

# Achieving Student Learning Objectives by Engaging Students in Programming Interactive Board Games

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## Introduction and Objective:

This poster paper<sup>1</sup> presents a method for teaching array processing through programming interactive board games. It is one of seven poster papers that focus on the details of goal directed course design<sup>2</sup>. This course design method originates in a statement of what students should know and care about upon successful completion of the course. This statement is supported by observable and measurable learning objectives that are aligned with the course goals.

The learning method described in this paper is realized in a two credit hour semester course on engineering problem solving using software tools namely MATLAB. Students all have had some experience with MATLAB when they enter the class. However they range in rank from sophomores to graduating seniors. As a result, some students enter the course with quite an extensive background in MATLAB from applications taught in their upper division engineering courses.

The objective of this paper is demonstration of how programming of board games facilitates students' understanding of arrays used to represent and manipulate data. In addition, students learn how MATLAB can be used to simulate a real-world application with GUIDE<sup>3</sup>, the sophisticated MATLAB graphic user interface and development environment.

## Method:

The initial idea of having students program a board game started from an exam problem where students were asked to program a main function, given all the sub-functions needed to implement an interactive Tic Tac Toe game. After receiving positive feedbacks from the students, mainly their positive performance during the exam, we decided introduce another game, Sudoku<sup>4</sup>. Again, we received positive feedback from the students. Going one step further, we added a Graphical User Interface (GUI) to the solution making the game appear more realistic. The MATLAB GUI named GUIDE demonstrates to the students how MATLAB facilitates interactive programming which is that basis for engineering applications of GUIDE.

In addition to learning about interactive programming, board games help students develop a solid understanding of how data is formatted, passed among functions, and manipulated in arrays. Arrays are one of most frequently used data structure in MATLAB programming, if not in all programming languages.

The Tic Tac Toe game is used as part of an exam problem. Here the students program only the core block part of the Tic Tac Toe game. The more advanced algorithms, used in other parts of the game, are beyond the general scope of exam material. These algorithms are made part of a “black-box” of sub-functions that are given to the students together with their prototypes. In this way, students can understand the concept of using arrays without being overwhelmed by complicated algorithm details. Students who would like to learn more about the “black-box” have the opportunity to do so through the term project “technical challenge” assignments.

Students experience how efficient and convenient it is to use MATLAB GUIDE in solving problems. Without GUIDE, exploring alternate solutions can involve a lot of redundant and time-consuming calculations. One of the other poster papers<sup>5</sup> addresses the “technical challenge” assignments that explore advanced applications of GUIDE.

## **Results:**

The figures on this poster illustrate the procedures of design, implementation and usage of the GUI interface and the core functional block. The figures are framed in the color representing the primary learning objective as follows:

**1. THINK** (coral): *Demonstrate ability in critical, creative and practical thinking through algorithm design, MATLAB software design and evaluation.* **For example:** Understanding algorithms representing the rules and logic underlying board games; and, Developing algorithms for implementing board game rules and logic using arrays.

**2. USE TOOLS** (purple): *Utilize MATLAB software tools to solve engineering problems.* **For example:** Developing a user interface using MATLAB GUIDE that realistically represents the playing board and the position of the players as the board game progresses.

**3. DESIGN** (lime): *Demonstrate the ability to create and design within the constraints of time, cost, quality, safety, and environmental impact.* **For example:** Designing the board game presentation on the GUIDE interface within constraints of the capabilities of the players. A board game for pre-school children would require audio and visual instructions in place of text instructions.

**4. COMMUNICATE** (orange): *Demonstrate skill in technical communication related to engineering and software development.* **For example:** Developing engaging board games is founded in designing effective audio and visual communications among players and between the machine and players. This requires skill in using GUIDE for communications.

Figure 1 shows the interface as it appears at the beginning of the Sudoku game. The initial values in the grids can be set to any default values (all zeros in the figure). If the user clicks on the “check it!” button, a dialog window pops-up displaying, “Please enter numeric values from 1 to 9 only.” This occurs because the values behind the scene have not been initialized yet. Figure 2 and figure 3 demonstrate example executions. When the solution is incorrect, the pop-up window indicates where the first error occurs in the solution.

The function “CheckSudoku” in Figure 4 displays the flowchart that students use to program the core game function. Figure 5 illustrates the implementation of GUIDE, a practical and powerful tool for interactive MATLAB programming. The students are all exposed to GUIDE but not required to master it. However, the opportunity to gain expertise in using GUIDE is offered to students who take on the “technical challenge” problem for their team’s term project.

Figures 6 through 10 illustrate how the game of Tic Tac Toe can be programmed using arrays. In Tic Tac Toe, the playing board is represented by a 3 by 3 array. Tic Tac Toe differs from Sudoku in that Tic Tac Toe is a competitive game involving two players whereas Sudoku is not.

Figure 6 shows the appearance of the game board when the game starts. One of the players marks moves by entering an X. The opponent player mark moves by entering an O on the Tic Tac Toe board. After each move, functions are called that update the screen, and check to see if either player has won, or if the game has ended in a stalemate. Figure 7 and 8 give an illustration of the capabilities of the GUI by showing the game interface with and without the GUI. Comparing these two figures demonstrates how powerful and practical MATLAB GUI, GUIDE is in comparison to conventional text user interfaces.

Figure 9 shows the appearance of the board at the end of the game when either one of the players wins or, the game ends in a stalemate. Figure 10 how the GUI is designed using MATLAB GUIDE. Students can be easily modified modify components of the GUI by using the GUIDE Inspector.

## **Conclusions:**

Teaching array processing through programming interactive board games meets multiple course goals and learning objectives. By programming the core function, students can gain a solid understanding of basic MATLAB programming concepts such as data structures and execution flows. Programming Sudoku introduces the students to the logic of the core functional block.

After finishing the program, the students switch roles from programmers to users. This helps the students gain a better understanding of interactive programming design. When implementing a program, consideration should be given both to programming methods, and to the users’ need to interact effectively with the computer. Students learn how GUIDE facilitates effective human-machine communications. Composing the Sudoku core function with GUIDE also exposes the students to ways that this powerful, advanced software tool could be used in engineering problem solving, as well as, games. The team term project poses “technical challenge” problems provide interested students with further problem solving experience with GUIDE.

The learning fostered by programming board games supports four of the five designated learning objectives of this course: *Demonstrate ability in critical, creative and practical thinking through algorithm design, MATLAB software design and evaluation; Utilize MATLAB software tools to solve engineering problems; Demonstrate the ability to create and design within the constraints of time, cost, quality, safety, and environmental impact; and, Demonstrate skill in technical communication related to engineering and software development.*

Board games engage the students in a competitive learning activity. They are driven to debug their game making it functions properly so that they can play their game. The drudgery of learning the details of array operations is replaced by the challenge of developing game software. Encouraging students to sharpen their MATLAB skills by programming board games using GUIDE, helps us achieve our educational goal of inspiring and motivating our students to use engineering tools to solve real-life engineering problems.

## References:

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