INTRODUCTION

In 2006, Wing popularized the term computational thinking arguing that it ‘represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use...[it] involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science’ (p. 33). Wing (2006) added, ‘computing and computers facilitate the spread of computational thinking’ (p. 33). This may explain the rich literature that associates computational thinking with computer sciences and computers, which often leads to the conclusion that computational thinking requires programming (Yadav et al., 2017); it cannot be developed beyond computer science (Voogt et al., 2015), or in technology/computer-poor environments. Yet, ‘solving problems computationally by designing solutions and processing data is not a digital skill, rather a mental skill’ (Caelli & Yadav, 2019, p. 1). Computational thinking provides a
process for addressing problems that can be applied in any setting (Bell & Roberts, 2016). Yadav et al. (2016, p. 566) add that computational thinking is essentially about breaking down complex problems into more familiar/manageable sub-problems (problem decomposition), using a sequence of steps (algorithms) to solve problems, reviewing how the solution transfers to similar problems (abstraction) and, finally, determining if a computer can help us more efficiently solve those problems (automation).

As such, computational thinking cannot be limited to digitized or technology-rich spaces. Computational thinking is a universal skill that everyone needs and not just a programming skill used by computer scientists alone (Kotsopoulos et al., 2017; Wing, 2006). This understanding explains researchers' growing enthusiasm for investigating computational thinking beyond digital environments (Bell & Lodi, 2019; Gero & Levin, 2019). It also aligns with the definition of computation thinking as the knowledge, skills and attitudes needed to solve problems in life using computers (Hsu & Chen, 2022; Korkmaz et al., 2017). As Eisenberg (2010) argued, computational thinking can be practiced and encouraged in different spaces through different objects. There is an emerging literature that explores computational thinking and its aspects beyond digitized or computerized environments, that is, 'naturalistic, non-programming settings' (Berland & Duncan, 2016, p. 29). The current study contributes to this growing literature by exploring computational thinking in the gameplay of a strategic African board game called Songo. Researchers are yet to have a single, clear and operationalized definition of computational thinking (Grover & Pea, 2013). Curzon et al. (2019) add that the development of systems involving information processing, and the particular focus on algorithmic solutions differentiates computational thinking from other problem-solving approaches. In this study, computational thinking is defined as 'the thought processes involved in formulating a problem and expressing its solution(s) in such a way that a computer—human or machine—can effectively carry out… [it]is not just about problem solving but also about problem formulation' (Wing, 2017, p. 8).
In other words, computation thinking refers to the mental activity involved in breaking down a problem and processing information to accept a computational solution that can be executed by a human or a machine (Curzon et al., 2019; Wing, 2017). Consequently, computational thinking can be expressed, that is, identified in a linguistic representation as a solution or a formulation of a problem is communicated to people, or machines (Wing, 2017). Hence, this study pays close attention to expressions or verbal representation of computational thinking. All aspects of computational thinking are not operationalized in this research; nor can all the categories of computational thinking as defined by others be found in this research. To identify computational activities/actions in players' interactions during gameplay, this study explored four categories of computational thinking as discussed by Berland and Lee (2011): conditional logic, algorithm building, debugging and simulation.

Computational thinking beyond digital settings

Scholars researching computational thinking in non-digitized spaces argue that as a problem-solving strategy, it can be learned and practiced in any environment just as literacy and numeracy (Yadav et al., 2014). Linking computational thinking to digital devices and computer scientists' thinking brings with it the difficulties in understanding this concept (Yaşar, 2018). Indeed, computational thinking is apparent in different spaces and places, and not just in computer programming (Lee & Recker, 2018). For instance, Caeli and Yadav (2019) use a historical perspective as evidence of computational thinking underpinning in non-digital environments. Eisenberg (2010) demonstrated how computational thinking could be expressed and embodied in the act of crafting objects such as beads. Yadav et al. (2016) showed how specific computational thinking concepts could be embedded across subject areas in elementary and secondary school. Lee and Recker (2018) showed that paper circuits are conducive spaces for engaging in computational thinking as they allow, for instance, for algorithmic thinking, conditional logic, debugging and parallel thinking. Interestingly, scholars, in recent years, have extended their research on computational thinking to board games.

Computational thinking in board games

A recent review of the literature on the use of board games to develop CT revealed that modern board games, particularly, European board games, can promote CT (Machuqueiro & Piedade, 2022). Berland and Duncan (2016) evidenced how players of the collaborative board game Pandemic engaged in aspects of CT (eg, algorithm building, abstraction, conditional logic, simulation and debugging) in a naturalistic laboratory environment. The authors argued that collaborative board games foster CT. Similar findings were revealed by Berland and Lee (2011) as they explained that players of Pandemic participated in CT aspects such as simulation, debugging, conditional logic, algorithm building and distributed computation. Berland (2011) further added that the thinking involved in playing strategic board games connects with CT. Kuo and Hsu (2020) found that board games are spaces where players can learn CT and participate in CT activities. Tsarava et al. (2018) designed two board games to cultivate computational thinking and demonstrated in a follow-up study that these games were spaces for young learners to practice computational thinking (Tsarava et al., 2019). Kuo and Hsu (2019) also showed that board gameplay improved seventh graders’ computational thinking, and modding board games supported computational thinking (Berland & Duncan, 2012). Scholars have also shown that Mancala enabled young kids to participate in computational thinking, in the process of becoming experts at the game (Phelps et al., 2017). Mancala is one of the world’s oldest board games with African origins (de Voogt, 2019).
It should also be noted that *Mancala* is a generic term often used to describe strategic African ‘sowing’ board games with a) two or more rows; b) multiple holes (de Voogt, 2005; Mbarga Owona, 2004); and c) played by two or more players who consecutively distribute seeds in holes, one by one (Meka Obam, 2008; Mkondiwa, 2020). However, using a generic term such as mancala to refer to various classic African board games (Bayeck, in press) tends to erase the creativity, design, language, history, and culture of the communities that designed these board games (Bayeck, 2021).

The goal of this paper is to explore the aspects of computational thinking displayed in *Songo* gameplay. Consequently, the author addresses the following questions: (a) what facets of computational thinking do players engage in during *Songo* gameplay? (b) how are these aspects of computational thinking displayed in this cultural context? and (c) what computing practices are specific to *Songo* board gameplay? This paper proposes that the African board game *Songo*, which belongs to the family of *Mancala* board games (Meka Obam, 2008), provides another productive space for exploring and understanding computational thinking, and its intersection with the cultural context. The basic gameplay setting of *Songo* (*Figure 1*) consists of a long board with 14 holes, 70 seeds, and two players who take turn to consecutively distribute seeds in holes in a clockwise direction (Bayeck, 2022; Meka Obam, 2008). While the seeds are shared equally among players at the beginning of the game (35), capturing 40 seeds determines a player’s victory (Meka Obam, 2008). As a strategic board game, *Songo* gameplay requires the use of complex thinking and strategies. Yet, unique to *Songo* gameplay in the naturalistic environment is the active participation of spectators who interact among themselves, and with the players (Mbarga Owona, 2004; Meka Obam, 2008). Meka Obam (2008) argued that *Songo* gameplay is a reflection of life in the Ekang/Fang society, a way of being and doing in a culture where living as a community is cultivated.

The active participation of the audience or spectators in the gameplay leads to various and complex interactions (Mbarga Owona, 2004). In this way, *Songo* gameplay provides multiple opportunities for players to engage in different culturally informed aspects of computational thinking.

This paper begins with a brief description of the game’s cultural background. The study context and findings in relation to the cultural context are discussed. This paper concludes with an allusion to future trends and implications for research in computational thinking.

*Songo* board game

As previously stated, *Songo* (*Figure 2*) is a strategic board game, made of 2 rows and 14 holes, played in Central Africa, particularly among the Ekang/Fang ethnic group of Central Africa for centuries (Bilongo, 1985; Meka Obam, 2008). *Songo* is, for Meka Obam (2008), a
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reflection of the Ekang/Fang ethnic group way of life and requires players to adopt various strategies to win (Mbarga Owona, 2004). The Ekang/Fang ethnic group is found in countries such as Cameroon, Gabon and Equatorial Guinea, which explains the presence of Songo in these countries (Bilongo, 1985; Mbarga Owona, 2004). The rules of gameplay slightly vary in each country (Mbarga Owona, 2004), and there are other classic African board games such as Songo across Africa (de Voogt, 2017; Ndukwe et al., 2014). However, the study focuses on Songo gameplay in Cameroon.

As a strategic board game, Songo rules eliminate randomness and turn players into computers as they implement the unambiguous game rules. As Berland and Duncan (2016) observed, strategic board games show an alternative and decadent case of computation, with explicit rules that reduce randomness, and allow players to enact and implement these rules as computers.

**Brief description of Songo gameplay**

Even though the rules of Songo vary based on location, ethnic group or players' expertise and cannot be all explained here, the gameplay of Songo starts with five seeds in each of the 14 holes of the board (Figure 3).

The gameplay consists of players in turn grabbing seeds from one a hole, and dropping one seed at a time, in a clockwise direction, that is from left to right, in the succeeding holes (Meka Obam, 2008). As shown in Figure 4, players take turns to distribute seeds on the board. Players can only capture (or eat as said in Songo gameplay) seeds in holes with a maximum of four seeds. In other words, any seed that falls into an opponent's hole with one, two or three seeds allows players to capture the seeds in the hole (Mbarga Owona, 2004; Mvé-Ondo, 1990). A player's capture ends when he encounters a hole with no seed during the gameplay. The player with 40 or more seeds wins the game, and the player with 30 seeds or less loses the game. Figure 4 shows scenes with the moves of one of the players.
as he takes seeds from one hole on his side of the board and distributes the seeds in a clockwise direction. The player then makes a capture in holes on his opponent side already containing two and three seeds given that a player can only ‘eat’, that is, capture two, three and four seeds.

*Songo* is all about strategizing to win against the opponent. For instance, a player can protect his seeds from being captured by the opponent by creating a *Nyindi*, which refers to a hole with five-twelve seeds. The *Nyindi* also protects all the seeds in holes that precede the *Nyindi*. This implies that players make strategic moves and complex computations to protect their seeds and capture the opponent’s seeds. It should be noted that a complete game of *Songo* played in Yaoundé, Cameroon consists of two rounds, that is, players play against each other twice (V. Ondoa, personal communication, July 30, 2018). The winner in both instances is the winner of the game, and a tie game occurs when each player wins one of the game rounds (J. Biloa, personal communication, August 3, 2018).

Previous research has discussed the mathematical aspects of *Songo* board gameplay (Mvé-Ondo, 1990; Njock, 1985), as well as other *Mancala* board games in different countries in Africa (Barton, 1996; Quaynor, 2007). Literature shows that board games such as *Songo* reflect culture and philosophy (Meka Obam, 2008; van Binsbergen, 2013) and a demonstration of the cultural underpinning of mathematical ideas and thinking. Hence, mathematical thinking embedded in games such as *Songo* should not be considered in isolation from the culture (Gerdes, 2010). In a similar vein, we argue that computational thinking in *Songo* board gameplay is informed by culture as such should not be examined in isolation of the cultural context.

**Context of the study**

The gameplay examined in this study takes place in Cameroon’s capital city, Yaoundé, in the borough of Elig-Essono. *Songo* is known in Cameroon to be the game of the Fang/Beti ethnic group. It should be noted that Cameroon is a bilingual country (i.e., French and English are
official languages), with more than 250 ethnic groups and languages, each represented in Yaoundé (Anchimbe, 2014; Djimadeu, 2015). In this vibrant and diverse city, Songo remains popular in Yaoundé to the extent that any study of social activities is incomplete without mentioning Songo and its players (Djimadeu, 2015). While previous studies have examined computational thinking in board gameplay, studies exploring computational thinking in the board gameplay of Songo in an African context such as Cameroon are scarce. This study is among the first to explore computational thinking in Songo board gameplay—especially, in a naturalistic environment and in a setting where the game has cultural, emotional and historical meaning.

METHODS

This qualitative study used microethnographic methods to explore computational thinking in Songo board gameplay in Cameroon. Microethnography provides ways of capturing the subtleties of human interaction (LeBaron, 2005). It has been used as a research method to study moment-to-moment verbal and non-verbal communication (eg, speech and gestures) in formal and informal environments (Kohonen-Aho & Alin, 2015; Streeck & Mehus, 2005). Moreover, from a microethnography perspective, interactions or behaviours make sense in context (Hannula & Irmann, 2016; LeBaron, 2008). Hence, microethnography assumes that context, and in this case, cultural context, informs interactions. In other words, interactions should be interpreted through the lenses of the context in which they occur for a better understanding of what is going on.1

To explore computational thinking in Songo board gameplay, the data were approached from a sociocultural perspective. Sociocultural theory argues that human activities take place in cultural contexts and learning as well as knowledge are intertwined with the context within which they occur (Prior, 2006). Also critical from this perspective is the distinct but interrelatedness of speaking and thinking activities (Lantolf et al., 2015). Thought is expressed through linguistic means, while linguistic activities (eg, gesture or speech) cannot be completely understood without considering them as a manifestation of thought (Lantolf et al., 2015). This understanding of the relationship between thinking and speaking is relevant for this study given the interest in interactions (ie, verbal and non-verbal) as unit of analysis to examine computational thinking.2

Participants, data collection and analysis

Multiple Songo games were played in Elig-Essono, Yaoundé, Cameroon. However, to identify specific computational analysis practices and focus on moment-to-moment interactions, selected scenes of gameplay were analysed in this study. Participants consisted of six adult male players with a range of socioeconomic and linguistic backgrounds. Participants were experienced Songo players, fluent in French, and in a variety of other local languages such as Ewondo, Bassa and Eton. Participants agreed to have their pictures taken.3

The gameplay was video-recorded, and semi-structured interviews were conducted with participants to capture the meaning of their interactions during the gameplay. The video and audio recording of interviews were transcribed and translated from French to English. The video recordings were analysed in V-Note, following Erickson’s (2006) approach to video data analysis, with a focus on dialogue/talk. The GoPro cameras automatically segmented hours of gameplay into sections of approximately 18min long. The researchers focused on interactions related to computational thinking. Hence, the iterative reviews of the videos yielded strips of gameplay containing rich data pertaining to the aspects of computational
thinking. Excerpts from these strips were coded. Participants’ interviews complemented our understanding of the game rules and practices. An abductive approach, which allowed the researcher to engage in a back-and-forth movement between theory and data to develop new theory or revise current theory (Awuzie & McDermott, 2017). Indeed, drawing on previous studies, this study considers the aspects of computational thinking such as conditional logic, algorithm building, debugging and simulation (Berland & Duncan, 2016; Berland & Lee, 2011).

Conditional logic involves using if-then logic, which implies considering, based on the game rules, the chains of events that may follow if a particular action is taken (Berland & Lee, 2011; Lee & Recker, 2018). With Songo, it is often enacted when players describe/discuss the potential consequences of a move that a player may make during the gameplay. Algorithm building consists of creating a plan of action that can be applied given the input or situation (Lee & Recker, 2018). For instance, players explaining a plan of action based on moves on the board or players anticipating the opponents’ moves as they play Songo.

Debugging involves identifying problems or errors in logic or behaviour that may prevent the system from working properly (Berland & Lee, 2011). In board gameplay, it often includes expounding gameplay rules or strategies (Berland & Lee, 2011). In Songo, this often means identifying the wrong move of a player or explaining the moves/positions that may prevent a player from making a capture or winning the game. Simulation is the enactment of plans or algorithms to assess the anticipated result (Berland & Lee, 2011). For example, Songo players discussing a move a player is about to make and its implication. This may encourage or prevent the player from completing the planned move based on the anticipated results. The aspects of computational thinking presented below are interconnected and interdependent (Berland & Duncan, 2016).

To transcribe the video data, the author followed a modified version of Jefferson’s transcription conventions (Atkinson & Heritage, 1984) and an adaptation of Ma’s (2017) approach to transcribing non-verbal interactions. Turns at talk were indicated by participants’ names; non-verbal interactions (eg, body movement, gaze or gesture) were italicized and put in parenthesis. Concurrent non-verbal actions were italicized and put in parenthesis next to participants involved. Equal sign (=) next to pseudonyms signalled overlapping talk, and (→) indicated overlapping of non-verbal and verbal actions. Brackets around the name of an individual (eg, [to Jean]) means the statement was directed to this individual. Finally, the translation from one language to another were italicized and put in brackets. These translations were situated and were context based.

RESULTS

As previously stated, all categories of computational thinking as described and discussed in previous studies on board games were neither examined nor found. Songo was played in a context where it has cultural and historical meaning. In this cultural context, this two-player, competitive and strategic board game allowed for the active participation of the audience during gameplay. Hence, participants engaged in significant crosstalk and made sense of actions collaboratively. For this reason, the authors argue that computational thinking is framed by the context and should be understood within the context in which it takes place as well. The excerpts below present examples of computational thinking and peculiar approaches to solving problems in Songo gameplay. Names used in this study are pseudonyms.
Algorithm building

Wing (2017) argues that computational thinking can also be expressed in different languages, which includes verbal expression. Algorithm building is a set of instructions—the planning of moves in the game (Berland & Lee, 2011). The following exchange occurs during the gameplay between Caulet and Jean and captures instances of algorithm building as it occur during Songo gameplay. Interestingly, the gameplay also engages spectators (Presido, Beau, Belib and Ayos) as shown in Figure 5. This excerpt begins at Caulet's turn to play, after Jean had played:

Excerpt 1
Caulet: (plays seeds in the 4th hole on his right)
Jean: je ne te donnes rien, tu vas bouffer, mais pas comme ça (plays seeds in the third hole on his left)
[I will not give you seeds, you will eat, but it is not going to be that easily]
Caulet: (plays seeds in the 2nd hole on his left)
Jean: je vais te donner tout (plays the seeds in the 5th hole on his right)
[I will make that capture]
Jean: oui, met tout là-bas, je vais te donner, même si tu es à n'importe quelle position, je vais te donner (pointing with his finger at holes on the left of Caulet)
[yes, drop all the seeds there, I will make that capture, no matter how you move, I will make that capture]
Caulet: (plays seeds in the second hole on his left)
Jean: voilà, bon appétit, good appetite (plays seeds in the first hole on his right, and captures seeds in consecutive holes)
[here you go, good appetite, good appetite]

In this exchange, Jean, gazing at Caulet's move, began by mentioning his plan of action as Caulet played when he says 'je ne te donnes rien, tu vas bouffer, mais pas comme ça, [I will not give you seeds, you will eat, but it is not going to be that easily]'. Meaning he was going to make it easy for Caulet to capture seeds, even though Caulet would make captures 'Tu vas bouffer [you will eat]'. Jean was moving his seeds making sure that his plan of capturing several seeds at once would irrespective of Caulet's moves. Thus, he said: 'oui, met tout là-bas, je vais te donner, même si tu es à n'importe quelle position, je vais te donner [yes, drop all the seeds there, I will make that capture, no matter how you move, I will make that capture]'. In this statement, Jean's successful planning for unknown events (ie, Caulet's moves) resulted in him capturing seeds in consecutive holes. Yet, sharing aloud his strategy in a competitive game evidenced the influence of the cultural context, where building and helping each other is valued (Nkwain, 2015).

FIGURE 5 A scene of Songo gameplay.
Conditional logic

This aspect of computational thinking is shown in the excerpt below. Conditional thinking requires players to think or anticipate the consequences of a move made at a specific moment. As in algorithm building, players’ language or verbal expression and game moves were the unit—not the game mechanics—analysed to identify conditional logic in Songo gameplay. In this game opposing Presido and Eno (Figure 6), Presido was in an advantageous position, after making a move that placed him in a position to capture many seeds from consecutive holes at once. As Eno gazed at the board at his turn to play, Presido said:

Excerpt 2

Presido: s’il me donne, je prends, je ne peux pas laisser
[If he allows me to make a capture, I will make it, I can’t leave it]
Eno: (counts seeds/pebbles in the second hole on his right)
Presido: <=> s’il me donne, je ne peux pas laisser, je vais seulement dire merci
[If he plays like that, I can’t leave it, I will just say thank you]
Eno: (touches the first hole on his right)
Presido:[to Eno] non, tu ne peux pas jouer là, c’est pas possible
[No, you can’t play that hole, it’s not possible]
Eno: (removes his from the first hole on his right)
Presido: <=> s’il joue là, ça tombe ici, je libère, je marches, et puis c’est fini (pointing at holes on the board)
[If he plays that hole, the seed falls here, I move, I drop seeds, and it is over]
Eno: (counts the seeds/pebbles from the first hole on his right)
Presido: <=> essaie de jouer ça, essaie (picks seeds from the first hole on his left)
[Try to play that hole, try]
Eno: (drops the seeds from the first hole)
Presido: touche encore là, tu vas voir, je joue là et là, est-ce qu’il y’a un problème ...il faut quand même lui montrer le bon jeu (points at some holes)
[Touch it again, you will see, I will play here and there, there is no problem... he must be showed how to play well]
Eno: (plays the third hole on his right)

As shown in the exchange above, Presido explained the logic he would follow if Eno made a specific move (ie, played seeds in the first hole on his right): ‘s’il me donne, je prends, je ne

FIGURE 6 Setting of the exchange.
peux pas laisser [If he allows me to make a capture, I will make it, I can't leave it]. Presido anticipated the consequences of Eno's move. Reacting to this comment, Eno counted seeds in the third hole on his right. Yet, when he was about to pick seeds in the first hole on his right, Presido added:

non, tu ne peux pas jouer là, c'est pas possible; s'il joue là, ça tombe ici, je libère, je marches, et puis c'est fini [No, you can't play that hole, it's not possible; If he plays that hole, the seed falls here, I move, I drop seeds, and it is over].

In explaining his logic, Presido also seized the opportunity to prevent Eno from making a move that would have been detrimental for him and would have given Presido an immediate victory. Helping the opponent do better at the game, and not allowing the opponent to lose face, was a recurrent practice in Songo gameplay in this context, thus, Presido's explication:

touche encore là, tu vas voir, je joue là et là, est-ce qu'il y'a un problème ...il faut quand même lui montrer le bon jeu [Touch it again, you will see, I will play here and there, there is no problem... he must be showed how to play well].

The practice of helping the opponent during gameplay aligns with a culture that values rendering or helping others (even the opponent) for the betterment of the community/group (Mbaku, 2005; Nkwain, 2015). Culture was embedded in the gameplay and as such reflected in players' practices. Conditional logic was shaped by the cultural context.

### Debugging

Debugging is about identifying a problem and providing a solution to the problem either by addressing the move or action causing the problem (Berland & Duncan, 2016). In Songo gameplay, debugging occurred in multiple instances. The excerpt below illustrates an instance of debugging in a game between Caulet and Abi. The exchange starts at Caulet's turn after Abi captured seeds on Caulet's side of the board.

**Excerpt 3**

Caulet: (plays the first hole on his right)
Abi: (counts the seeds in the first hole on right, and gazes at holes on the left on Caulet's side of the board)
Caulet: ⇔ si tu envoies seulement les deux, je te prends ici et ici (Points at two seeds on his side of the board)
[If you only play these two seeds, I will make a capture here and here]
Abi: ⇔ (plays the two seeds in the fourth hole on his right)
Caulet: tu ne sais pas jouer, apprends à jouer (plays the first hole on his left)
[You don't know how to play, learn how to play]
Abi: (looks at the board)
Caulet: voilà², maintenant tu as neuf, voilà huit, comment tu vas construire ⇔ (Points at a hole on his side of the board)
[Now, you have nine, here are eight seeds, how will you build?]
Abi: (gazes at the board for few more seconds, and plays the second hole on his right)
Players in this game knew the rules of the game, yet at this moment of the game, Caulet noticed that Abi was making a wrong move. The decision he took to play seeds in the fourth hole on his right, prompted Caulet to say: ‘tu ne sais pas jouer, apprends à jouer [You don’t know how to play, learn how to play]’. At this comment, Abi gazed at the board, and Caulet added ‘voilà, maintenant tu as neuf, voilà huit, comment tu vas construire? [Now, you have nine, here are eight seeds, how will you build?]’. Caulet identified the problem and provided a solution (ie, debugged) by asking Abi how he will build, that is, create a house with more than 10 seeds. Based on the game rules, Abi could only succeed to build if he played, at this moment, seeds from the second hole on his right. This facet of computational thinking was framed by the cultural context, given that Caulet, Abi’s opponent in the game, enacted debugging in this context. Caulet’s intervention (common in Songo gameplay) demonstrated the connection between the cultural context and debugging. The cultural value of helping the other, even the opponent, informs debugging in this instance (Mbaku, 2005; Nkwain, 2015).

Simulation

Simulation as defined above is the execution of plans or algorithms (Berland & Lee, 2011). The following conversation occurred in the second game between Jean and Caulet. It was Jean's turn to play; he picked seeds in the second hole on his right, dropped them back, looked at the board and asked about the number of seeds in a hole on Caulet’s side of the board. Knowing the number of seeds in that hole informed Jean's next move; Jean was able to execute his plan after formulating a solution based on the information he gathered.

Excerpt 4

Jean: tu as combien? [how many seeds do you have?]
Caulet: 21
Jean: compte bien [count very well]
Caulet: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 21 (counts the seeds in the third hole on his right)
Jean: (counts seeds in the second hole on his right)
Caulet: tu vas mettre 22 (pointing at his hole with the 21 seeds) [you will drop the 22nd seed]
Jean: (plays the seeds in the fourth hole on his right)
Caulet: le temps-là est révolu (while playing the hole with 21 seeds) [that time is over]
Jean: c’est révolu hein, tu vas voir? [it is over right, hein, you will see]
Caulet: le temps là est révolu (captures seeds in two consecutive holes) [that time is over]

Simulation was illustrated in this excerpt when Jean (after counting seeds in the second hole on his right indicating computation and enactment of plans) decided to play seeds in the fourth hole on his right when Caulet said: ‘tu vas mettre 22 [you will drop the 22nd seed]’. Jean's enactment of his plans and evaluation of anticipated results is further evidenced when he asked: ‘tu as combien? [how many seeds do you have?]’; then insisted ‘compte bien [count very well]’. Playing seeds in the fourth hole showed that Jean had completed the testing of his plans, which led him to play these seeds, instead of seeds in the second hole. Indeed, playing seeds in the second hole, would have added one seed in Caulet's hole with
21 seeds, and allowed him to have a *nyindi* of 22 seeds. Such nyindi automatically allowed Caulet to capture more than five seeds from two consecutive holes at once. However, Jean engagement with his opponent in this process, and Caulet’s comment reflected peculiar cultural practices of sharing, and caring for the other embedded in the Cameroonian context (Mbaku, 2005). The cultural context facilitated simulation in this scene of *Songo* gameplay.

**Songoputation**

The analysis of the data also revealed a computational practice and approach to solving problems peculiar to *Songo* board gameplay, termed songoputation. Songoputation is a form of computation peculiar to *Songo* gameplay. It simultaneously engages players and the audience in various aspects of computational thinking such as algorithm building, conditional logic, simulation and debugging. As previously mentioned, *Songo* is a competitive strategic board game, played in a community driven cultural context, which supported active player and audience interactions. Songoputation is the shared involvement of the audience and players in different aspects of computational thinking in a non-collaborative and competitive board game such as *Songo*. The excerpt below shows an instance of songoputation as it occurred in a game opposing Caulet and Jean, with Ayos, and Presido as members of the audience. The excerpt starts at Caulet’s turn:

*Excerpt 5*

Caulet: *(touches seeds in the 4th hole on his left)*
Jean [to Caulet]: je vais te donner au moins du temps
*[I will give you some time]*
Presido: Caulet ya³ (Leaning over the board)
*[Caulet what is happening]*
Ayos: il va seulement enlever un pion; il a déjà cinq; il lui faut 14
*[he will just remove one seed; he already has five; he needs 14]*
Presido: 1, 2, 3, 4, 5, oui il y’a 14 pions au tableau (leaning over and counting)
*[1, 2, 3, 4, 5, yes there are 14 seeds on the board]*
Jean: c'est 14 pions non (pointing at the last hole on his left)
*[there are 14 seeds, right?]*
Presido: c'est 14
*[they are 14]*
Jean: *(plays seeds in the first hole on his left)*
Ayos: [to Jean] tu dois seulement enlever un pion; il a déjà cinq *(pointing at the board)*
*[you should only remove one seed; he already has five seeds]*
Presido: c'est ce qu'il faut, c'est 14 *(counts seeds on the board with his finger)*
*[that is what is needed, it’s 14 seeds]*
Jean: c'est 14 non?
*[They are 14 seeds, right?]*
Presido: c'est 14
*[it’s 14]*
Caulet: *(counts seeds in his hand)*
Ayos: [to Jean] tu peux aller comme ça *(touches the third hole on the left of Jean)*
*[You can play like this]*
Caulet: ⇔ *(recounts seeds in his hand)*
Presido: [to Jean] non, ne va pas là-bas; s'il va comme ça, Caulet va seulement plier et lancer
[No, do not go there; if he plays like that, Caulet will just play and reposition himself]
Jean: je vais jouer, qu'il plie donc, on va voir (plays the third hole on his right)
[I will play, let him play, we will see]
Caulet: (plays the fourth hole on his right)
Presido: [to Jean] c'est tout ce il va jouer, comme ça; ç'est ce qui lui donne cinq pions
[that is all he will play, like that; this is what gives him five seeds]
Jean: = qu'il plie
[let him play that hole]
Presido: [to Jean] sinon il aurait mouillé, c'est comme ça
[Otherwise, he would have failed woefully, that how it is]
Jean: = qu'il plie, qu'il plie (plays the fourth hole on his right)
[let him play that hole, let him play that hole]
Caulet: (touches the first hole on his right)
Presido: ≠ [to Jean] s'il part là-bas, tu vas lui donner (points at Jean's side of the board)
[if he plays that hole, you will beat him]
Jean: partout je le finis (plays the first hole on his right)
[I beat him with any hole I play]

The excerpt exemplified songoputation, with players and the audience engaging in different aspects of computational thinking including conditional logic: ‘Presido: ≠ [to Jean] s’il part là-bas, tu vas lui donner [if he plays that hole, you will beat him]’; algorithm building:

Ayos: [to Jean] tu dois seulement enlever un pion; il a déjà cinq
[you should only remove one seed; he already has five seeds]
Presido: c'est ce qu'il faut, c'est 14
[that is what is needed, it's 14 seeds]
Jean: c'est 14 non?
[They are 14 seeds, right?]

The distributed participation of players and the audience in computational practices exposes the influence of the cultural context on computation in Songo board gameplay. These interactions were unplanned and did reflect cultural values pertaining to this environment. As previously discussed, in this setting, relationships between individuals and the wider community, working together, and building each other are values embedded in the culture (Mbaku, 2005; Nkwain, 2015). Songoputation then be linked to the cultural context.

CONCLUSION AND FURTHER STUDY

Research has shown that computational thinking can be found and practice in unplugged environments (Caeli & Yadav, 2019; Lee & Recker, 2018). Strategic board games have been shown as sites for computational thinking (Berland & Duncan, 2016). This study adds to this literature by uncovering computational thinking in the gameplay of Songo and the influence of culture in shaping computational activities/actions. This study also revealed a peculiar approach to computationally solving problems specific to Songo, identified here as songoputation. Songoputation, as previously mentioned, highligths unplanned and spontaneous collaborative approach to not
just solving problems, but also formulating problem, which includes a way of processing information, rooted in cultural principles of sharing with and caring for the other. We argue that *Songo* game represents an interesting cultural and historical example of a board game that encourages computational thinking—it is an example worth knowing about and understanding. As other strategic board games designed over the centuries before digital computers, *Songo* has given a safe space for people to explore, practice and enjoy using computational thinking skills. *Songo* has the potential to be used as a space for acquiring or developing computational thinking skills that could be applied in different fields. This study adds to computational thinking research, with songoputation, another way of thinking and practicing computing to address problems that is informed by culture. The increasing focus on computational thinking in the past decade may lead one to consider computational thinking as a new concept, practiced with digital computers. Yet, computational thinking is not a new concept and has been practiced for centuries in games such as *Songo*.

The paper broadens our understanding of computational thinking in another cultural context. For this reason, it is important for research on computational thinking not only to explore non-western settings but also to take into consideration the role of culture in framing practices. Such considerations will help us recognize how computational thinking is expressed in various contexts and will enrich the literature with various approaches to problem formulation. As Wing (2017) explained, computational thinking can be learned without machines. The author argues that computational thinking can be learned with analog technologies such as *Songo*. As shown in this paper, games like *Songo* create an opportunity for a culturally and context relevant equitable access to computational thinking in countries, regions or contexts where digital computers are not always accessible to all. Therefore, it is important to explore and use local or culturally relevant tools to advance the field of computational thinking and to support it is integration into learning spaces across the world, particularly in classrooms. In other words, it is increasingly critical to integrate in curriculums locally built or designed tools to enhance and democratize access to computational thinking and other forms of computationally solving issues.

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There are no conflicts of interest to declare.

**DATA AVAILABILITY STATEMENT**
The data of this study are not publicly available due to confidentiality agreements, but samples of the data can be accessed by contacting the author.

**ETHICS STATEMENT**
This study adhered to all national and international regulations for protecting human subjects.

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**ENDNOTES**
1 Cameroon is a multilingual country with more than 250 languages, in addition to English, French, Pidgin English and languages resulting from the interactions of French, English, Pidgin English and local languages such as Camfranglais (Anchimbe, 2014; Ntsobé et al., 2008).
REFERENCES


