Team Proposal Report

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Introduction

Our group's project aims to help high school/university students better understand the concepts of Set Theory interactively. The program titled "Interactive Set Operations" allows students to practice basic set theory concepts and understand the ideas behind well-known laws using a blend of numerical problems and visual aid programs. It also enables teachers to create problem sheets with numerical challenges for students. This tool will help create an online learning resource that is convenient and useful for high-school/university students.

Set theory is a fundamental concept while studying Computer Science at university. It is essential for students to keep all these concepts fresh in memory and for teachers to help students do so. We will enable students to get thorough with set theory laws using interactive flashcards, practice numerical problems in MCQ format, and map set expressions onto Venn Diagrams. Teachers can ask students to enter results of set operations on atmost three sets.

The diagram below gives a very high-level overview of the functionalities provided by our tool.

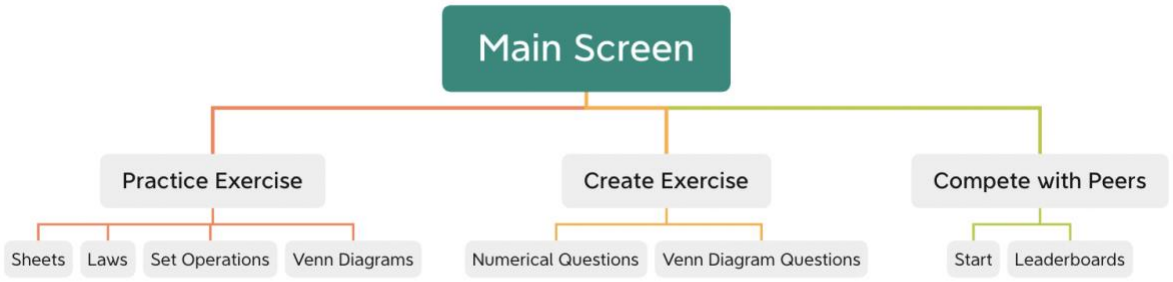

Figure-1

Framework/Language:

The tool will be implemented using Python. This decision was made keeping in mind the useful visualisation libraries available in Python. For designing the Graphical User Interface (GUI), we will be using PyQT as it offers a large number of widgets and more comprehensive looks if compared to other Python GUI Libraries. We will be using the Matplotlib library of Python to draw Venn Diagrams.

Implementation Subtasks:

- **User interface:**
  The user will use a Graphical User Interface (GUI) to interact with the program. The main user interface will be produced using the PyQT module. The home screen of the tool consists of 3 buttons that represent the interactive modes, namely "Practice Mode", "Create Mode", and "Compete Mode". Upon pressing a button, the user will be redirected to the selected interactive mode.

    - **Practice Mode:**
      The screen consists of four buttons describing the type of questions to practice.
      Practice Sheets – The GUI for this section will initially allow students to load the practice sheet (created by teachers) they wish to solve into the tool. Further it consists of three

sub-sections on the screen: The top of the screen will consists of the question and question number. There will be a text box for the student to enter their answer which will be verified. Finally, there are buttons at the bottom of the screen to move back and forth through the questions. Once the student has submitted their answer, a message will appear indicating if the answer was correct.

Practice Laws – This section enables the students to self-practice and revise common set laws that have been mentioned in the "SET LAWS" section below. Students are presented with a flashcard over which the question is written. By hovering over a flashcard, the student can check if their answer was correct or not. There are buttons at the bottom of the screen to move back and forth through the questions and an EXIT button which will end the practice session if the user wishes to do so.

Practice Set Operations – The GUI for this section consists of 3 components: The top of the screen consists of the question number and the question. Following the question, 4 options will be displayed along with a submit button. After the student has selected an answer, their answer will be checked with the one stored in the back end. In case of a wrong answer, hints will appear on the screen on how to approach the given problem. There are buttons at the bottom of the screen to move back and forth through the questions and an EXIT which will end the practice session if the user wishes to do so.

Practice Venn Diagrams – Students will be asked to shade the venn diagram based on the equation presented to them. The screen consists of the equation, an unshaded venn diagram and a submit button. Once the student submits their answer, a message will appear indicating if the answer was correct. There is an EXIT button at the bottom of the screen which will end the practice session if the user wishes to do so.

- **Create Mode:**

The GUI for this section will initially allow the user to input the number of questions they want to create. The user will be directed to another screen which asks whether the user wishes to create an expression for 2 or 3 sets, and then enables them to enter the equation and the values of the respective sets. There will also be an on-screen keyboard on the screen for the user to enter the equation. Assuming that the teacher wishes to create an equation for 2 sets, Figure-2 is an example of how the GUI for this section will look like.

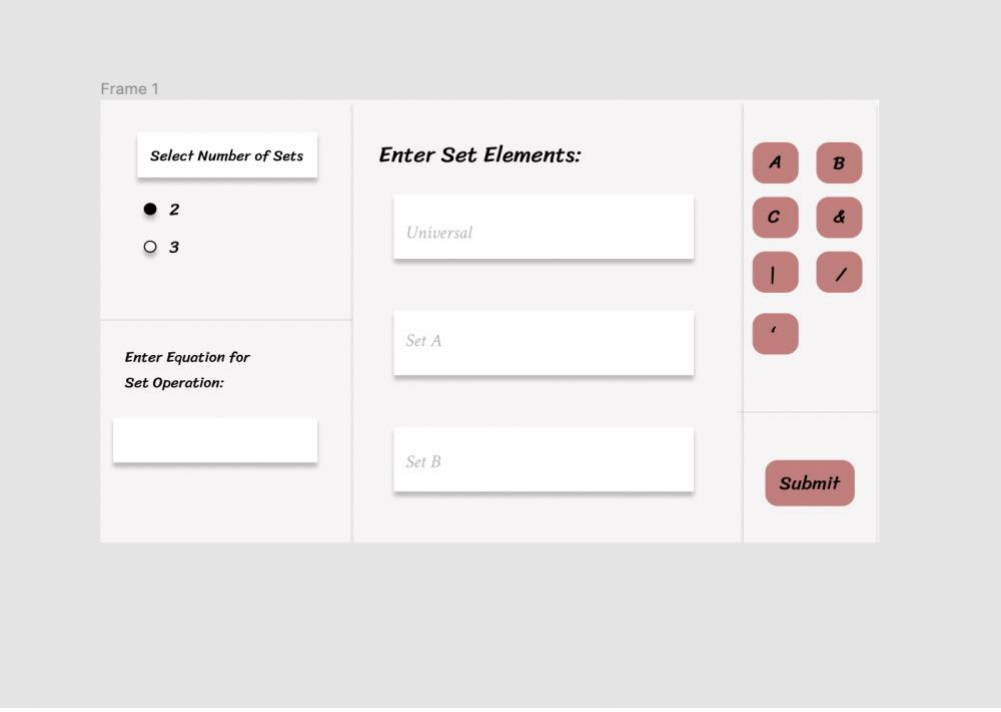

Figure-2

- **User input validation:**
  In this tool, validation of input is needed when the teacher enters an expression while creating an exercise. Validation is done in two parts:
  - **Validation of every character**: To input an expression, the user can either use the on-screen keyboard or their device keyboard. If they use their device keyboard, the input string needs to be checked for invalid characters. The only valid characters are A-C for sets and 4 operators denoted as shown in Table-1. All the characters that are not a part of the on-screen keyboard are invalid. If an invalid character is found, a pop-up message will be displayed.

OR	|
AND	&
NOT	'
DIFFERENCE	/

Table-1

  - **Validation of the equation**: The input equation needs to be checked for computability. For example, an invalid equation might contain unbalanced brackets or wrong number of sets for a unary or binary operation. If an invalid equation is entered, a warning pop-up message will be displayed.

- **Displaying Venn Diagrams and hovering effect**:
  In this tool, Venn Diagrams are displayed to improve the user's understanding of basic set laws. In the practice laws section, once the user hovers over a flashcard, the colour of the flashcard changes. This reveals an explanation of how a particular law works. The venn diagrams are displayed using the matplotlib library of python and the hover effects are produced by using CSS stylesheets with PyQT.

- **Accepting user input through buttons**
  If the student chooses to practice Set Operations or Venn Diagrams, they will be asked to enter the input using buttons (either MCQ or Venn Diagram Shading). Example questions have been demonstrated in Figure x and Figure y. The tool will convert the input into a string and then compare it with the correct answer stored in our system.

- **Creating numerical practice sheets**
  Teachers can create practice sheets for students using our tool. The process for the same is shown in the flowchart [Figure-3]. The tool will automatically calculate answers for the questions entered by the teachers and store them in the same file. Once the teacher has created a sheet, the text file will be available for the students. They can load the file into the tool and start practicing the questions.

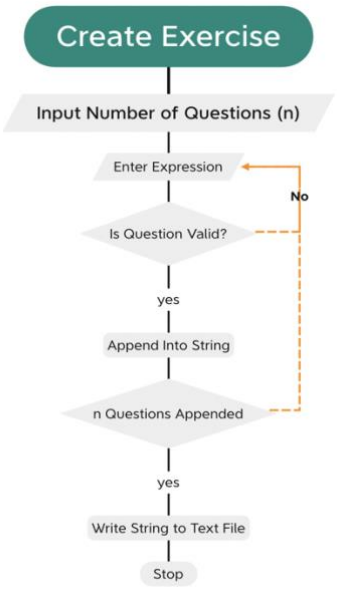

Figure-3

Project Extensions

We will prioritise implementing Practice and Create modes as mentioned in this report. If there is extra time left, the following features will be added to the tool:

- **A compete mode** : This mode enables the student to compete with their friends. There is a quiz in MCQ format which consists of 10 questions and the students are marked for every correct answer they enter. The questions are based on either set operations or venn diagrams. The mode also consists of a leaderboard which shows the 10 highest scorers of the quiz.

- Another extension is enabling the teacher to enter questions which prompt the student to shade Venn Diagrams appropriately. The student can shade the diagrams using buttons and the input will be converted to a string. This will be compared with the answer determined by the tool.

Data Structures and Storage

Python Strings: Whenever the input is captured from the text box, the input will be stored as a string as it is easy to compare two strings in Python.

Python Sets: When the teacher creates a question, they also input values to be entered into a set. These values are first stored as a string, and then converted to a Python Set as Python's implementation of a set makes it extremely easy to perform basic operations such as union, intersection, difference, and complement.

Python Lists: If we implement the Compete Mode of our tool, a Python list will be used to store the name and score of the top 10 scorers of the quiz.

Algorithms

If the Compete Mode is implemented, We will be using **Binary Seach** and **Insertion Sort** to maintain the leaderboard. Binary Search will determine if the score of the current user should be a part of the leaderboard. If it is, insertion sort will sort the leaderboard once the user name and score are entered based on the score.

The following flowchart demonstrates how the Practice Mode of our tool will be implemented:

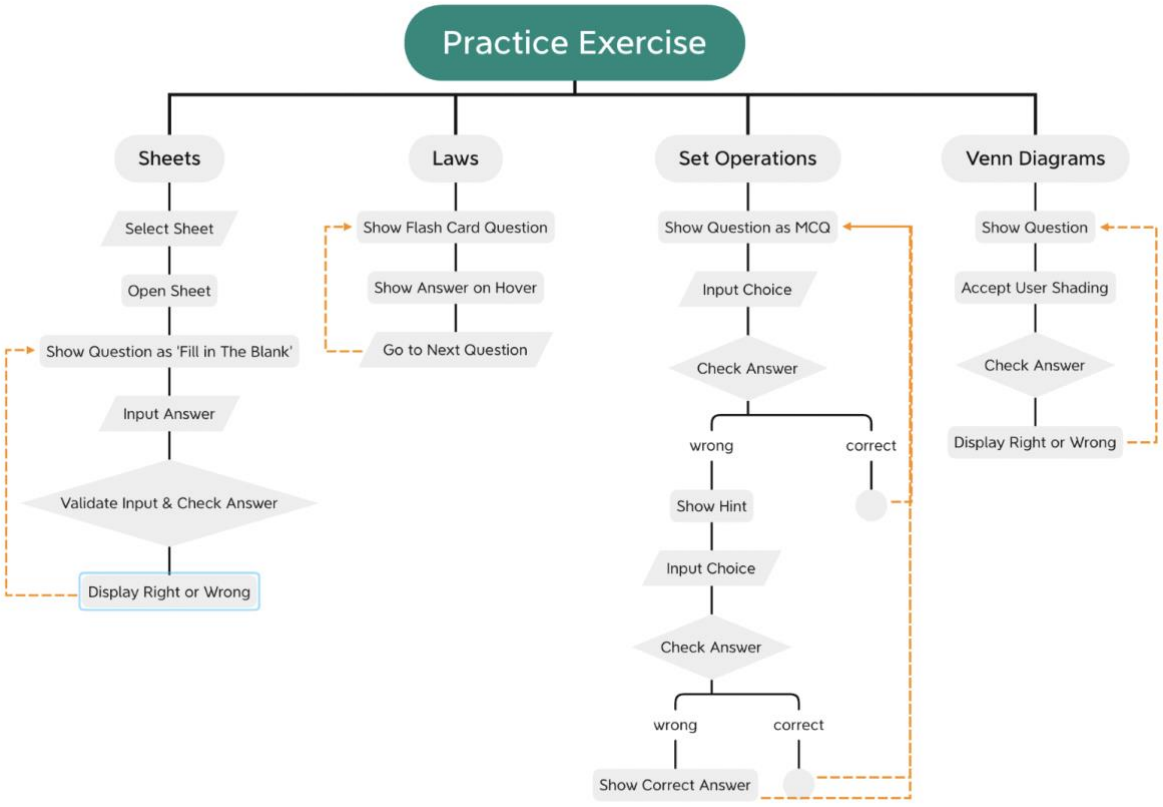

Figure-4

The flowchart shows that the user has four options to choose from after clicking the Practice button. Each section has its own unique way of helping the student revise set theory concepts. The Sheets loop continues until the student has answered all the questions of the chosen practice sheet. All the other loops will terminate either if 10 questions have been answered, or the user chooses the end the practice session by clicking on the EXIT button.

Examples of Questions

- **Practice Set Operations:** In this section, the user will be asked to solve a question based on applying set operations. Questions will be in MCQ format and the user has to choose one of the four given options. If the answer is wrong, a warning pop-up message will be displayed. Figure-5 is a demonstration of how a question will look like:

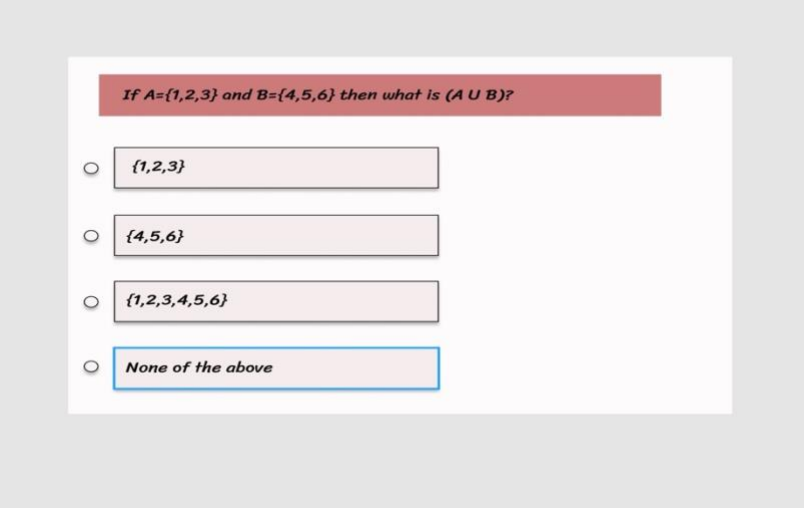

Figure-5

- **Practice Laws:** In this section, the user will be asked a question relating to a particular set theory law. Once they figure out the answer, they don't have to submit it. Rather they will verify it themselves by hovering over the question area. Once they hover, the answer will be revealed and the user can check if they were right or not. Along with the answer, a Venn-Diagram visualisation of the law will also be displayed to make it easier for the user to understand the law. Figure-6 is a demonstration of how a question will look like and Figure-7 displays how the answer will appear once the user hovers over the flashcard.

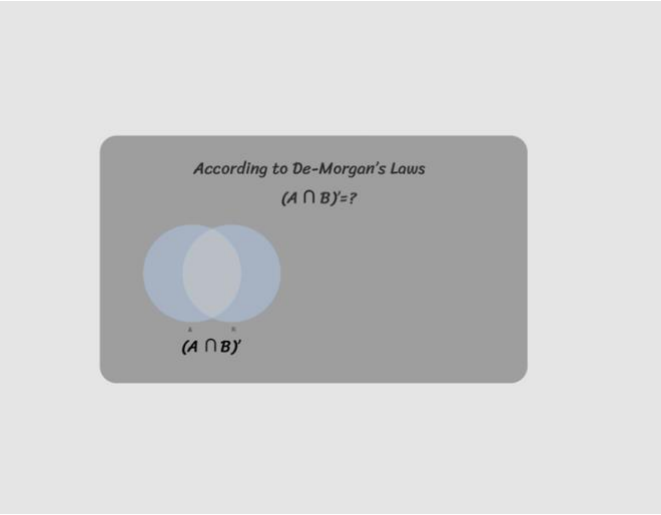

Figure-6

Figure-7

- **Practice Venn Diagrams:** In this section, the user will be presented with an equation of atmost three sets and an unshaded Venn Diagram. The user has to shade the Venn Diagram

appropriately by clicking on buttons associated with a particular patch in the diagram. Once the user has made all the selections and submitted their choices, the correct answer will appear as demonstrated in figure-8.

Figure-8

Conclusion

In conclusion, as a result of the innovative teaching approaches adopted by our team, our tool stands out if compared to other tools created in the past. Functionalities like explaining set laws via the Hover effect and Venn Diagram Representation ensure that students are exposed to creative ways of learning. The automatic calculation of answers to questions entered by the teachers clearly shows that our tool is extremely easy to use when creating practice sheets. This tool will be a one-stop solution for students who wish to practice Set theory interactively.