to its relevance in problem-solving skills development.

Cognitive Attributes Associated with Problem Solving for Computer Programming

Papadopoulos & Tegos (2012) concluded that programming requires higher level thinking skills such as problem solving, critical, and computational thinking skills. All of these require abstract thinking. Likewise, Gomes & Mendes (2008) posit that problem solving, computational thinking, abstraction, critical thinking, and analytical thinking are all important attributes required for problem solving in computer programming. To problem solve for programming, the problem must be analysed and then the logic (program design) created. Critical thinking and strategy are a large component of this process, which will include higher order thinking skills and pattern recognition.

Aligning Cognitive Properties of Morabaraba and Problem Solving

Similarities can be drawn based on the mechanics and rules of Morabaraba and the cognitive requirements for problem solving and therefore programming. Strategic thinking and problem-solving are entrenched in the winning rules of the game (see Table 1 below) and social constructivism with the two players.

Table 1

Aligning the Cognitive Properties of Morabaraba and Problem Solving

	Morabaraba	Problem Solving
1. Tools required	• Board with 3 nested squares /levels. Each square has 8 junctions. • 2 players • 12 tokens per player	• Pseudocode and flowcharts are used in the planning of the logic for computer programming
2. Cognitive abilities required	• Strategic thinking. • Analysis of moves. • Problem-solving skills. • Abstract decision making. • Computational thinking. • Logical thinking. • Pattern recognition.	• Strategic thinking. • Analysis of the problem to solve. • Abstract thinking • Computational thinking. • Logical thinking • Pattern recognition.

Recommendations and Conclusion

The alignment of the cognitive abilities associated with Morabaraba and problem solving is noticeable. Previous research into the benefits of chess for problem solving suggests that Morabaraba will have similar benefits. While Morabaraba has traditionally been played using a physical board or by drawing a board in the sand, the game can also be played online and can be downloaded as a mobile app. This study argues that playing the game in any form or version affords an opportunity to enhance a learner's programming skills. We argue that the skills gained by playing Morabaraba are transferrable to learners studying programming in higher education. Future studies will be carried out which will evaluate player experience and learning outcomes in the primary target population of students undertaking programming in their undergraduate studies.

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