A Virtual Board Game: Monosoil

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ABSTRACT

Monosoil is a virtual board game inspired by the well-known game Monopoly. Players compete with each other by answering questions related to the basic concepts of soil mechanics. The questions cover a wide range of topics, from theoretical concepts to laboratory tests. The game has been developed via MATLAB GUI, allowing players to experience an interactive learning session. The game aims to familiarize senior civil engineering students with soil mechanics by introducing the essentials of the field while enjoying the competition. The entertaining features such as the bonuses and penalties of the regular board games are embedded into the game to preserve players' attention throughout the game. The game constitutes supplementary materials for educational institutions to utilize digital sources during the COVID-19 pandemic. The game offers a fun way to learn soil mechanics concepts for students. Questions can be easily updated without manipulating the codes. In this way, a flexible and adjustable teaching experience is offered to educational professionals. Therefore, the game can be adapted to any undergraduate or graduate geotechnical engineering course.

INTRODUCTION

In the last three decades, analysis and design software tools have been heavily used in the geotechnical engineering field. With the development of software technologies, the role of computers in geotechnics increases day by day. Apart from such advancements, there is an ongoing trend to employ such technologies to educate future geotechnical engineers. Especially within the COVID-19 pandemic period, the importance of implementing such technologies and tools in distance education has increased a lot. Therefore, new methods, tools, and software are needed to innovate geotechnical engineering education for the better. With this idea in mind, in this paper, a novel engineering game, Monosoil, is introduced into the geotechnical engineering education literature to train undergraduate engineering students to understand fundamental concepts in soil mechanics better.

Monosoil is a computer-based board game that offers a multiplayer gameplay experience while teaching the basics of soil mechanics. The game has been developed with *MATLAB GUI* in the scope of the undergraduate course CE461: Computer Applications in Foundation Engineering, in Middle East Technical University, Department of Civil Engineering. The authors got inspiration from the classic board game *Monopoly*, in which the aim is to be the richest by doing the right moves and tactics. Similarly, in Monosoil, students aim to become the first-ranking team by outperforming others with knowledge in soil mechanics. The game's scope covers the subjects in the undergraduate curriculum, such as the laboratory tests, seepage and consolidation theories, and some observed phenomena that the students will most likely face during their future careers. However, advanced topics such as deep excavations, ground improvement, etc., are not included in the current version of the game.

The adaptation of computer games to engineering education has been dealt with in many studies. Deshpande and Huang (2011) summarize the state-of-the-art simulation games developed for various engineering fields. Among those, Veshosky and Johannes H. (1991) deliver a simulation game developed for project management, and Philpot et al. (2005) introduces interactive games for engineering mechanics, to mention a few. Virtual trip applications have been investigated in the recent studies of Wen and Gheisari (2021) and Patiar et al. (2021). Wirth et al. (2017) draw attention to the need for non-lecture-based learning activities providing interactive modules and other entertaining features. Having introduced cooperative learning (CL) in an undergraduate soil mechanics class, Pinho-Lopes et al. (2011) reported that the implementation of CL by allowing student teamwork resulted in a great learning environment, according to the student and instructor feedback. Bennett et al. (2017) state that learning from mistakes is valuable for undergraduate students, especially in safety and environmental topics.

Monosoil complies with the literature findings in many aspects. For instance, it allows making mistakes without severe consequences, such as losing points in an actual exam. Without feeling any pressure, students may recap the soil mechanics class. Monosoil also provides to work in groups to build teamwork skills.

The paper's backbone is organized such that initially, the general structure of Monosoil is presented in the *Philosophy* section. Then, gameplay features are mentioned. Lastly, a summary of the current work and a brief discussion about the future work are given.

PHILOSOPHY

In Monosoil, contestants achieve power according to their knowledge in geotechnics. Competition between students in an entertaining way is expected to boost their enthusiasm to learn soil mechanics concepts. Players answer conceptual and simple numerical questions with different difficulty levels during the game. Those questions are grouped and presented in two different topics: General Questions and Lab Questions. The flowchart belonging to these two types is presented in Figure 1. As seen, the workload of a team increases as the rivals occupy more places on the board because empty places offer the most straightforward questions, whereas the occupied ones trap the opponents to more complex ones. Therefore, students tend to answer more questions to occupy more places than the others, just like Monopoly players do.

The game intends to teach some concepts implicitly. For example, one of the cells on the board imitates the behavior of clays. When students consider the consequences of landing on that cell or landing on the cell several times, they are expected to understand the basics of consolidation theory. During the game's development stage, authors paid particular attention to

soil mechanics laboratory tests as they think that students sometimes do not emphasize this field. However, the game offers instructors an opportunity to modify the questions according to their purposes, as stated previously.
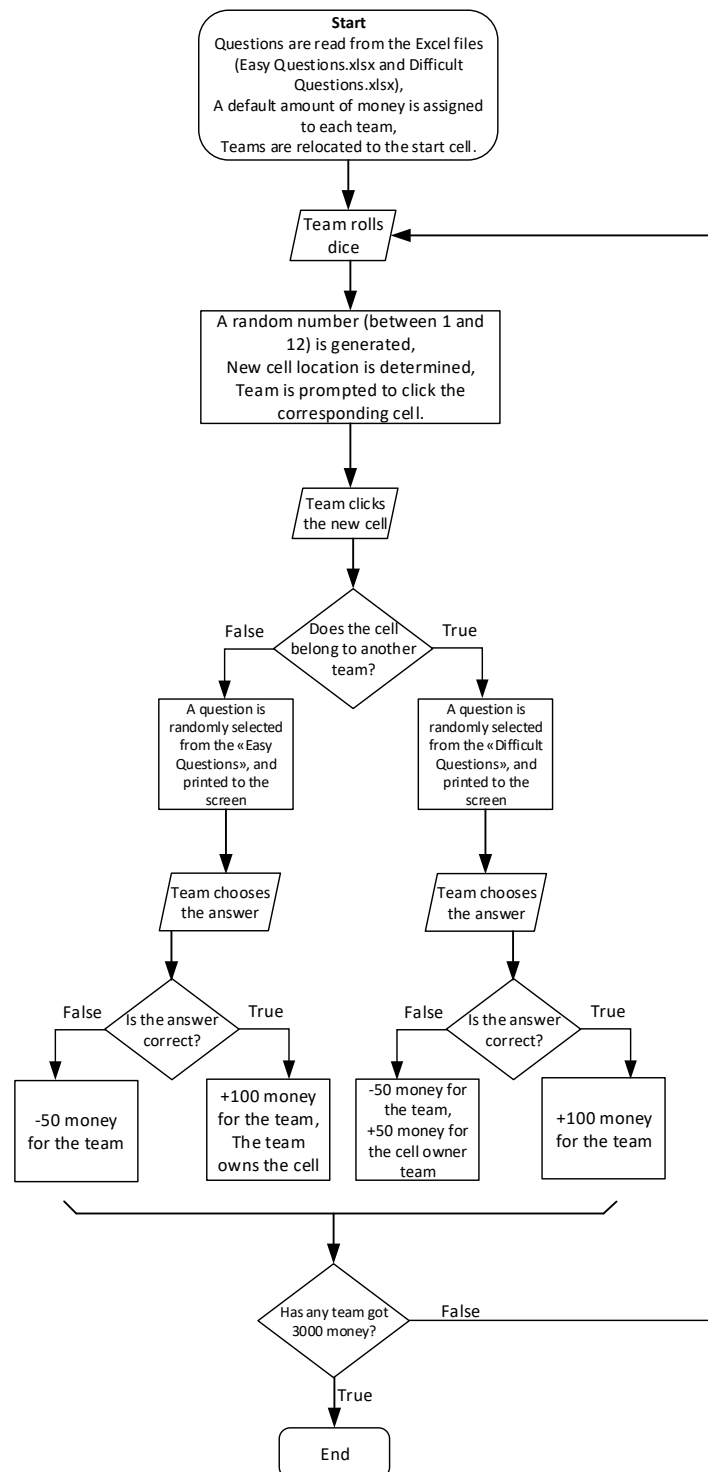
Figure 1. Flowchart of General and Lab Questions.

The game has been built modularly so that the questions can be comfortably changed by a non-programmer, using an external *MS Excel* file. Indeed, this feature of Monosoil makes it possible to be easily adapted to any other engineering topic. However, the topic preference may be limited to geotechnical engineering as the game includes unique features inspired by soil behavior such as consolidation. By having these unique features, the game brings an exceptional user experience to interactive board games. Students may also be encouraged to prepare their questions to compete with their friends. Thuswise, a significant contribution to engaged learning can be made in soil mechanics courses.

GAME

The game board is shown in Figure 2. Seven different types make 37 cells in total. These cell types are (with colors):
- General Questions (orange)
- Lab Questions (cyan)
- Luck (green)
- Bonus (purple)
- Hey Taxi! (yellow)
- Oops, Soft Clay! (red)
- Universal (olive)

Figure 2. General view of the board.

General and Lab Questions

These cells include numerical and conceptual questions related to the soil mechanics topics such as effective stress, seepage, consolidation, shear strength, and laboratory tests. A sample scenario is given in Figure 3. From this figure, the following can be interpreted:

- The question is shown next to the board, and the team selects one of the alternatives.
- Dice is a push-button that generates a random integer between 1 and 12.
- The new location is shown on the screen based on the dice value, and the team is prompted to click the corresponding cell.
- The team number is shown with a pop-up menu that can be changed both manually and automatically.
- A table summarizing the current instant of the game is placed at the bottom. The colors symbolize cell ownership (E.g., cell #17 and #28 belong to Team 2 since the background of the cell is grey).
- Upon being clicked, the text color of the cell is darkened unless it is not owned (E.g., cell #6 has been clicked before, while cell#7 has not been clicked yet).
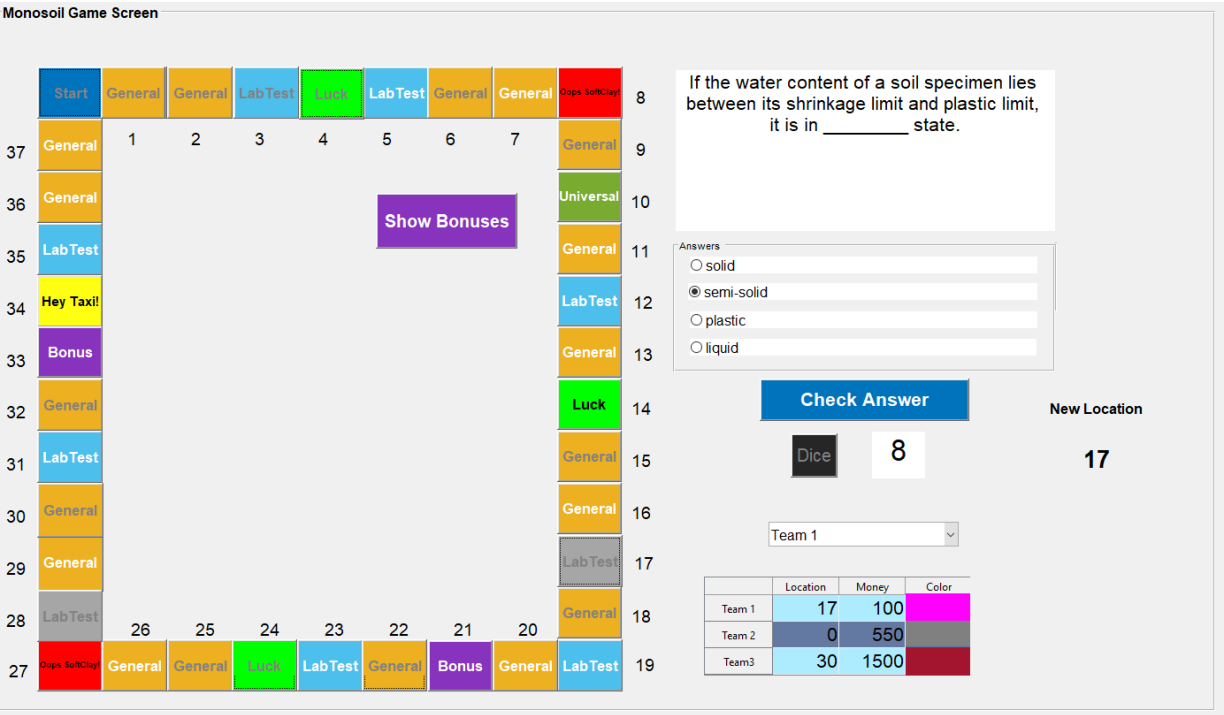

Figure 3. Sample General Question.

Luck

This type of cell may include a gift or a penalty for the arriving team. For example, teams may be rewarded by getting money from the bank or making other players pay. These cells are designed so that the game proceeds in a fun way. The following list summarizes seven different luck cards with their probabilities of occurrences in the game.

- *"Choose a General or Lab Question. Take 150 money from the bank for the correct answer. Pay 150 money to the bank for the wrong answer."* (p = 0.137)
- *"Dice once. If it is an even number, get 100 money from each team; if it is odd, pay 100 to each of them."* (p = 0.137)
- *"Dice twice. If the sum is between 6-12, take 200 money from the bank."* (p = 0.137)
- *"Take 50 money from each team."* (p = 0.137)
- "Pay your taxes! Pay 50 money to the bank." (p = 0.137)
- *"If you have + 1500 money, pay 100 money to the bank; if you don't, raise your money to 1500."* (p = 0.137)
- *"Switch money with another team."* (p = 0.078)
- *"Change location with another team and take 150 money from them."* (p = 0.078)

Oops, Soft Clay!

Analogous to a place grounded with soft clay, the cell is regarded as placed on soft clay. If a team is the first to land on this cell, they will have to consolidate the clay underneath it by losing 10% of their money. On the other hand, if the team has more money than the previous visitor, they must further consolidate the clay by paying 10% of the difference between their money. In this case, the cell mimics the behavior of normally consolidated clays. When a team consolidates the clay, their money is assigned as the preconsolidation pressure (or *preconsolidation money* in this case), and the money of the latest visitor acts as if it is a load. Therefore, if a team has less money than the *preconsolidation money*, no fee is charged.

Bonus

The team lands on a *Bonus* cell chooses the reward from a list of available options, in addition to 100 money. In addition, the team can choose the reward from the available bonus options. Teams may keep these bonus cards for the upcoming rounds or use them right away. There are four bonus cards in the game:
- *"Choose another team to answer."*
- *"Double dice."*
- *"Trap a player to soft clay."*
- *"Get out of the soft clay."*

Universal

This cell opens a *Universal* screen that includes three questions for each team. Different from the other question types, there is a time counter. After each team answers their question, the team that finds the correct answer in the shortest time gets 500 money.

Hey Taxi!

This cell allows the teams to travel to the cell they want. The chance factor is inherently brought into the game. With this cell, teams can go to a Bonus cell or take a Luck card. Also, an additional 100 money is taken if the team passes to the start cell after taking a full turn around the board.

Game Strategy

Although knowledgeable players are expected to be more successful in Monosoil, it is still possible for players with lesser knowledge to win the game with the help of the Luck and Bonus cells. For example, a team may switch money with the current leader when the related Luck card is taken. There is always a chance to win the game, even by answering fewer questions.

It is worth noting that players must use Luck cards right away. In contrast, Bonus cards may be used whenever wanted. Therefore, it may be wiser to keep those cards as a countermeasure to bad luck. For example, the leader most likely loses money when they land on the soft clay since the *preconsolidation money* tends to be lesser than the leader's money. For that reason, keeping the *"Get out of the soft clay"* card would be a good strategy for knowledgeable players. In general, the authors tried to incorporate both luck and strategy into the game.

CONCLUSION

Computer games have been viable alternatives to traditional education tools, especially when using blended learning approaches, considering their strong capabilities in teaching and entertaining simultaneously. Within this perspective, this paper presents a novel virtual board game called Monosoil. The following conclusions can be drawn based on this study:

- A well-known board game can be adapted to the field of geotechnical engineering education.
- The behavior of normally consolidated clays can be mimicked by the "load-money" and "settlement-payment" analogies.

Monosoil needs to be played by its target group, undergraduate students; feedback should be gathered and presented in further studies. Likewise, student opinions and the effect on learning are missing parts to be covered in the future. A proper evaluation technique (e.g., survey, interview, etc.) may be utilized to meet such requirements.

Game development in the future may cover the following: (i) Arranging the total number of teams to any desired number (it is fixed to three teams in the current version), (ii) Suitability of the game to the web for easier access and better multiplayer experience, (iii) Adding new original concepts similar to "Oops, soft clay!" cell, and (iv) Implementing a time limit to make the game more challenging.

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