Math Scholar Pro

USER'S GUIDE

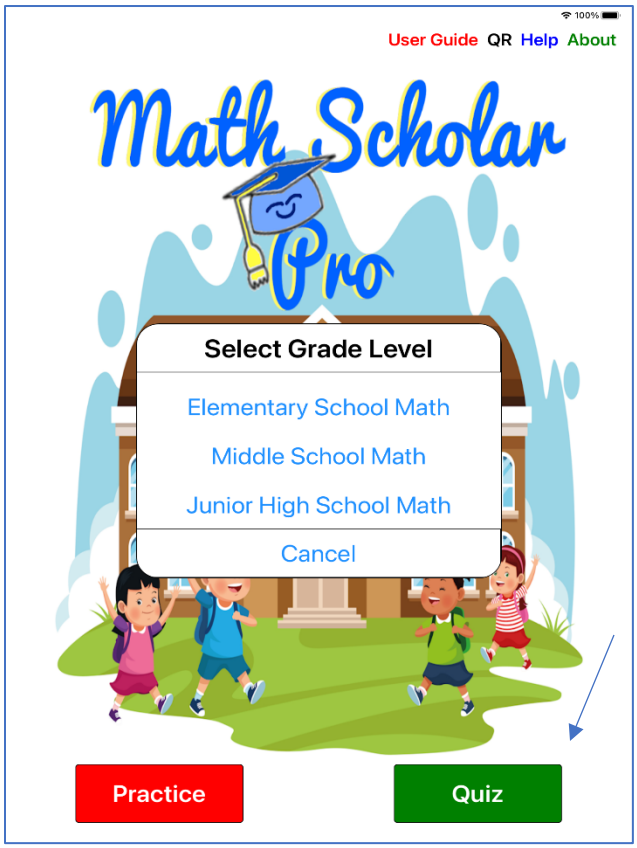
Math Scholar Pro is a fun educational app that helps kids dramatically sharpen their math skills! The learning objective of Math Scholar Pro is to build mental math skill through the use of a simple, entertaining interface.

MODES

Math Scholar Pro has two basic modes; Practice and Quiz. Within each mode are three learning levels; Elementary School, Middle School and Junior High School. The Practice Mode also features two study aids; Math Tables and Math Flash Cards.

This is the iPad opening screen.
(Note: The Top Menu items are addressed in Appendix M)

Pressing the Practice Button calls the Practice menu with its three Practice Sessions and two Study Aids



Pressing the Quiz Button calls the Quiz menu with its three Practice Sessions

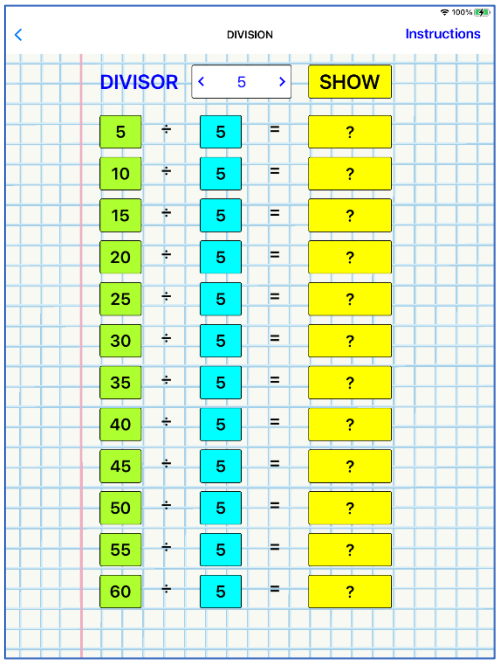
I. Study Aids.

A. Math Tables

The "Times Tables" have been around since math was first taught. The ability to mentally calculate simple multiplication problems is useful in school, on the job and, maybe most obviously, in everyday life.

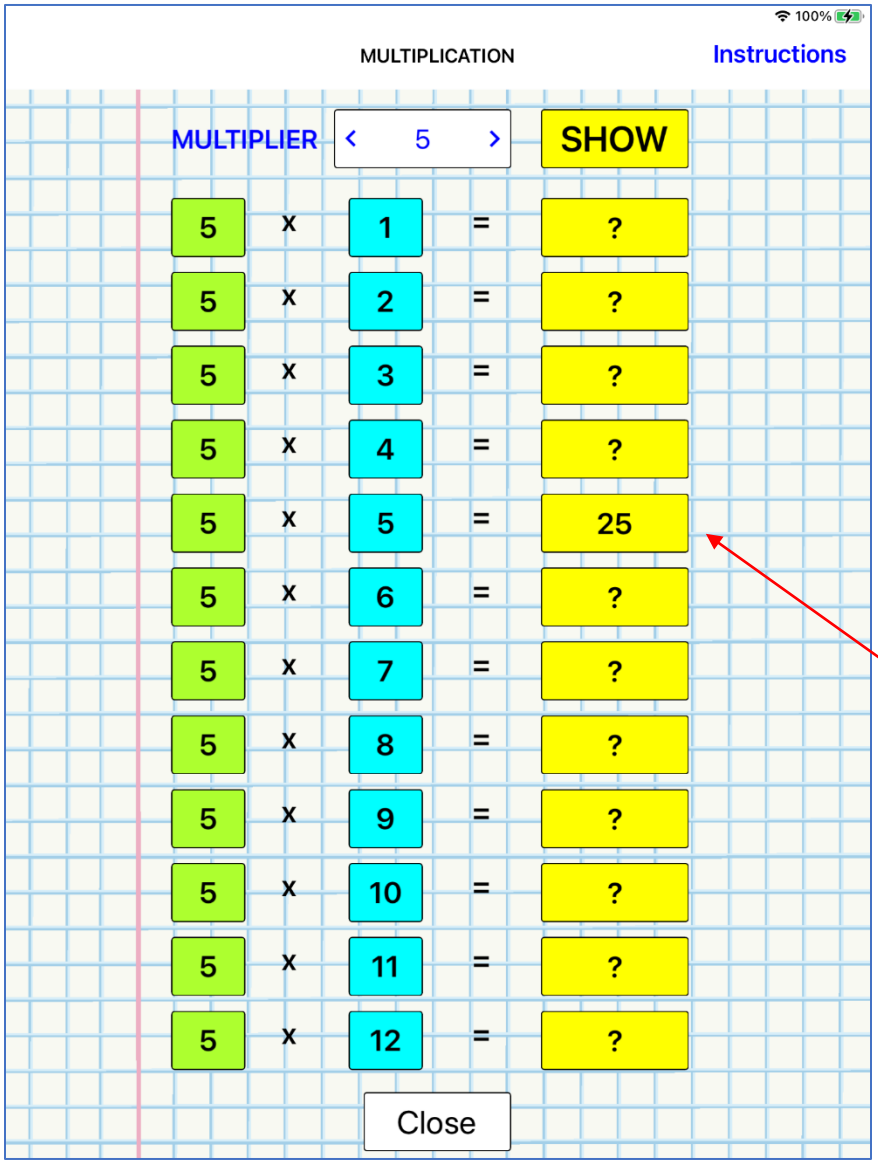
While the Times Tables are the most frequently studied in math class, there is value in being able to accurately add, subtract, and divide numbers mentally (in case that calculator isn't handy!).

Math Scholar Pro includes the four basic math tables:



The advantage to using these tables instead of pencil and paper is that there is no need for pencil and paper!

Let's look at the Times Table to see how the tables are presented.



In this example, the student is practicing the "5 times table".

The student randomly picks the 5 x 5 line and, using *mental* math, thinks of the answer. Then, by pressing the yellow box, the answer is shown. No more covering up one side of a piece of paper!

To view a table entirely, press SHOW. The yellow boxes will show all the answers at once and the button is relabeled as "HIDE". Pressing HIDE replaces the answers with "?"s.

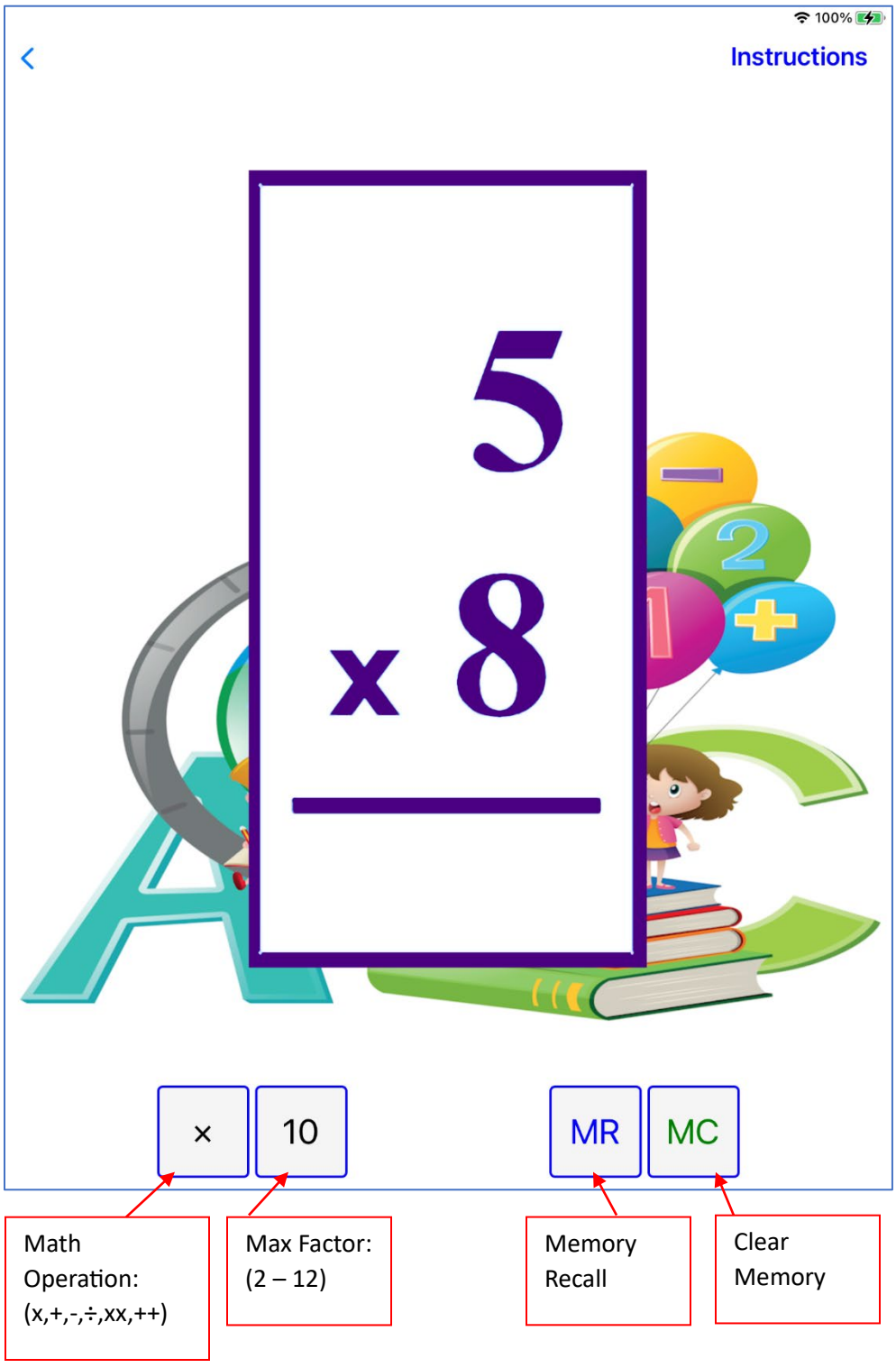
Use the "Multiplier" selector to change the table. Range is 2 to 12.

The remaining three tables are set up in a fashion similar to the Multiplication table. Subtraction and Division tables are structured so that they always have positive integer solutions.

B. Flash Cards

Flashcards are one of the most common study aids, and ones with which most students have some familiarity. Flashcards help them actively engage in learning by stimulating memories and creating lasting connections to the material.

This is a typical opening screen when Flash Cards are selected from the Practice Mode menu.



The buttons at the bottom of the page have these functions:

- Math Operation (rotary):

  + add

  - subtract

  x multiply

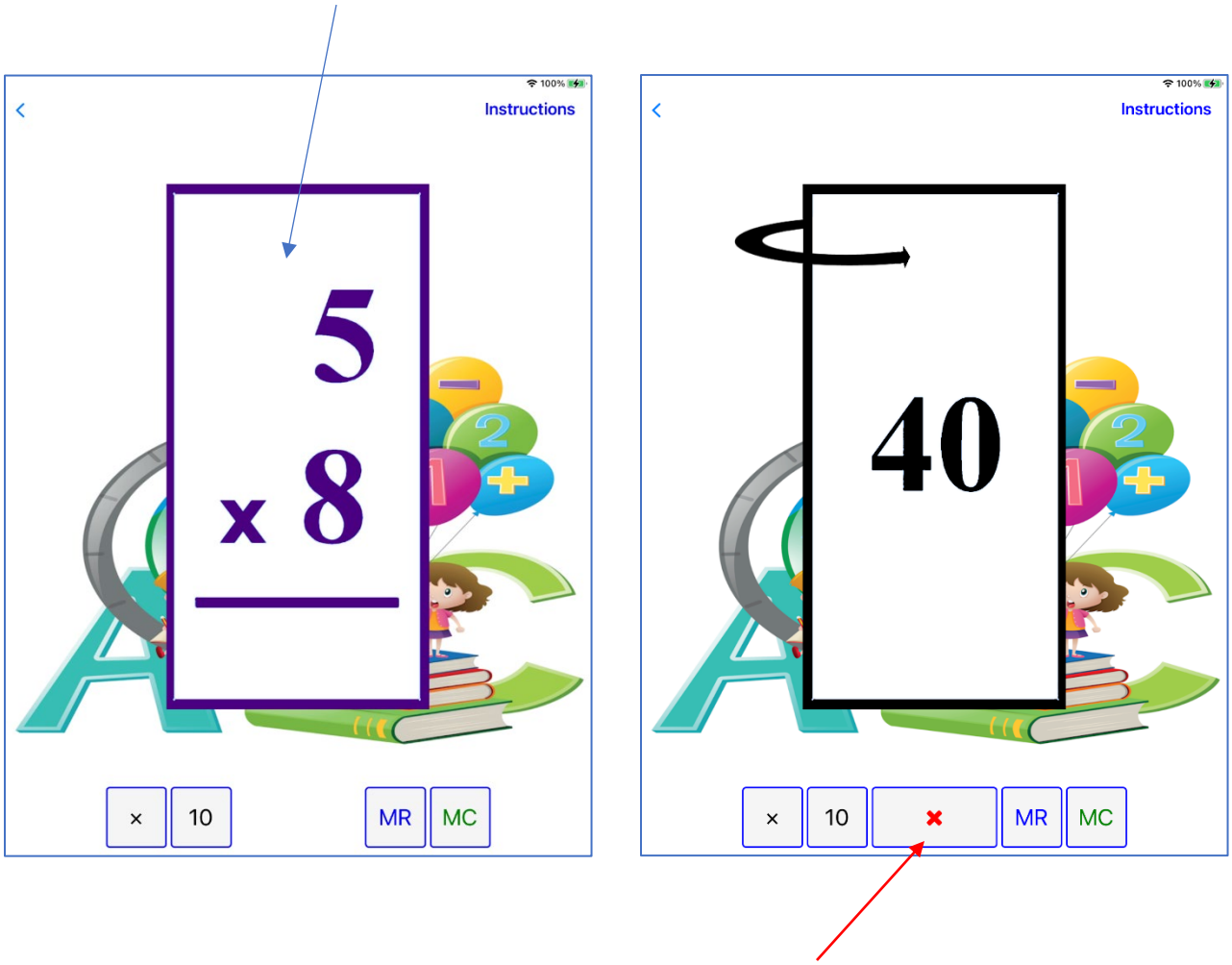
  ÷ divide

  ++ addition pairs (e.g. 3 + 3, 4 + 4, etc.)

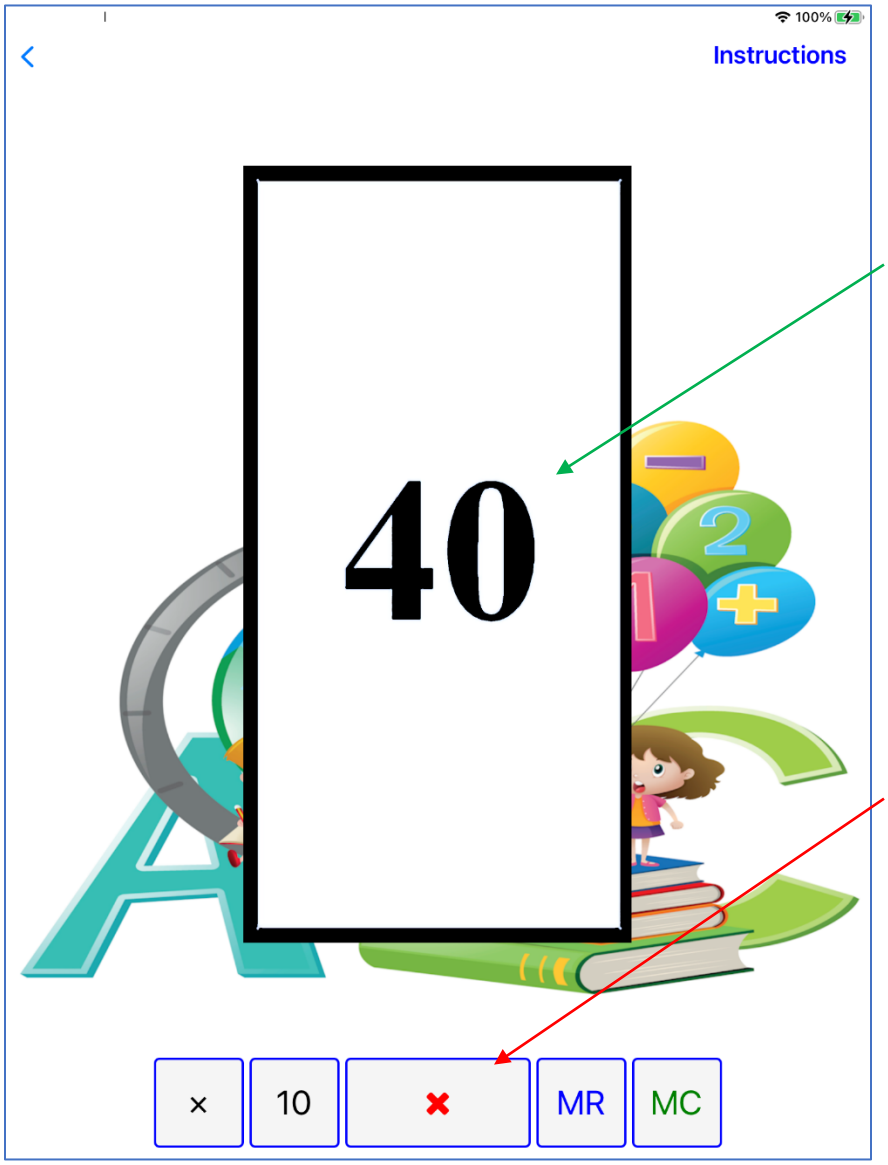
  xx multiplication pairs (e.g. 3 x 3, 4 x 4, etc.)

- Max Factor (rotary). The maximum argument value; the range is 2 to 12. Each press advances the rotary.
- Memory Recall. Up to 10 cards that were answered incorrectly can be saved. Press MR to recall saved cards.
- Memory Clear. Clears memory of all saved cards.

After a card is displayed, the student uses *mental* math to determine the solution, then taps the question card to check the answer:



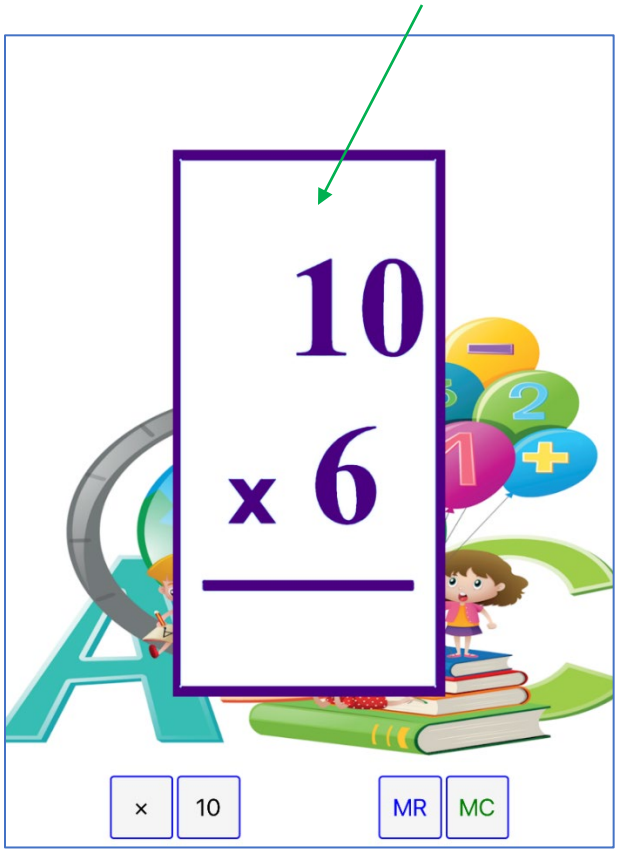
When the answer card is displayed, an additional button appears at the bottom of the screen.

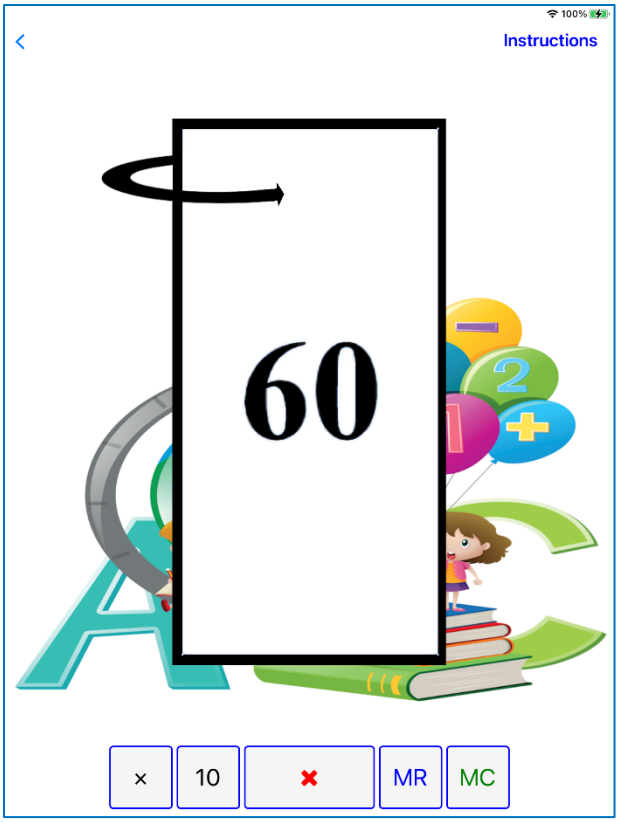


If the mental math answer was CORRECT, tap the answer card and a fresh card will be displayed.

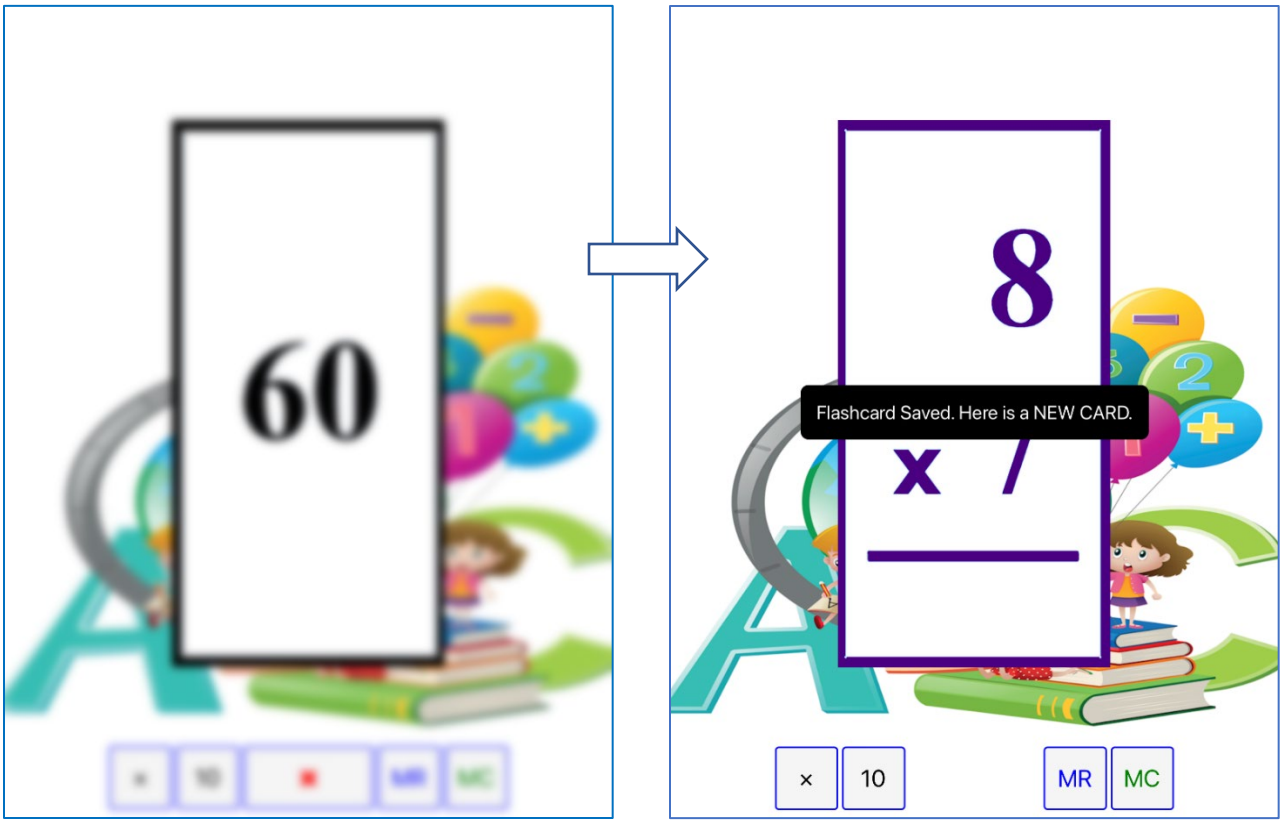
If the answer was INCORRECT, press the **Red X**. The card will be saved in memory, available for recall. A fresh card will be displayed.

Let's assume that the last card was answered correctly. Pressing that Answer card produces this new Question card, which, when pressed, produces its corresponding Answer card.





This time, let's say we guessed (via mental math) 50. Since the answer was incorrect we press the **Red X**

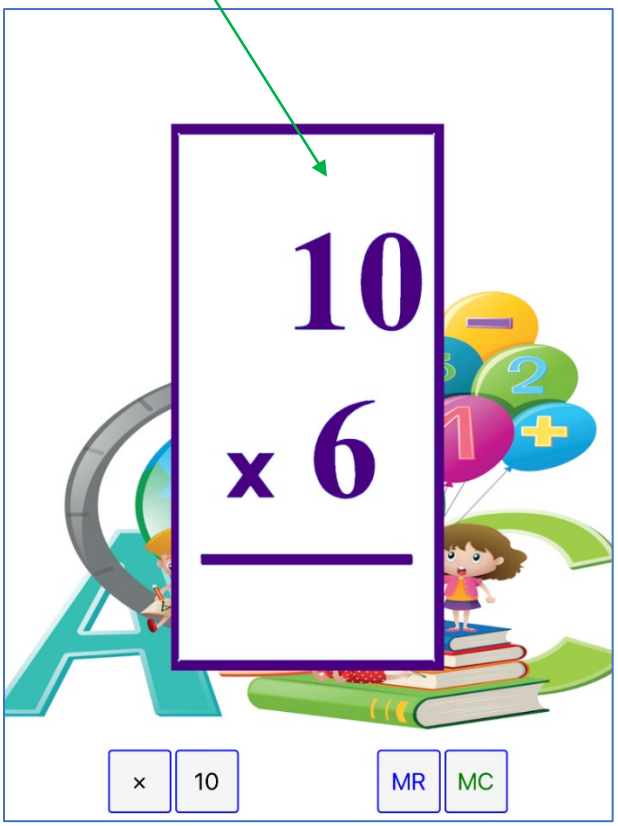


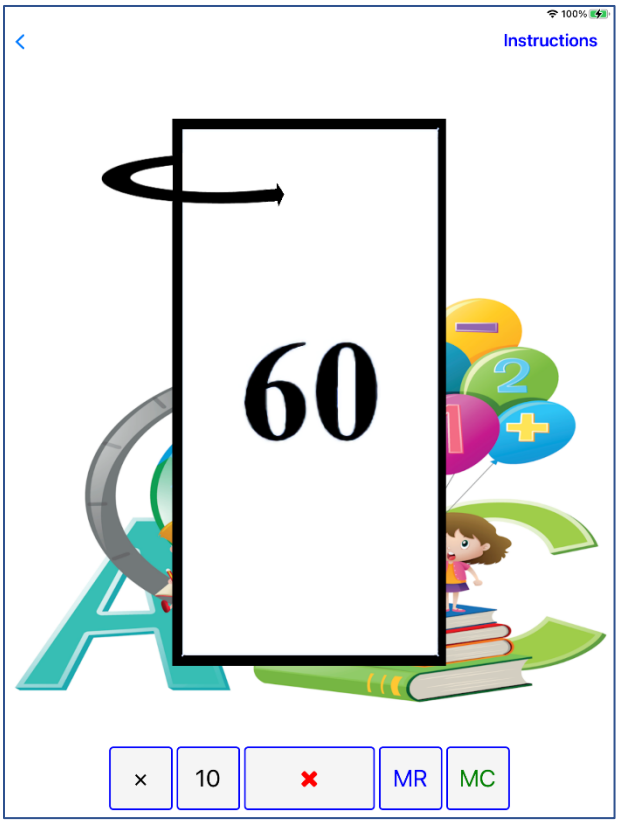
A brief notification that the previous card was saved is shown, then a new card is displayed.

Let's say that after several more cards are answered correctly, the student decides to review the saved cards.

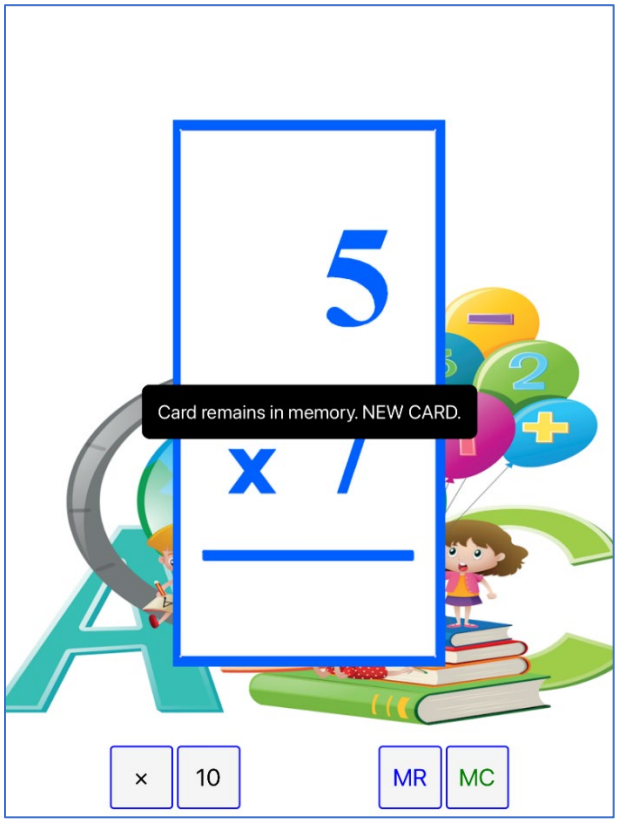
The **MR** button is pressed and the first saved card reappears, with a brief notification that this is a RECALLED CARD from memory.

Pressing the recalled Question card, the Answer card appears.

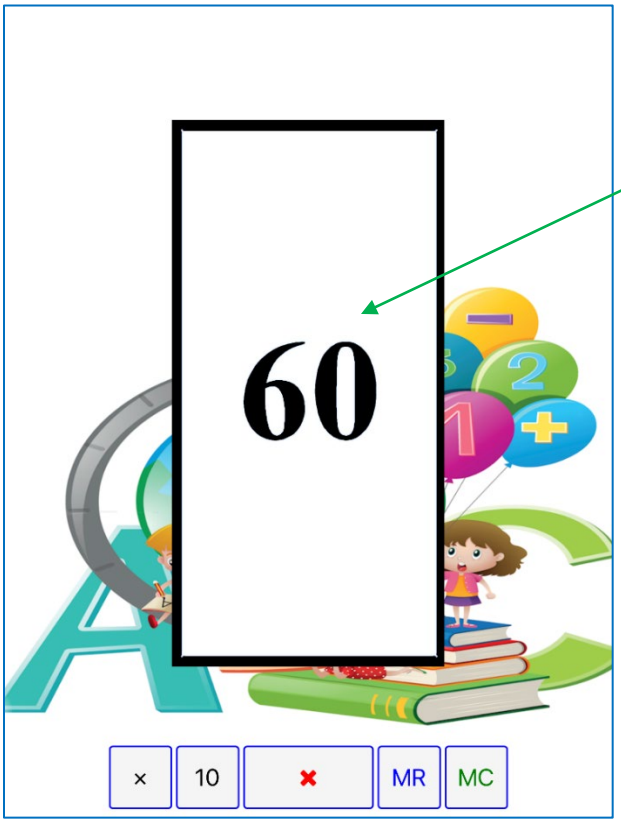




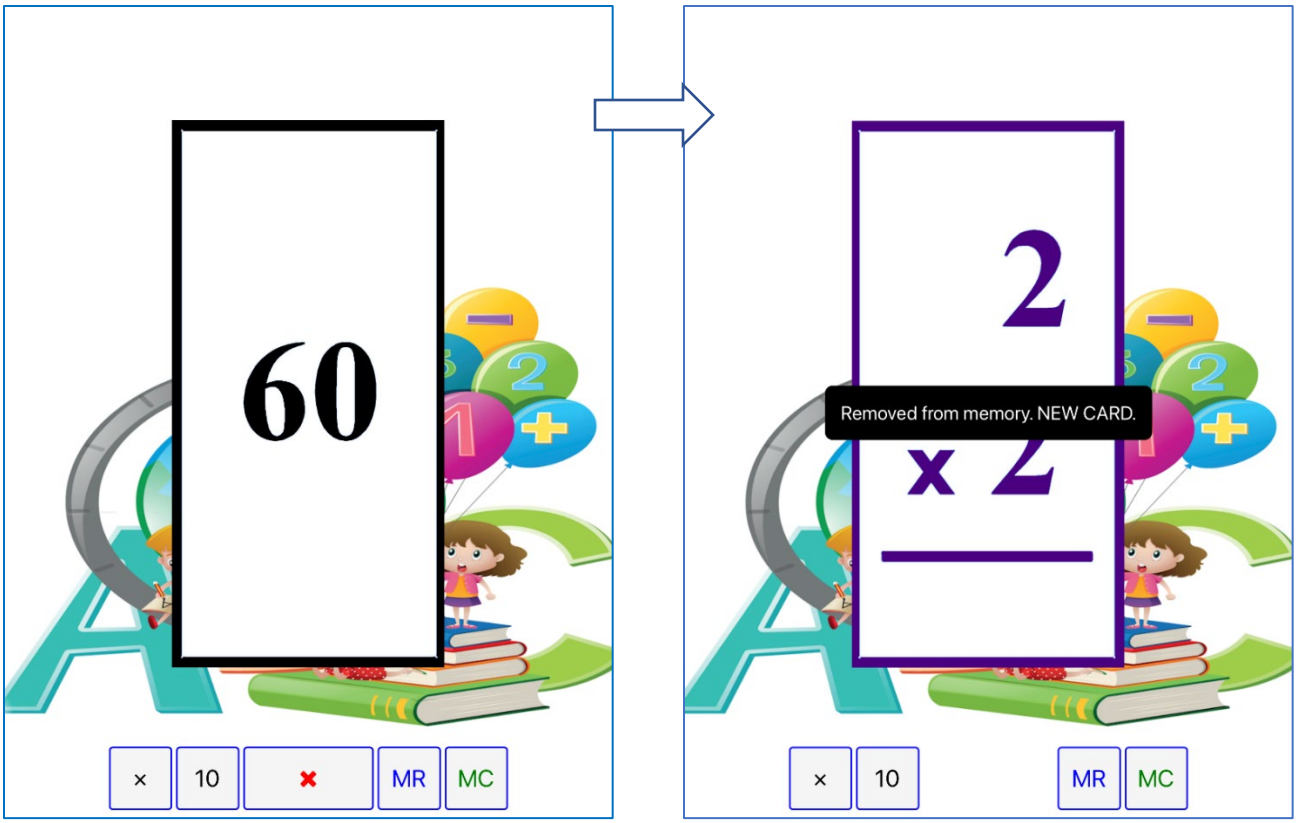
Suppose that the card is answered incorrectly *again*. As before, press the **Red X**.



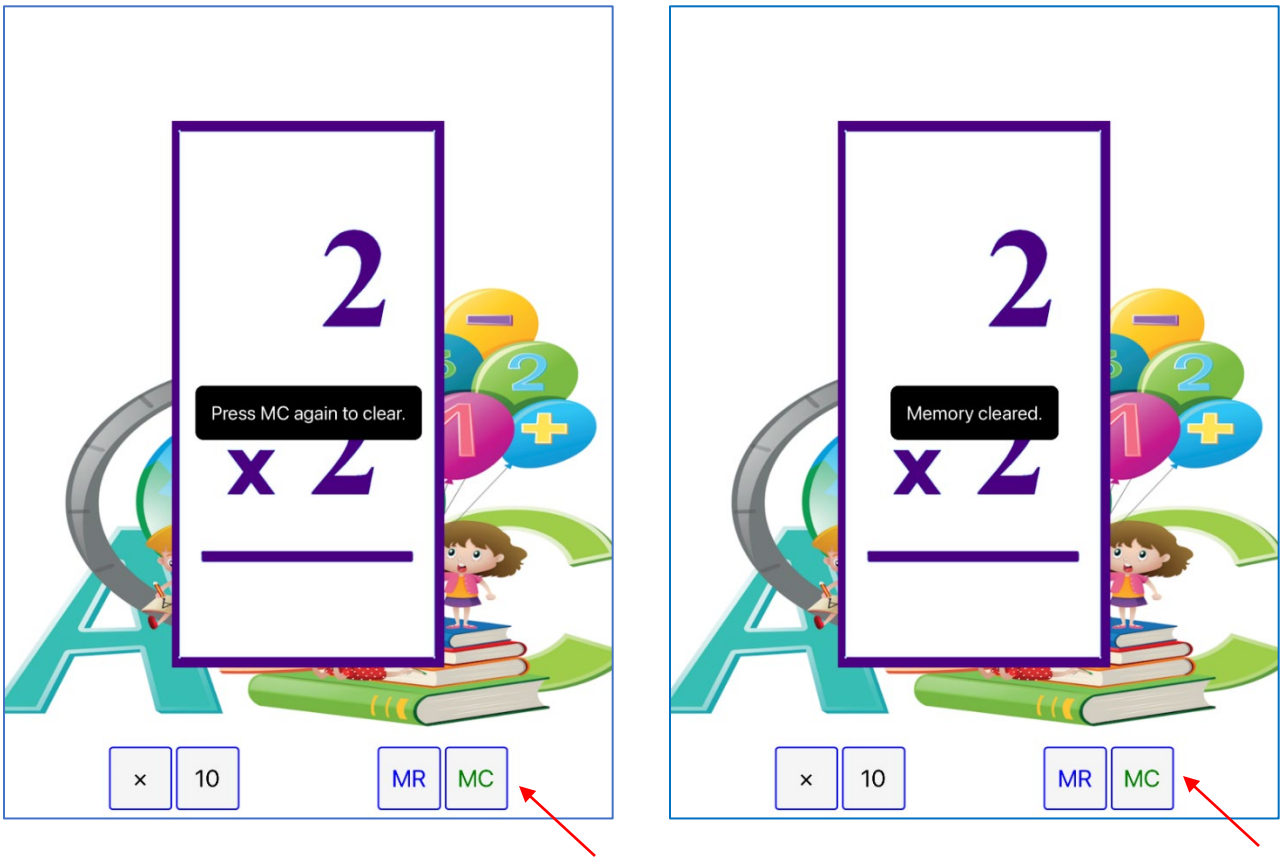
A brief notification that the card was retained in memory is shown (the card is not saved twice). A fresh card is displayed.



Suppose that the saved card is recalled and is finally answered **correctly**. Press the Answer card.



A brief notification that the card was released from memory is shown, and a new card is displayed.



To clear memory, press the **MC** button twice

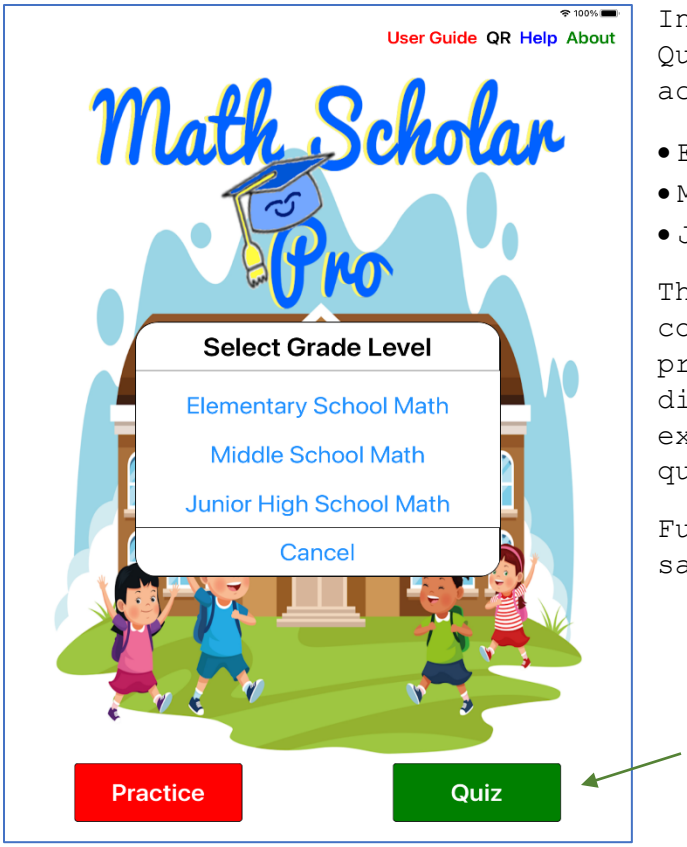
MODE DISCUSSION

In the Practice Mode, there are three Practice options, organized according to learning levels:

- Elementary School
- Middle School
- Junior High School

Practice sessions are untimed and ungraded. They present the student with grade level math problems that hone their mental math skills.

These sessions do not require pencil and paper. A keyboard is not needed.



In the Quiz Mode, there are three Quiz options, also organized according to learning levels:

- Elementary School
- Middle School
- Junior High School

The quizzes mirror their practice counterparts, using the same problem presentation formats. The difference between Practice exercises and quizzes is that quizzes are TIMED and GRADED.

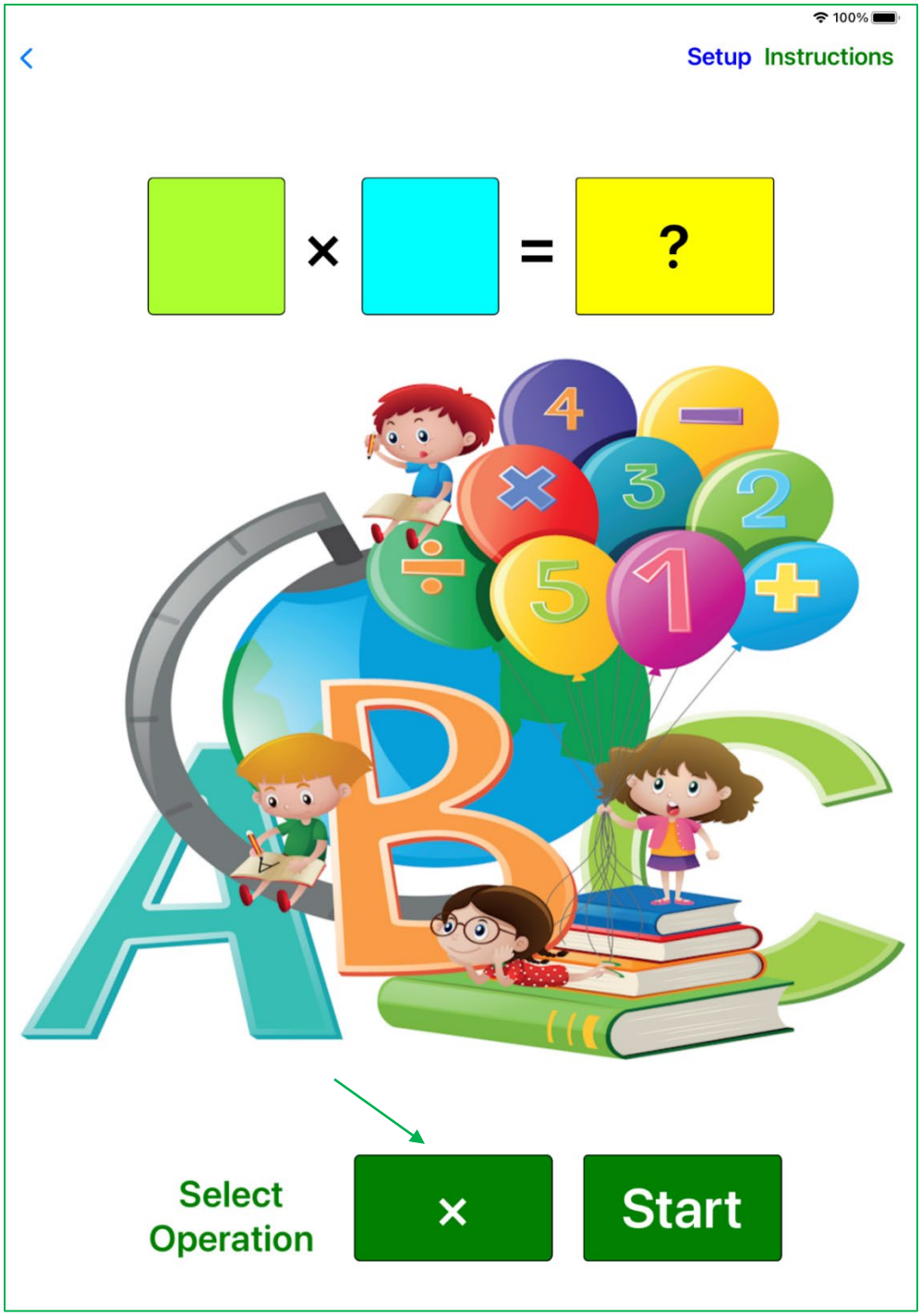
Furthermore, high scores are saved to promote competition.

II. PRACTICE MODE

A. Elementary School Level (two term mental math)

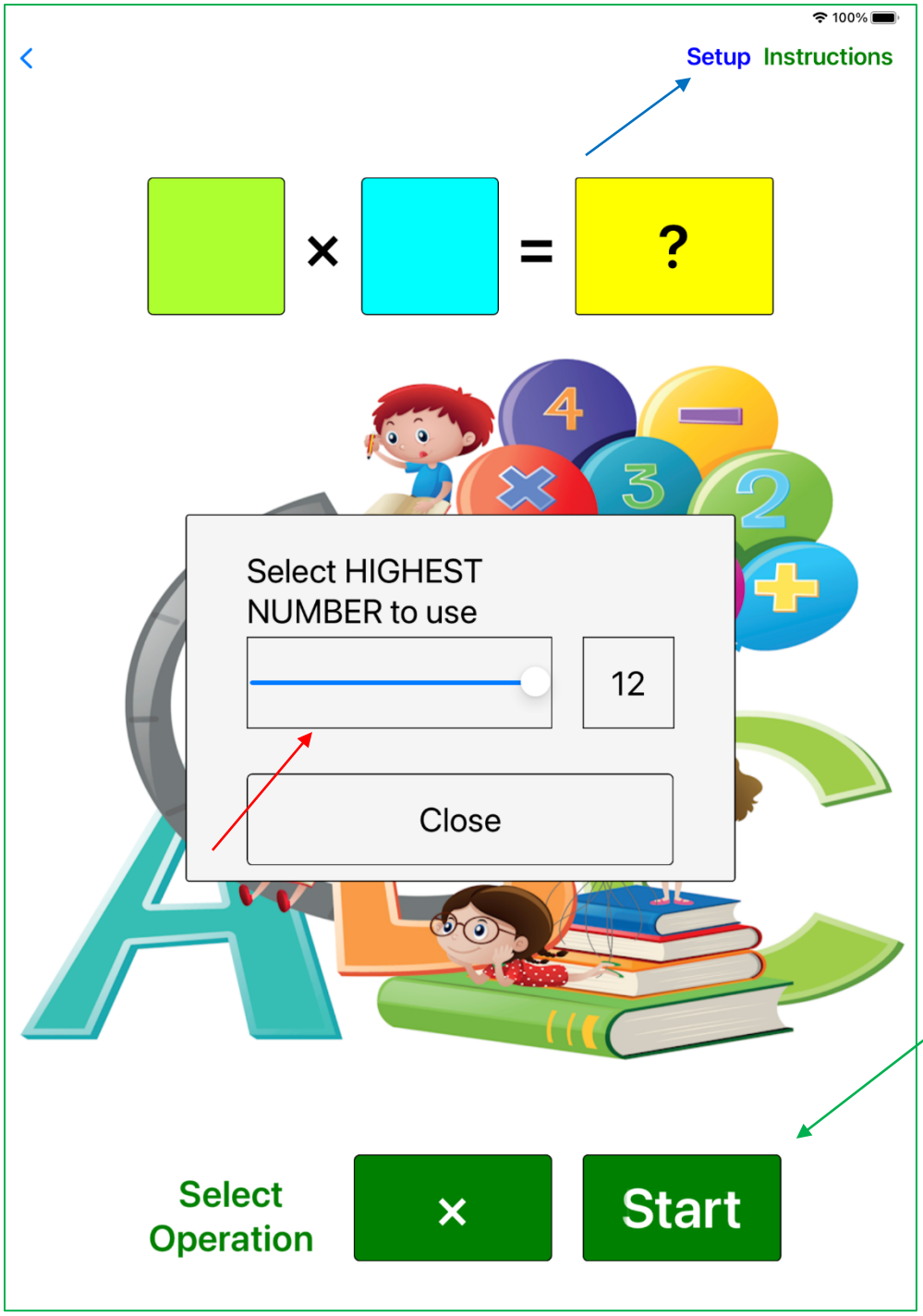
All problems follow the format as shown here.

arg 1	*op*	arg 2	=	Answer



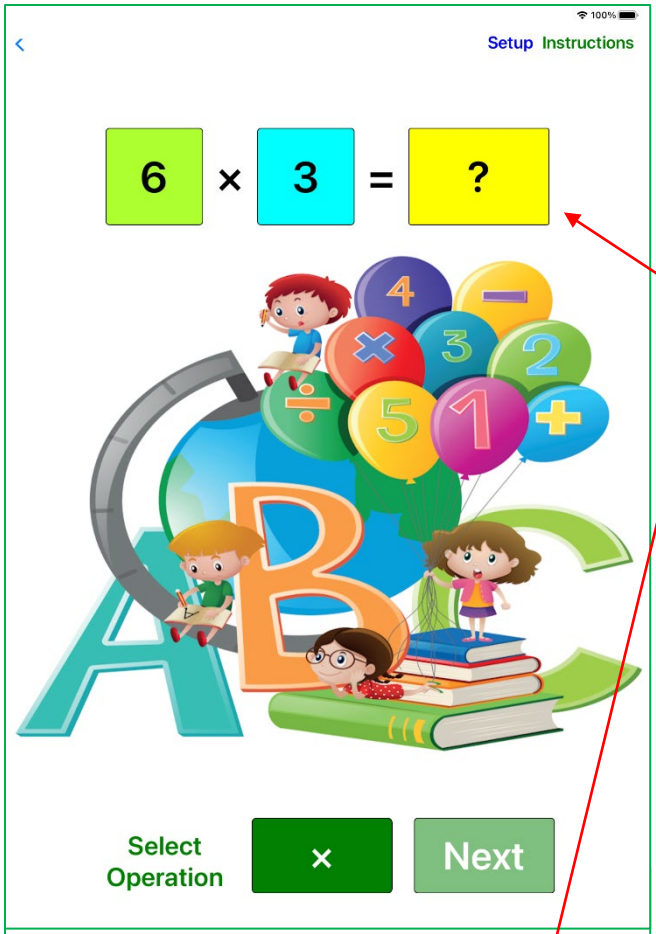
Step 1. Select the desired math operation by pressing the "Operator" button. Each press of the button cycles through the four basic math operations (+, -, x, ÷).

Step 2. Press the Setup menu item.



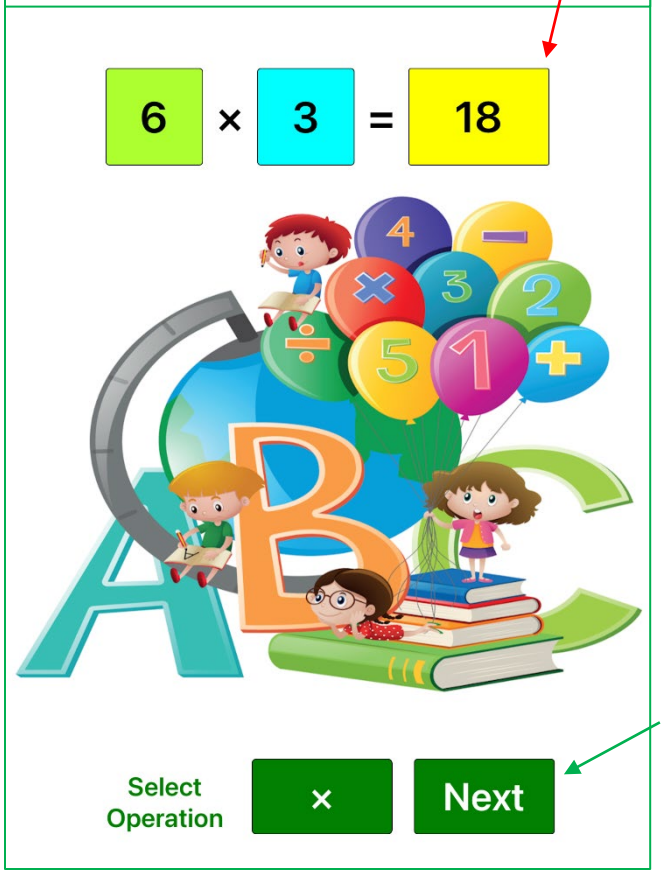
Step 3. Select the maximum value for the problem's arguments using the slider.

Step 4. Press START



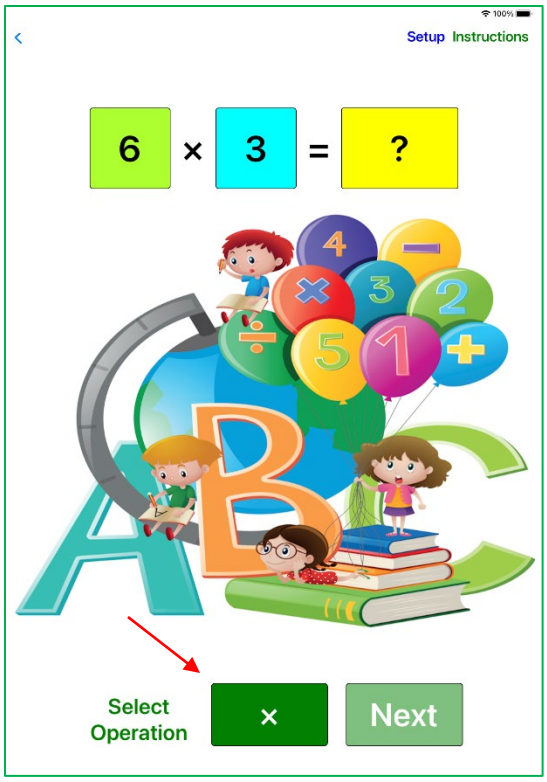
This is a typical opening screen for a multiplication problem. The student should use mental math to solve the problem.

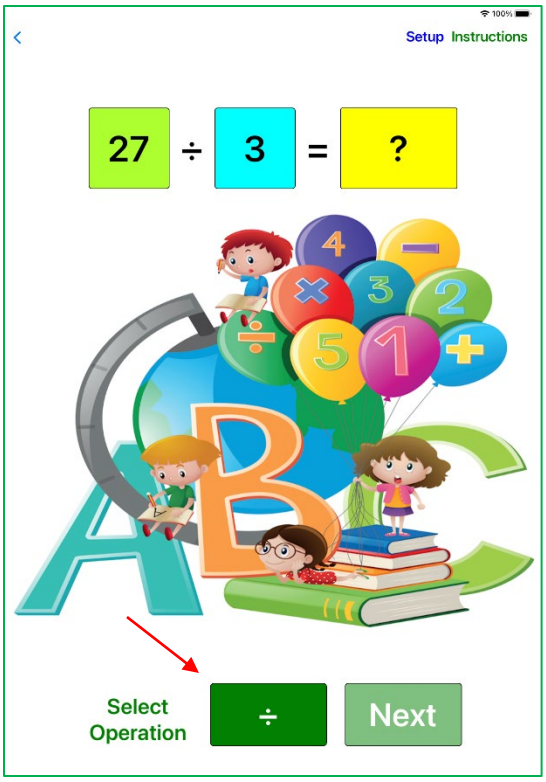
Press the “?” in the yellow boxes to reveal the answer

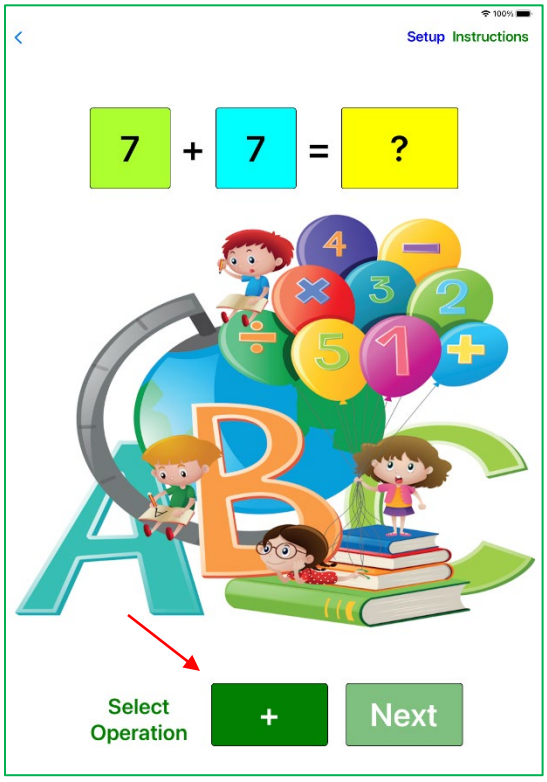


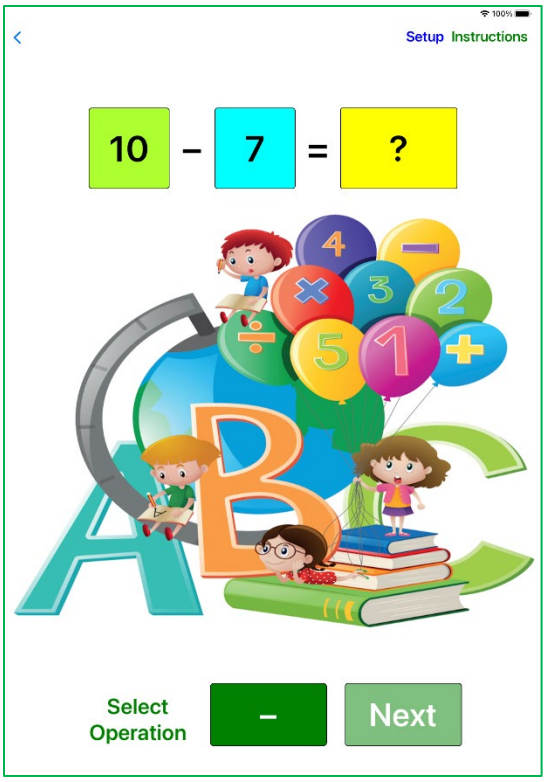
Press NEXT to move on to the next problem

Pressing the Operator button will cycle through the four basic math operations used at the elementary school level









Note that all subtraction and division problems yield positive integer answers. No negative or mixed numbers.

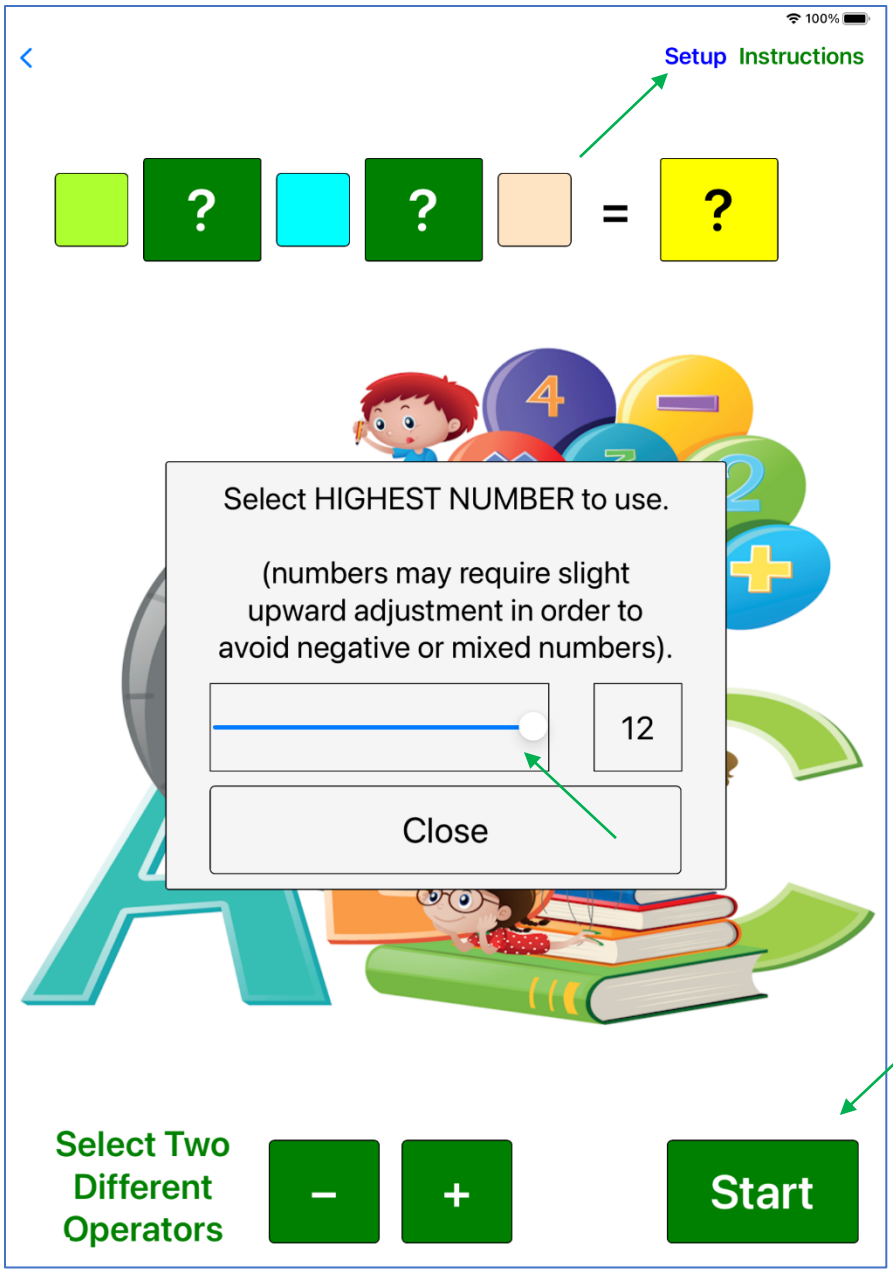
B. Middle School Level (three term mental math).

In addition to practicing compound problems, the Order of Operation rules are also in play at this level. Remember that expressions are read from left to right, with Multiplication and Division having precedence over Addition and Subtraction.

This problem set is unusual in that not only are the arguments known, but so is the answer. The objective is to select the two missing operators that will make the equation valid.

Let's look at a typical opening screen:

Step 1. Select the two operators that will be used in the expression. These must be non-matching operators. Pressing either Operator button will cycle through the four basic math operators (+, -, x, ÷).



Step 2. Press the Setup menu item.

Step 3. Select the maximum value for the problem's arguments using the slider.

Step 4. Press START

NOTES:

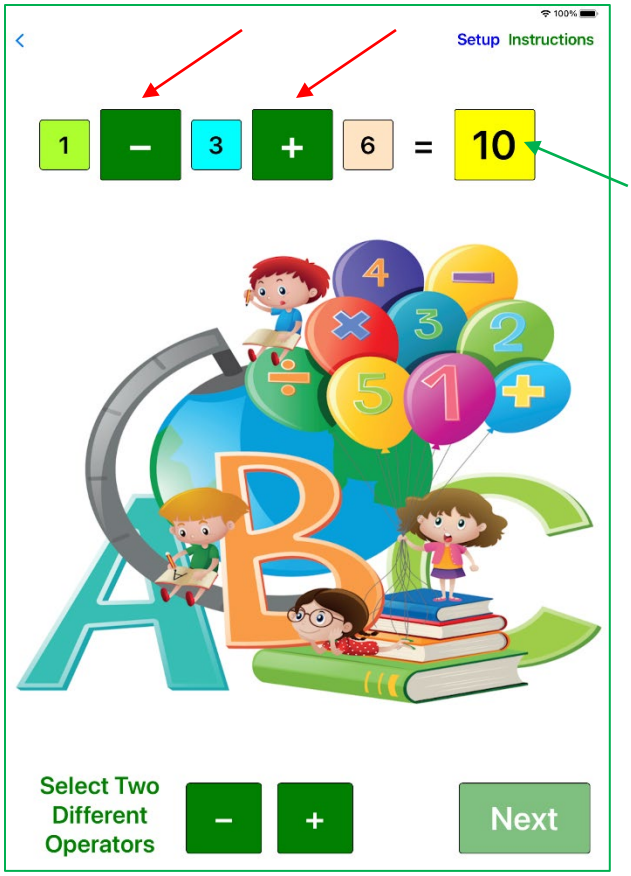
- The program will not allow the selection of matching operators.
- Changing the operator pair can be done at any time.
- The arguments are always adjusted so that no negative numbers are encountered, nor are there mixed numbers (no fractions). All the math is done using integers only.
- The maximum value selection occasionally requires a slight upward adjustment in order to avoid mixed numbers. This can occur when division is chosen as an operator.

Example. After pressing Start (with Subtraction and Addition selected), this problem was displayed. The arguments were chosen semi-randomly; subsequent problems will be different.

To solve the problem, press the green Operator boxes [?] until the desired operator(s) appears.

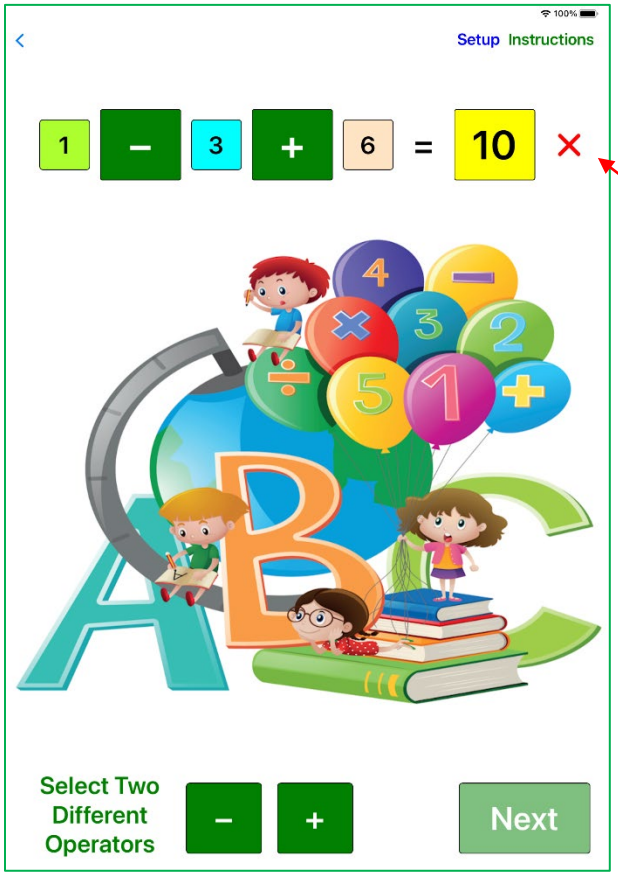
Because addition and subtraction were chosen in Step 1, only these operators are available.

As such, the buttons will toggle between + and −.



By way of example, let's put incorrect values into the Operator boxes.

To check your answer, press the yellow answer box.

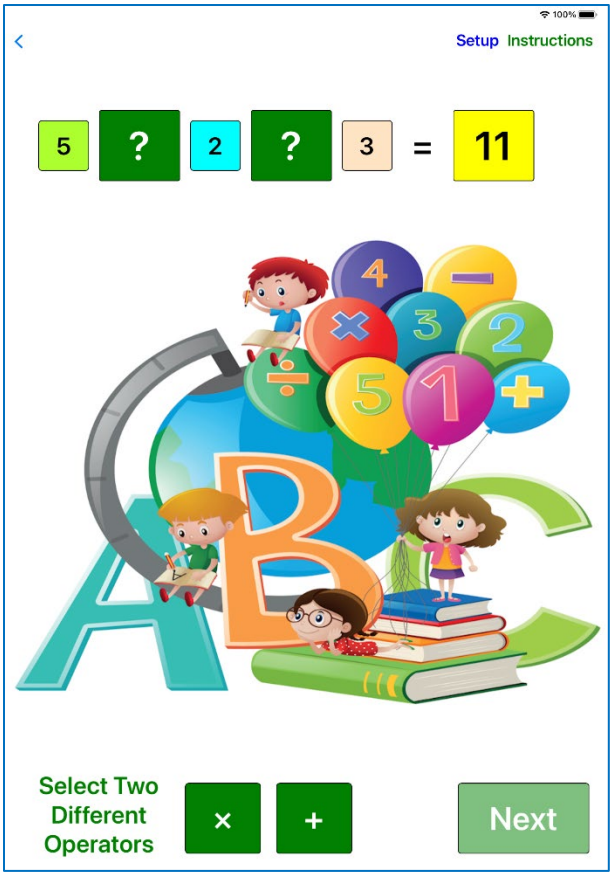


The wrong answer was flagged. Go back and fix the operator choices.

After correcting the mistake, Press the answer box. The answer is flagged as correct.

A correct answer will make the Next button active, allowing the student to proceed to the next problem

Order of Operations problems can be tricky. Remember the rules. Multiply first then add.



C. Junior High School Level (polynomials, Order of Operation).

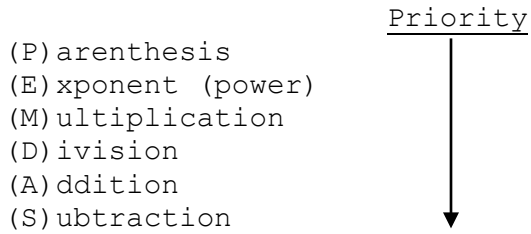
It is assumed that the student is familiar with basic polynomial equations as well as basic algebra at this education level.

Important to both concepts is an understanding of Order of Operations fundamentals.

Furthermore, the algorithm used to evaluate a compound polynomial is useful for the study of some aspects of basic computer programming (stacks and queues) taught at the Junior High School grade level.

Discussion.

PEMDAS is an acronym taught in middle/junior high schools across the nation. A related mnemonic is the phrase "**P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally". Both help students remember the operator hierarchy, or Order of Operations, when interpreting compound expressions involving multiple numbers and operators. The order of operations are:



To illustrate, take this simple polynomial expression:

1 + 2 x 3 = ?

By convention, expressions are solved from left to right. Without PEMDAS rules, one might come up with:

1 + 2 x 3 = ?

3 x 3 = 9

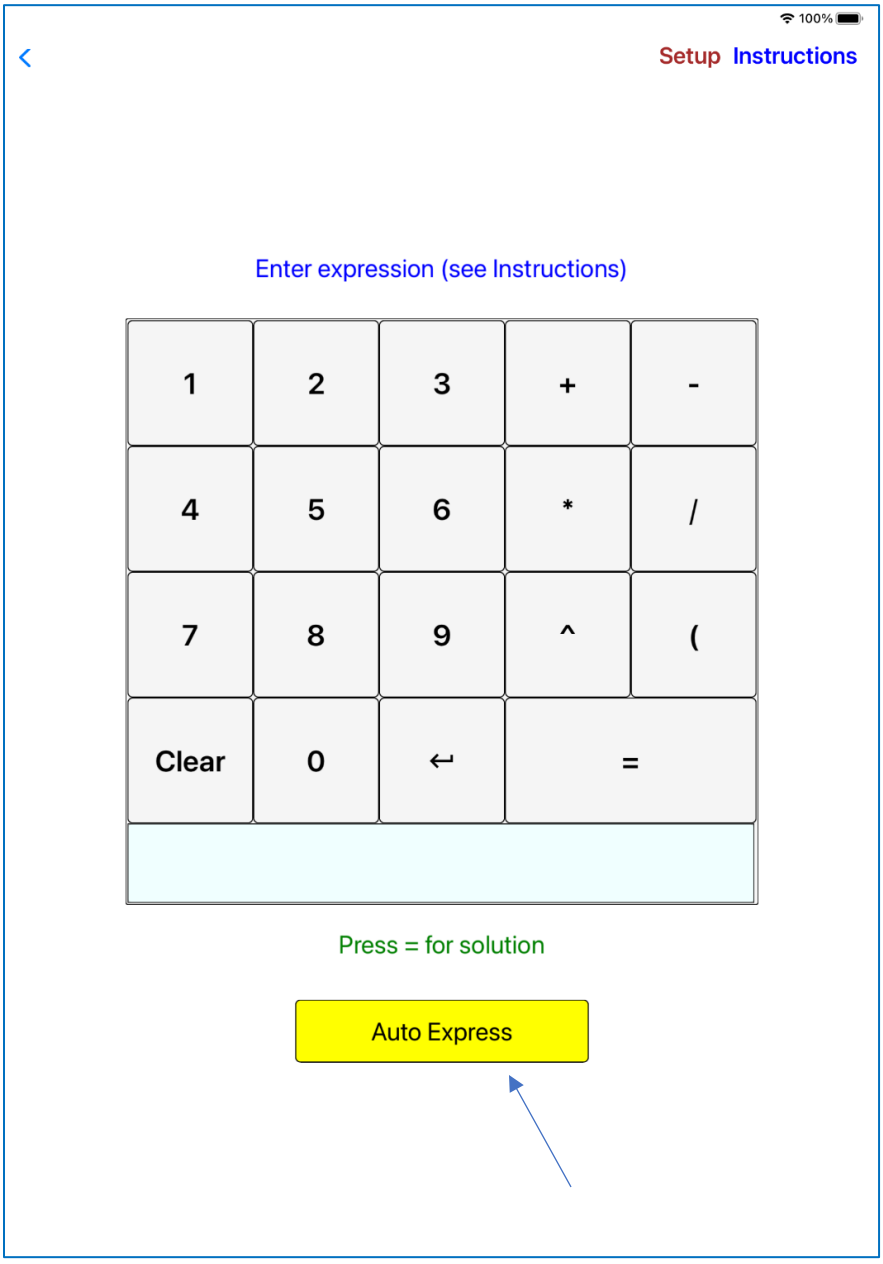
But under PEMDAS rules, multiplication is a higher priority than addition, so multiplication is done first. The correct answer is:

1 + 2 x 3 = ?

1 + **6** = 7

The opening screen features a custom calculator containing only the keys needed to manually enter a polynomial expression to be evaluated.

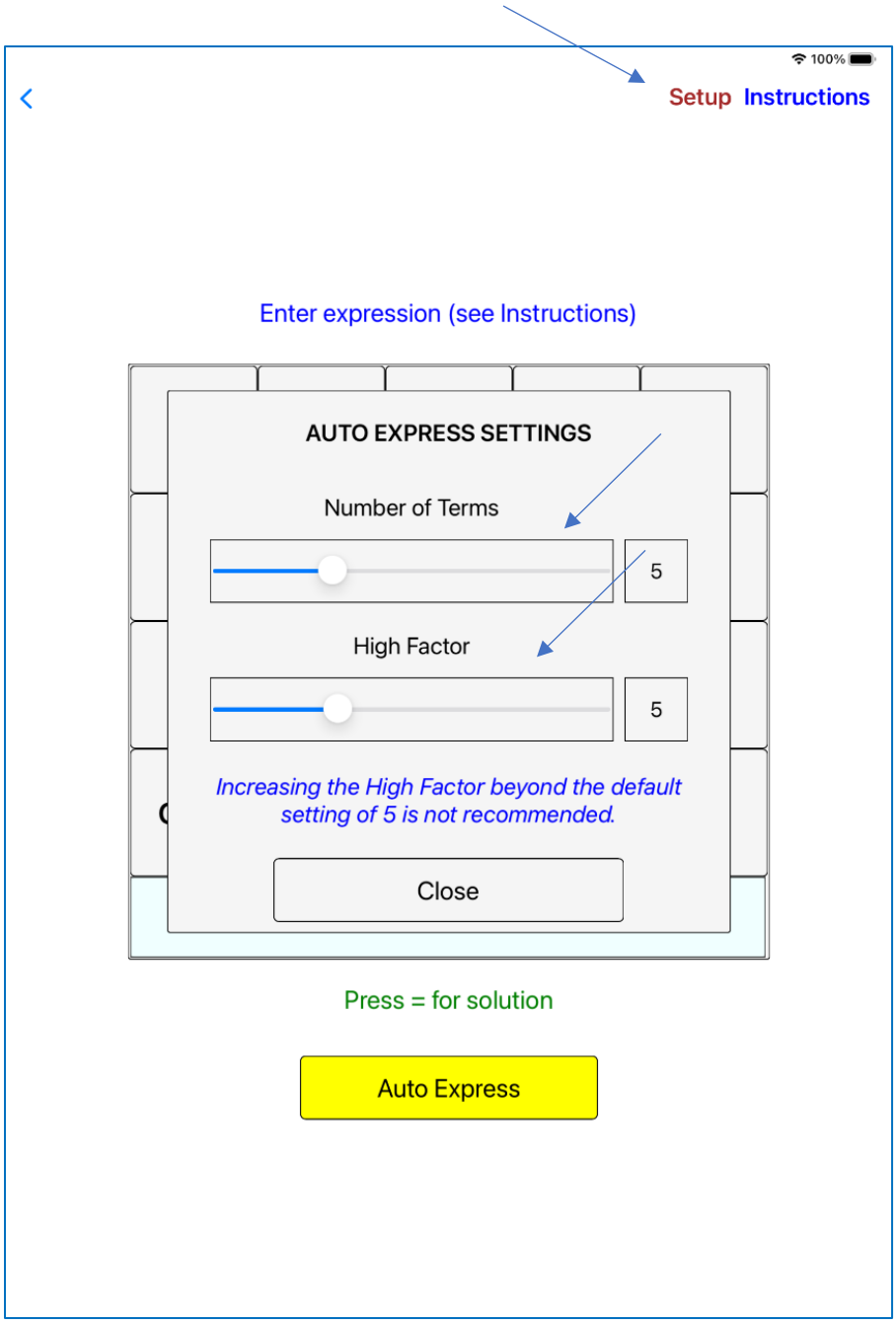
Expressions can be entered freehand-style using the keyboard, or a random polynomial expression can be auto-generated.



For freehand-style entry, type a mathematical expression use any combination of basic mathematical operators (+ - * /) as well as exponent (^) and one level of parenthesis. *The freehand practice mode is useful for entering homework problems* and observing how the PEMDAS rules apply. There is a maximum limit of ten variables, but no limit to their magnitude in the practice mode.

For an auto-generated entry, press the [Auto Express] button to generate a random polynomial expression.

The Auto Express option has a separate Setup page which can be accessed via the Main Menu



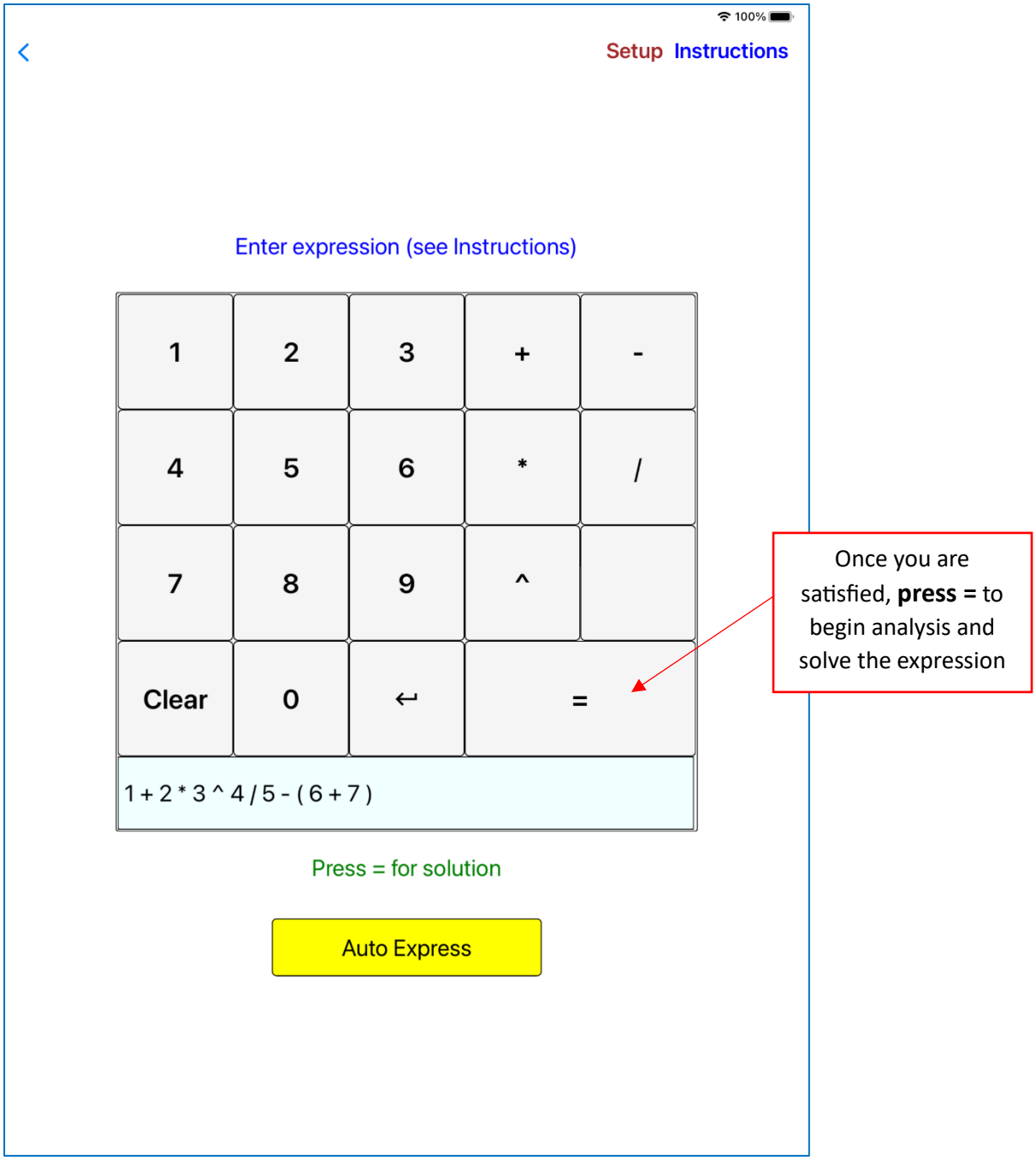
The sliders are used to set the number of terms in the polynomial and the highest factor in the expression.

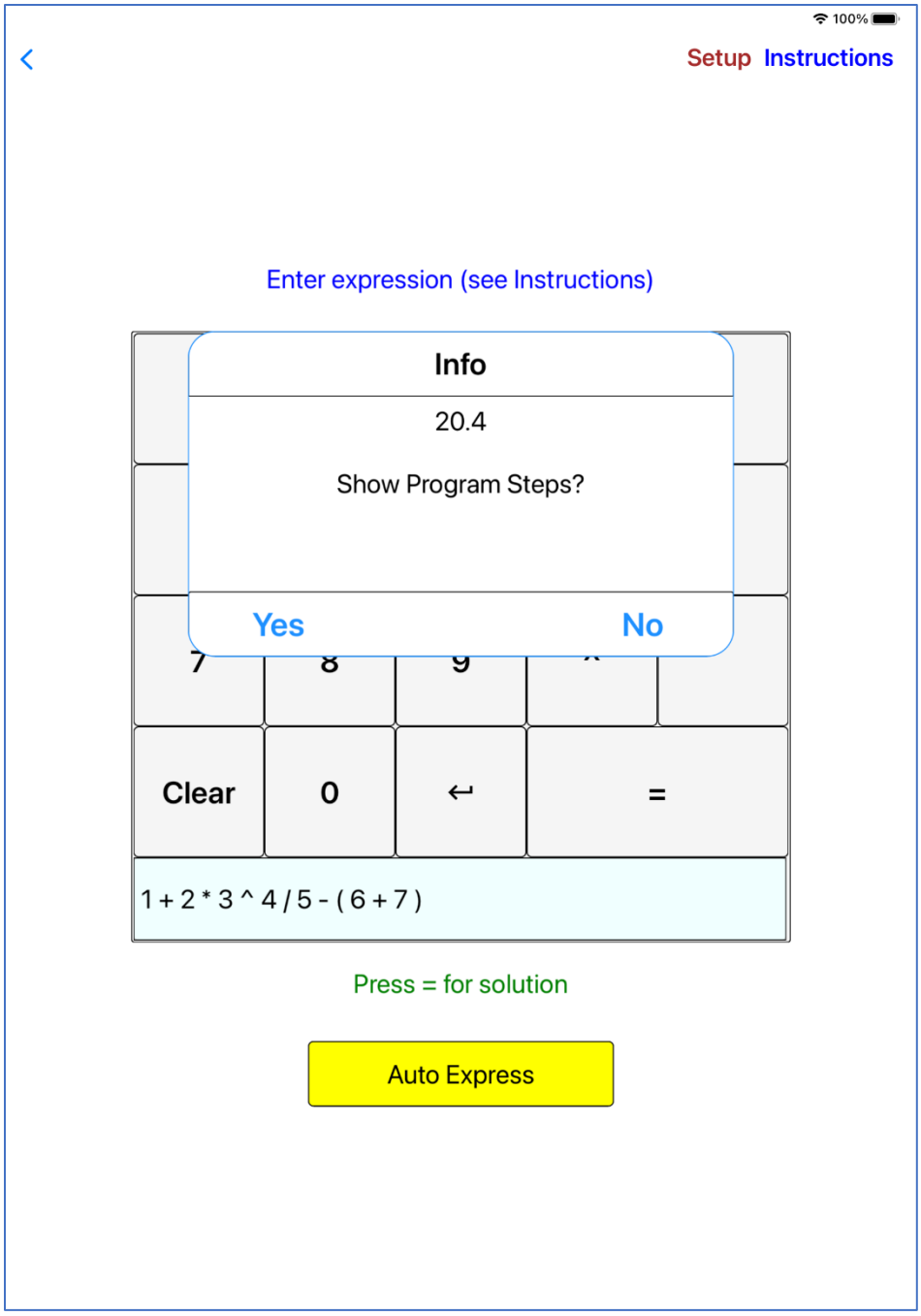
The expression generated will have randomly selected factors and operator.

Because of the possibility of an exponent (power) operator being randomly selected, it is not advisable to increase the High Factor beyond 5.

Freehand Example:

Using the keyboard, enter a string of numbers and operators. In this example, all the available operators and one level of parenthesis are entered.





The solution to the expression is displayed in an information box along with an invitation to see a step-by-step analysis of the solution, utilizing the SHUNT YARD algorithm.

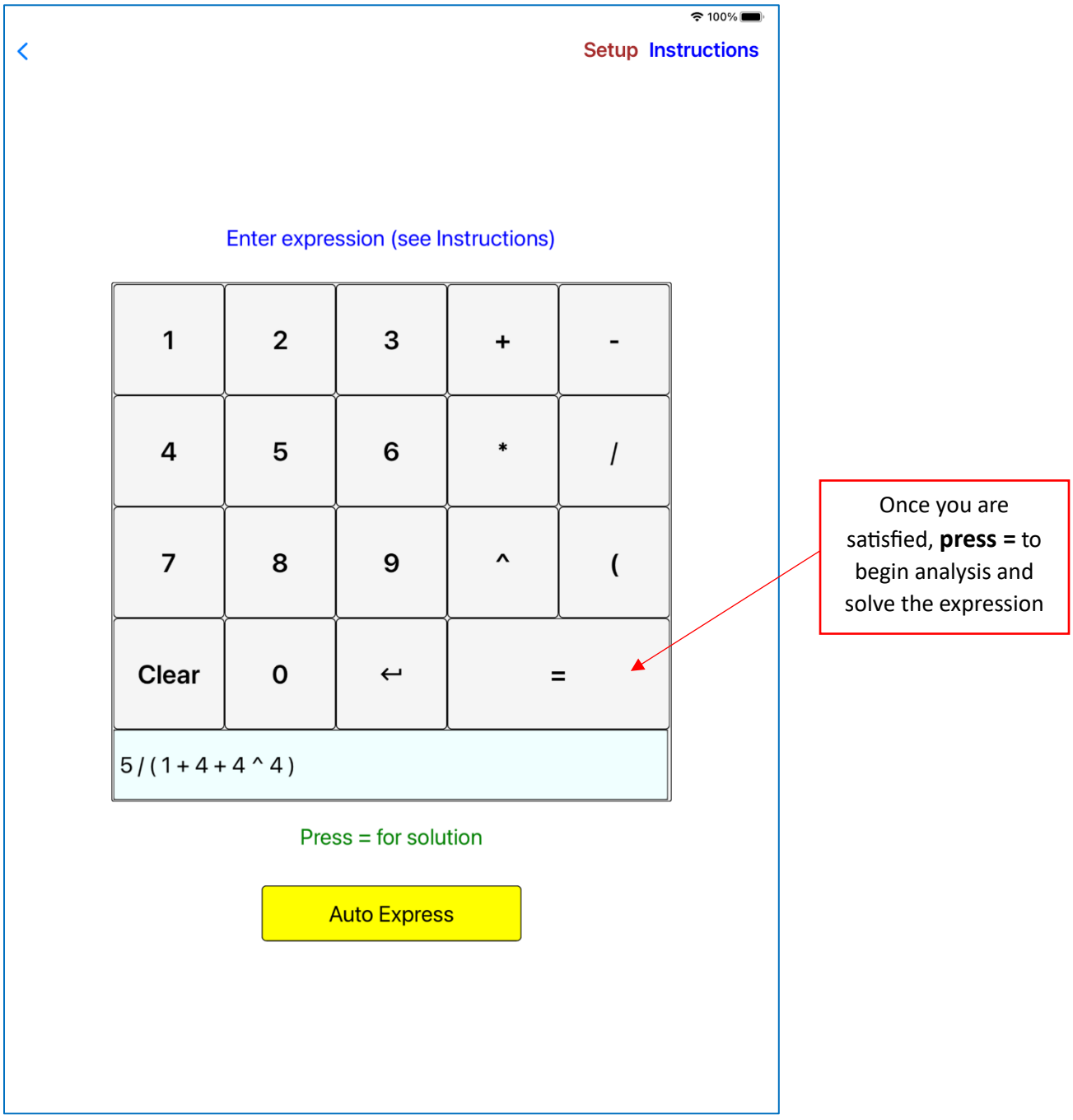
(A discussion of this algorithm is available at appendix S.)

This series of screenshots depict stepping though the Shunt Yard algorithm. Intermediate results are shown with each step and the queue and stack activity merit special attention.

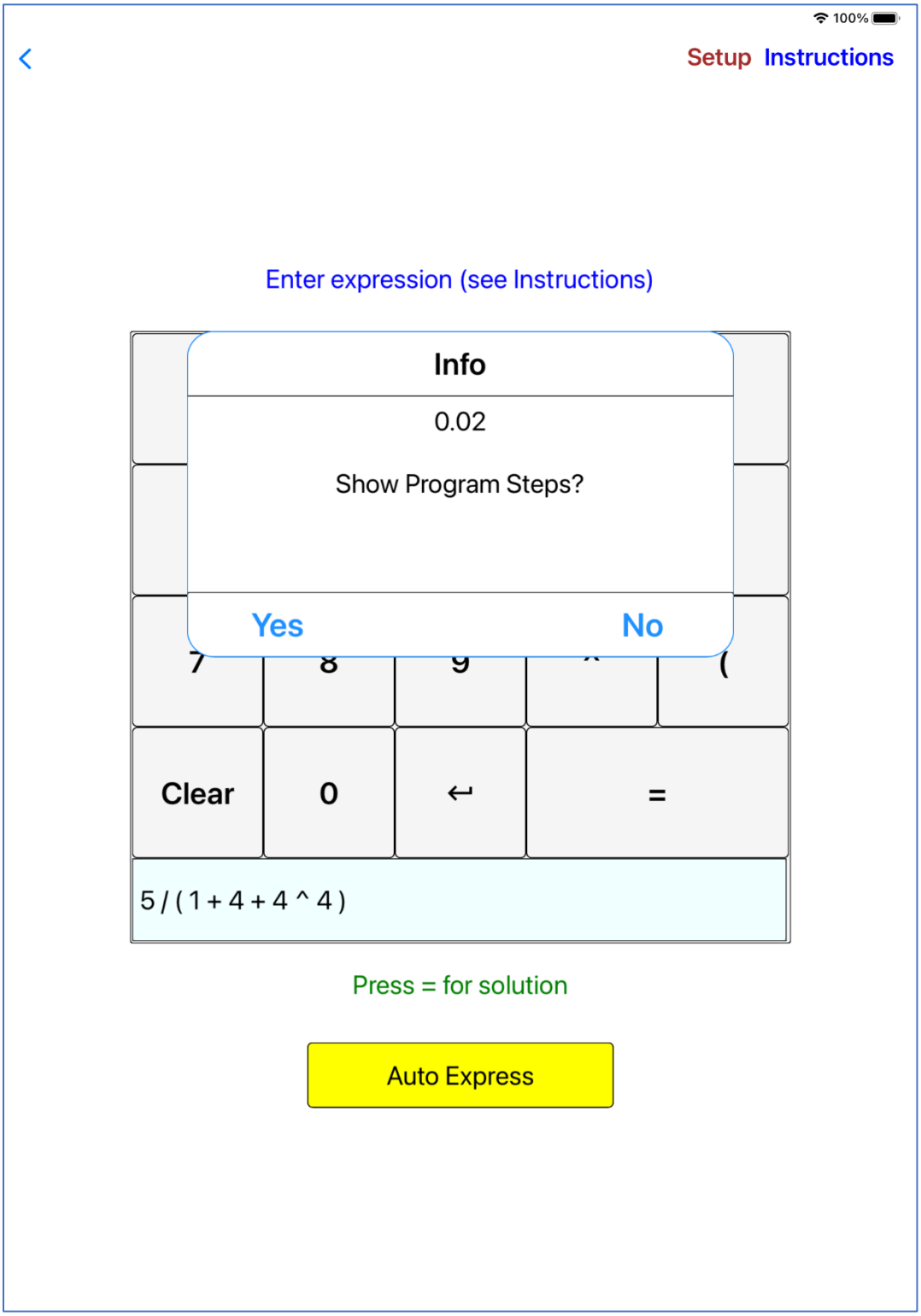
Pressing the highlighted buttons advance the algorithm to the next step.

Auto Express Example:

Press the **Auto Express** button. Repeated presses will generate new random expressions.



As with the freehand example, the student is given the option of examining the answer by stepping through the algorithm.

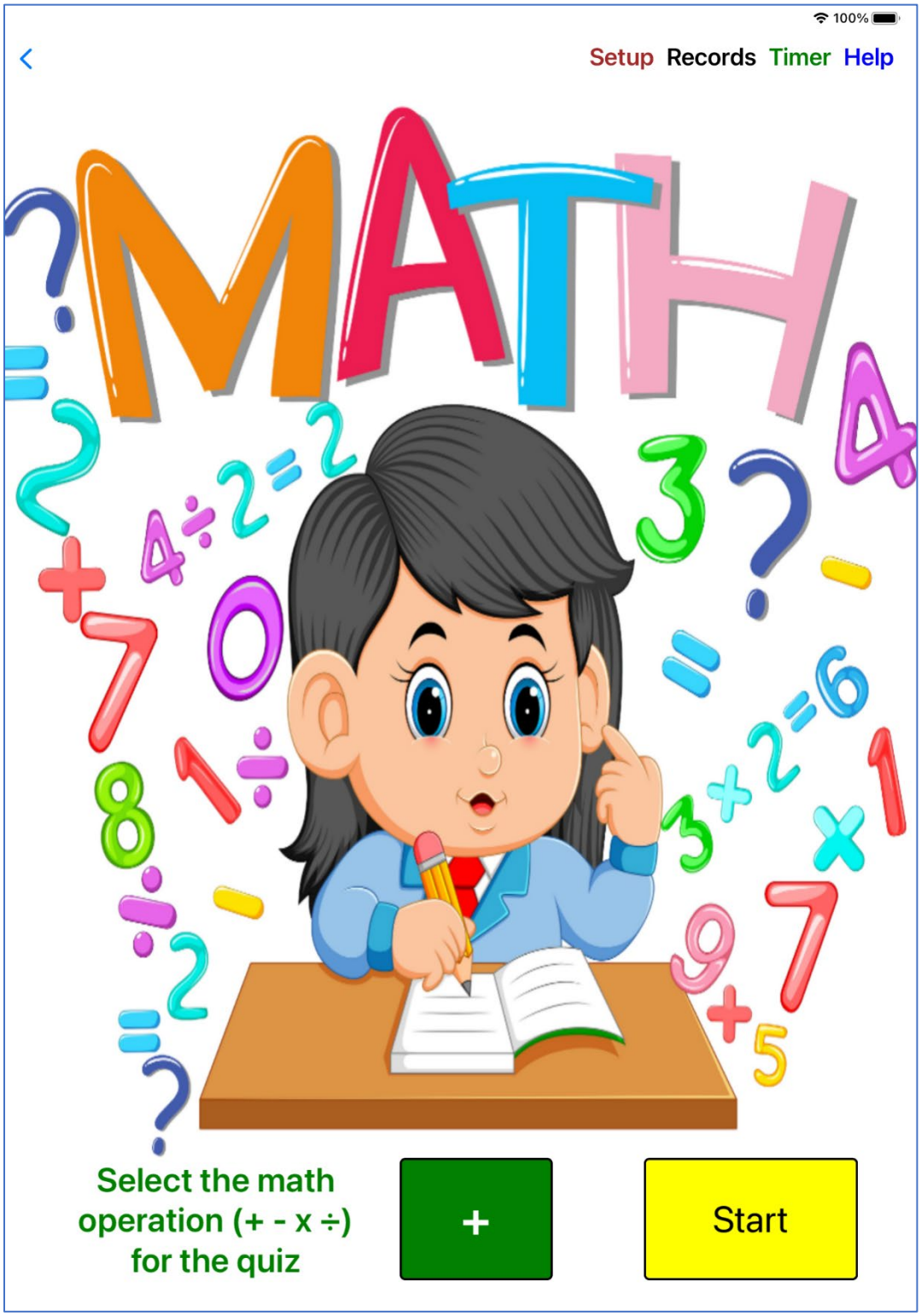


In the event that the solution has a fractional component, the program rounds to two decimal places.

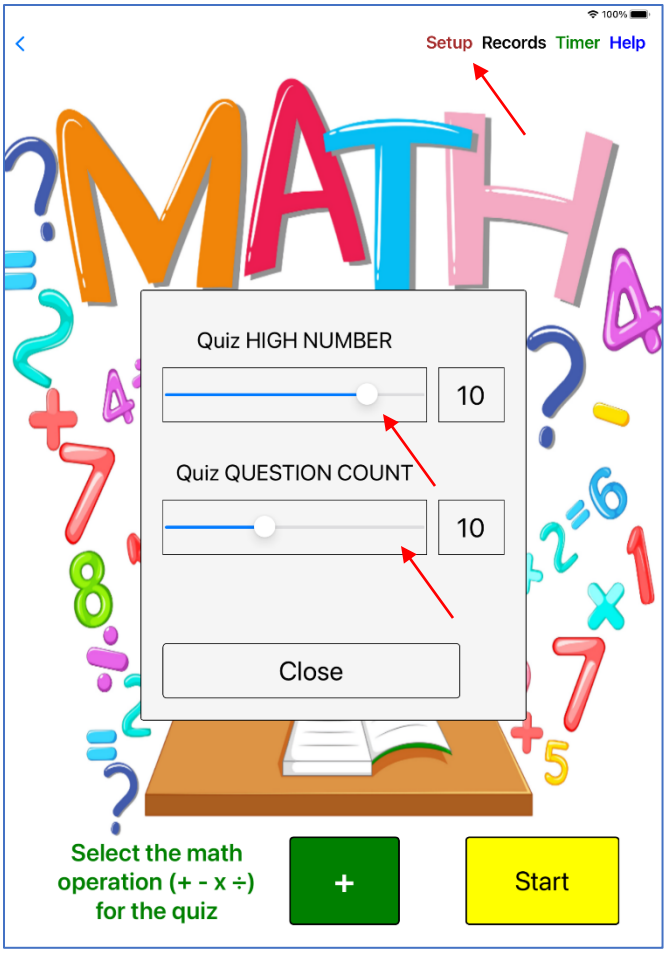
III. QUIZ MODE

A. Elementary School Level (two term mental math)

The opening screen:



Before starting a quiz, use the Setup and Timer menu options at the top of the screen to set up parameters for the quizzes.

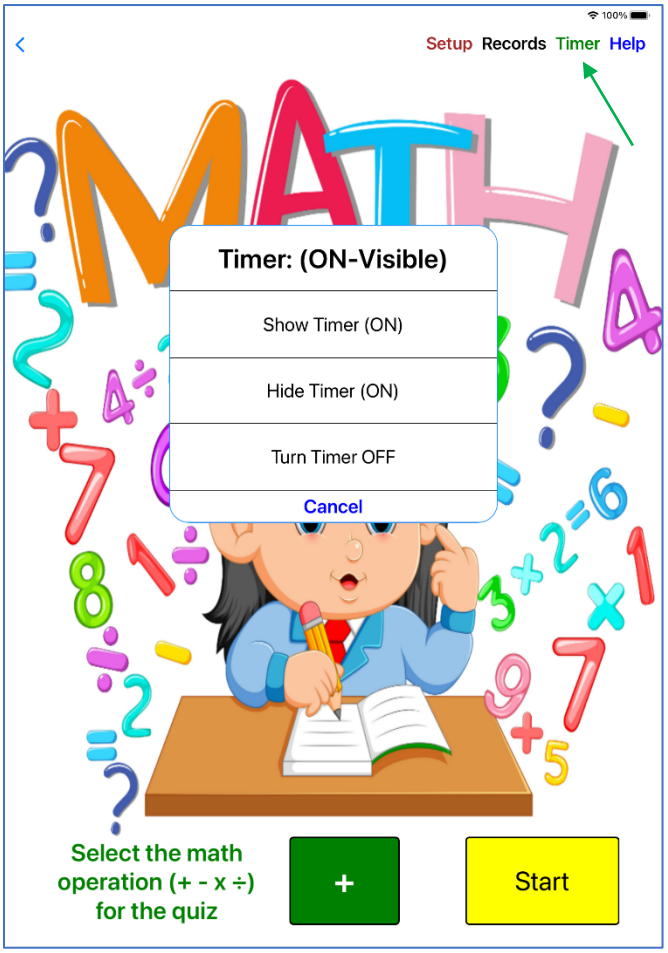


Use the **Setup** option to set the high number and question count parameters for your quizzes, using the sliders as shown.

Records are tied to these parameters. Changing them later on will clear the Records for the level.

This prevents record contamination.

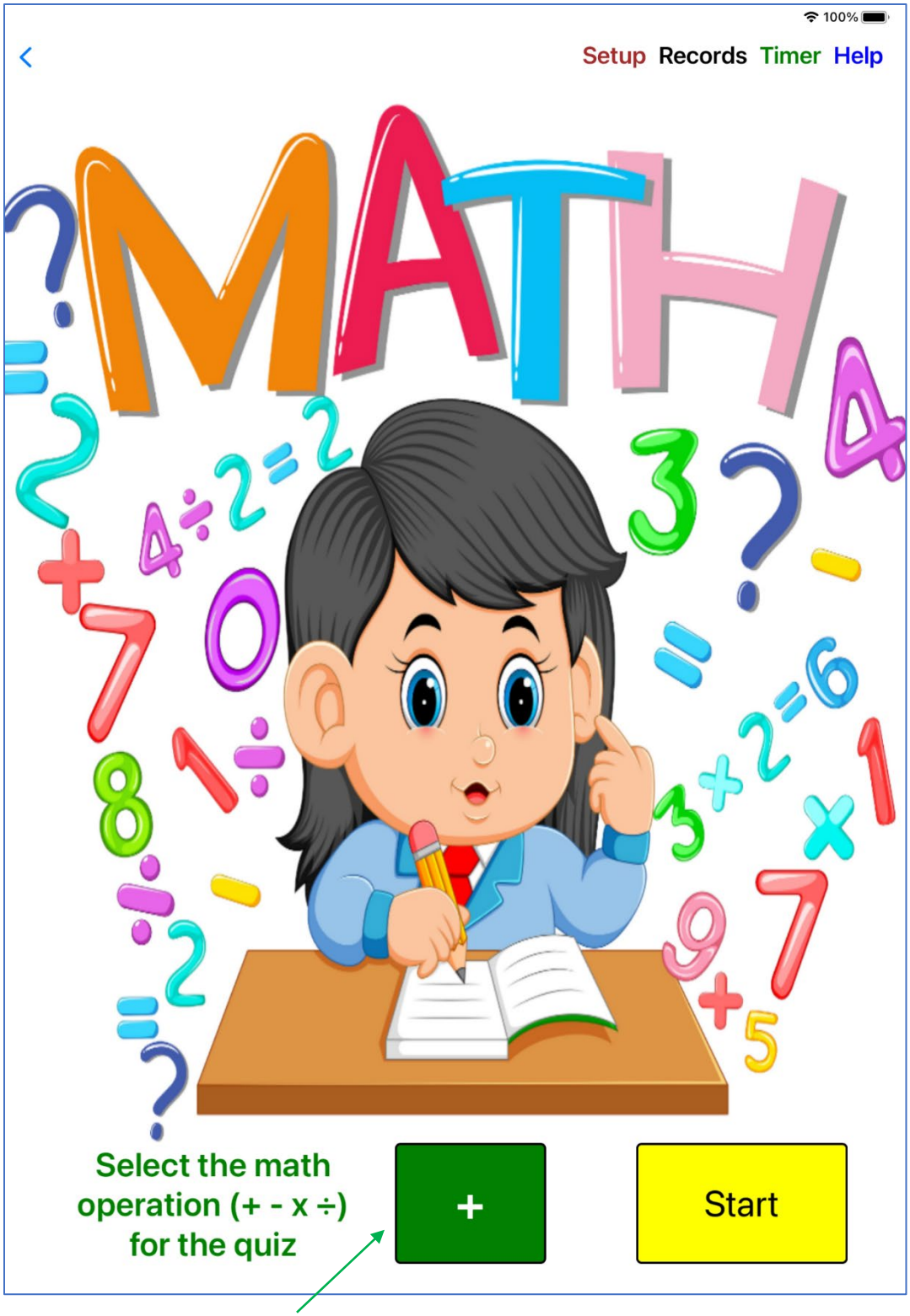
For instance, if records were previously based on a 10-question quiz, changing to a 5-question quiz will result in a different scoring basis, so previous records are automatically cleared.



Use the **Timer** option to set the state of the timer. The timer can be Shown, Hidden (if it proves distracting) or turned Off all together.

If in the OFF state, no records are saved.

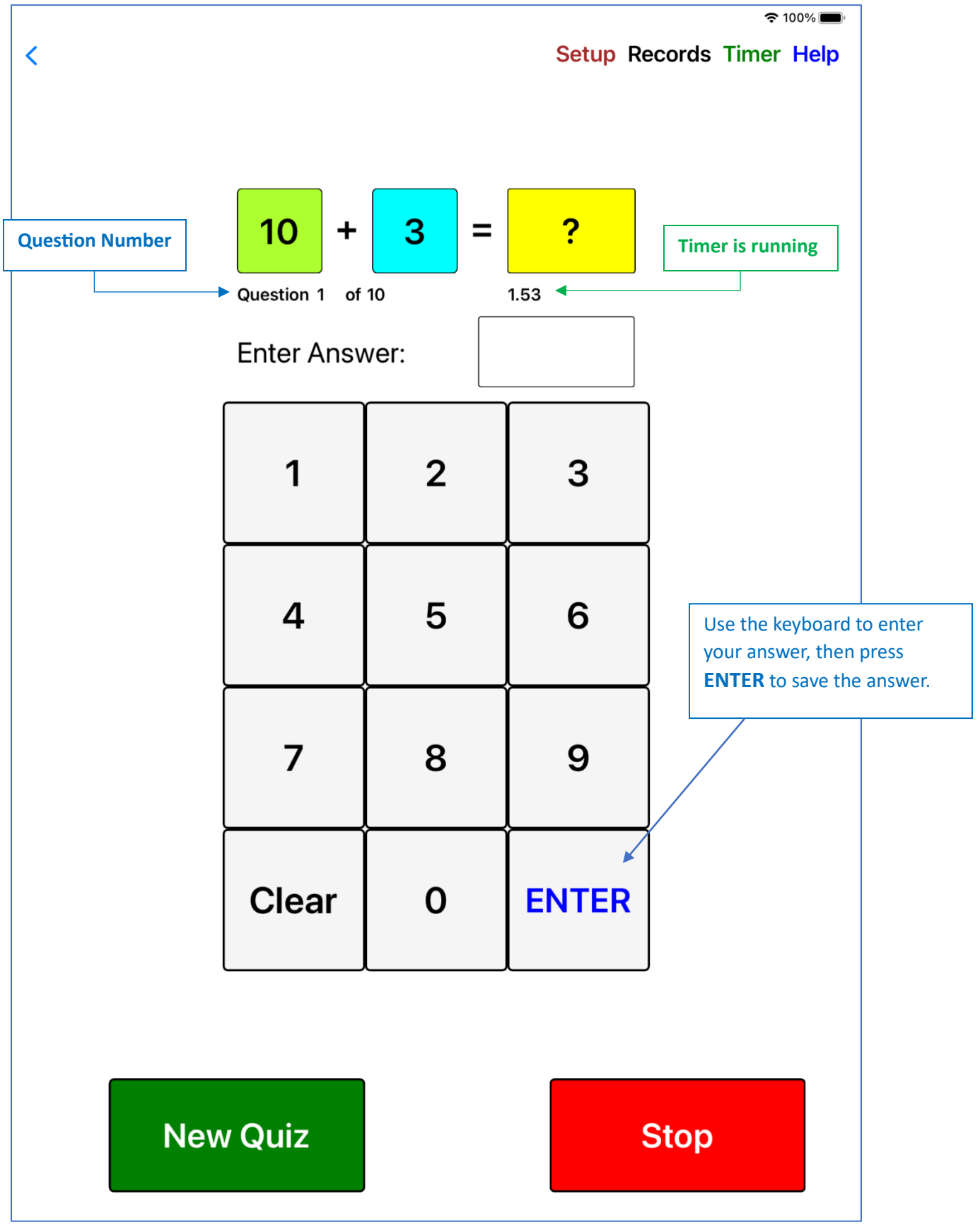
Taking a quiz.



Step 1. Select the desired math operation by pressing the "Operator" button. Each press of the button cycles through the four basic math operations (+, -, x, ÷).

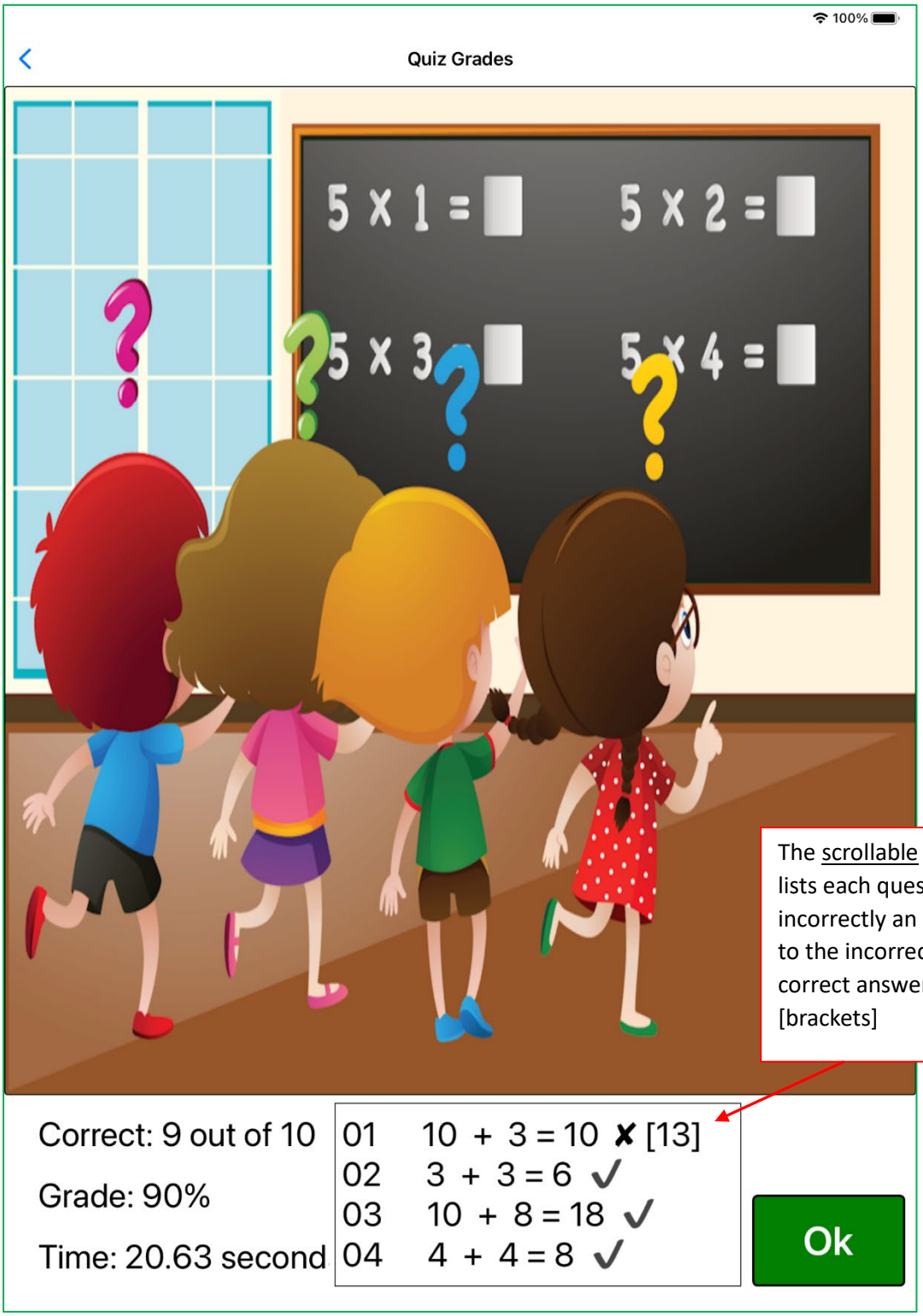
Step 2. Press Start.

The quiz starts with Question 1

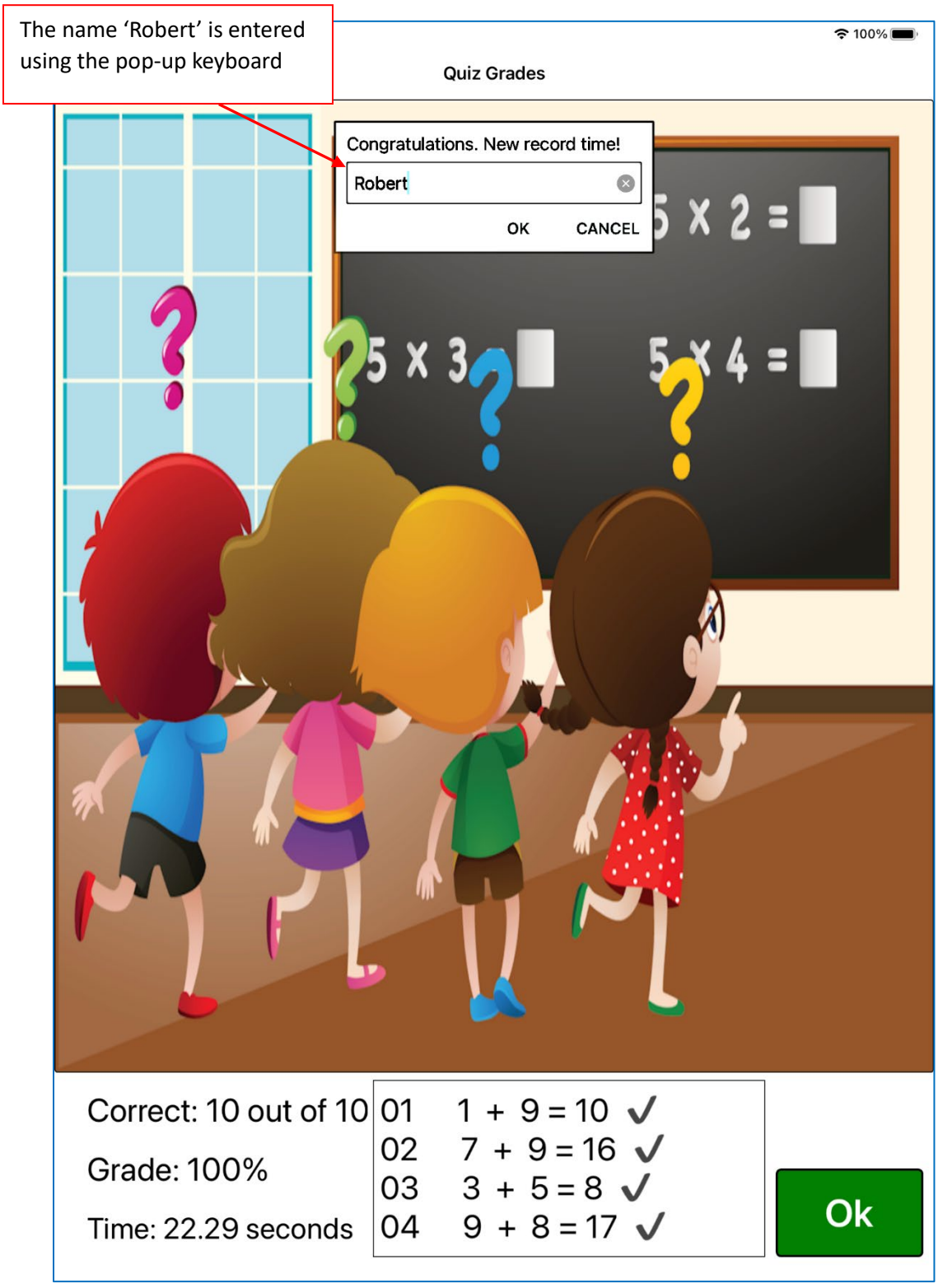


After an answer is saved, the next question is shown. When the last question is answered, the Timer is stopped (if enabled) and the SCORING PAGE is displayed.

In this 10-question test example, question #1 was purposely answered incorrectly. The incorrect answer is flagged and the final grade and time are posted. Note that the RESULTS Window is scrollable. All 10 questions are reviewable.

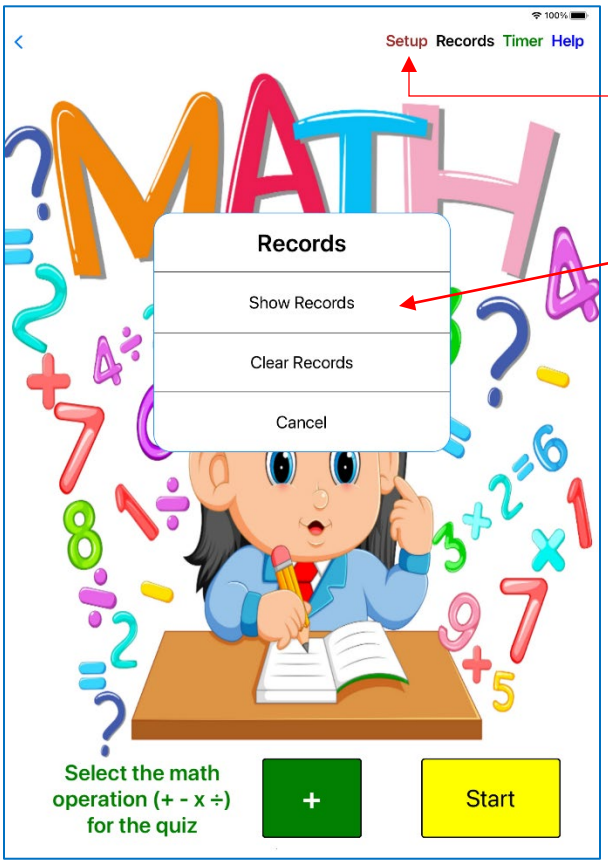


Let's say that a new 10-question test is taken. All question were answered correctly and the results are shown below. Because the Timer was turned ON, a comparison was made to the previous record low time for this operation (addition). The comparison verified that this test time was lower. As a result, a name is requested to enter into the record books.



Note: If the Timer is OFF, no comparison is possible, therefore any existing time records are unaffected.

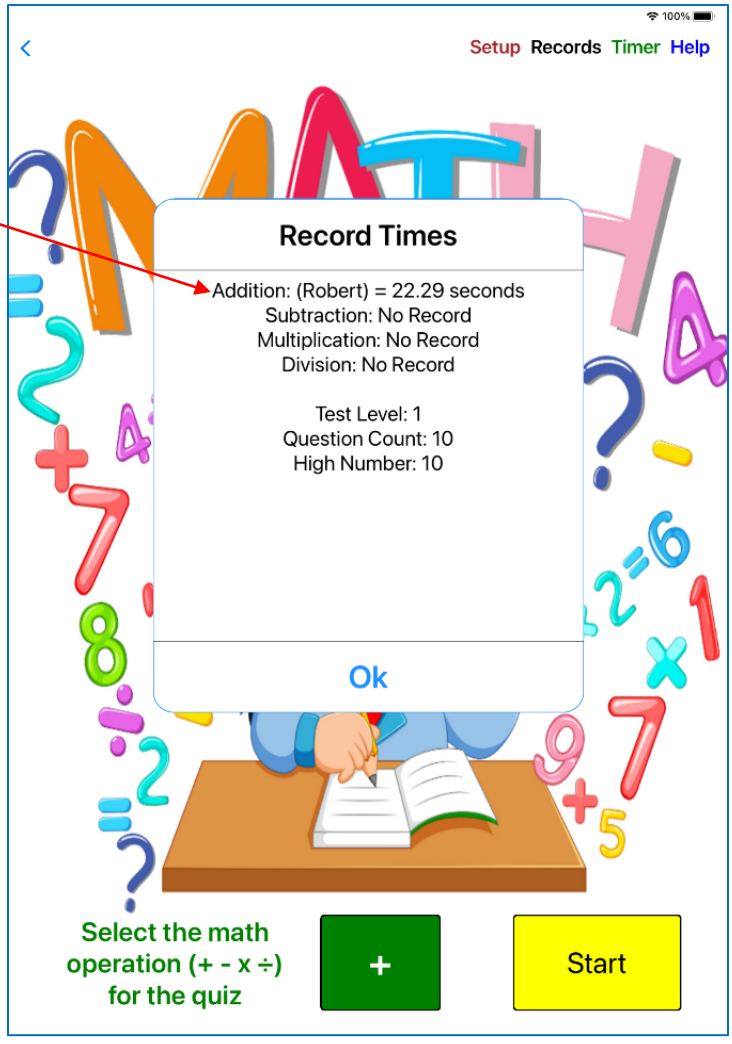
Return to the Elementary Quiz home screen.



Select the Records menu item

Select Show Records

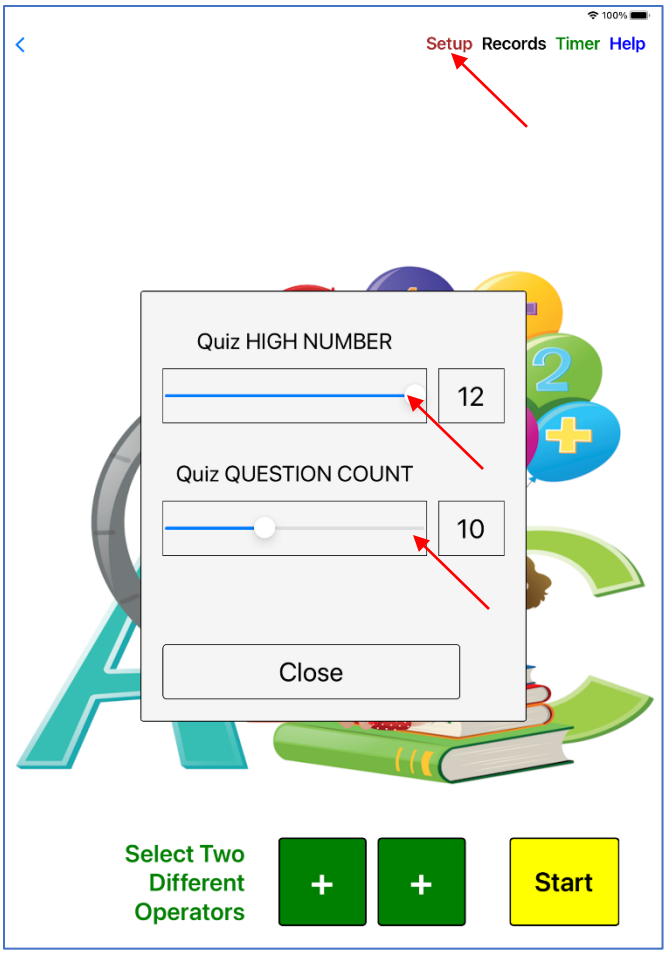
Robert's name has been recorded as the record holder for the addition operation. Quiz parameters are included



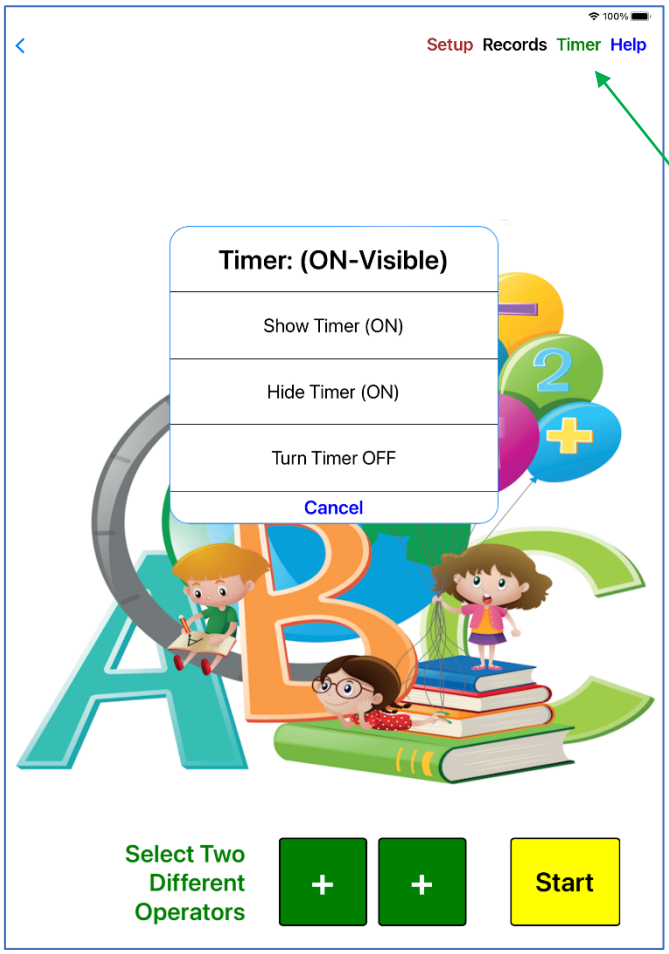
B. Middle School Level (three term mental math).

The opening screen:

Before starting a quiz, use the Options menu at the top of the screen to set up parameters governing the quiz.



As with the Elementary Level Quiz mode, use the **Setup** option to set the High Number and Question Count for your Middle School quizzes, using the sliders as shown.



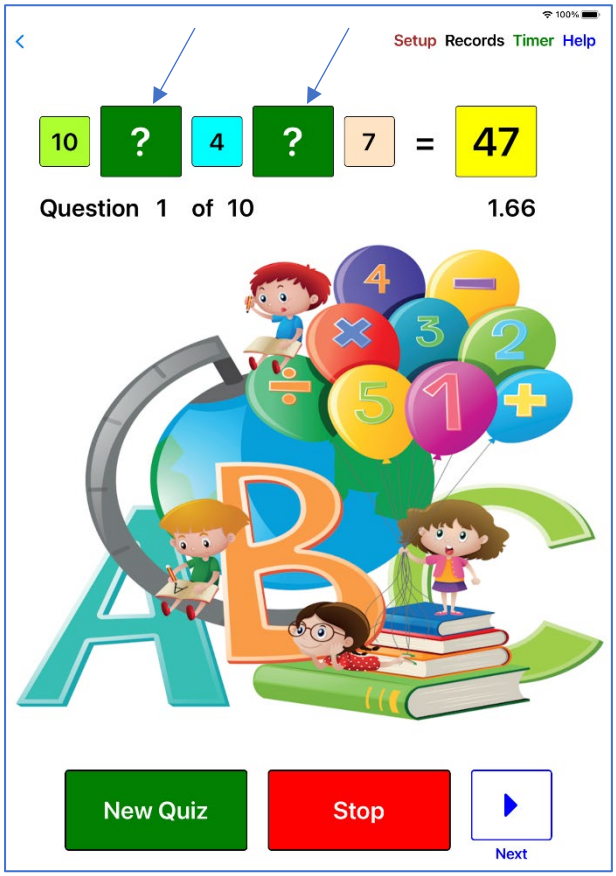
Use the **Timer** option to set the state of the timer.

Step 1. Select two non-matching math operators for the quiz using the Operator buttons at the bottom of the screen. Each press of the buttons cycle through the four basic math operations (+, -, x, ÷).

For this quiz, addition and multiplication operators were chosen.

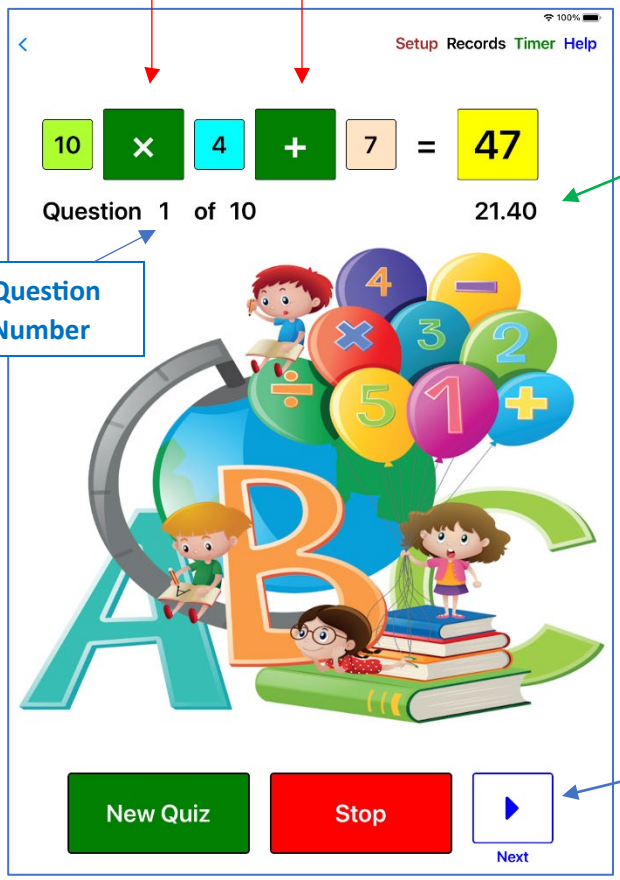
Step 2. Press Start.

The quiz begins with Question 1



Press the operator button(s) until the equation expresses a true statement

Operators chosen



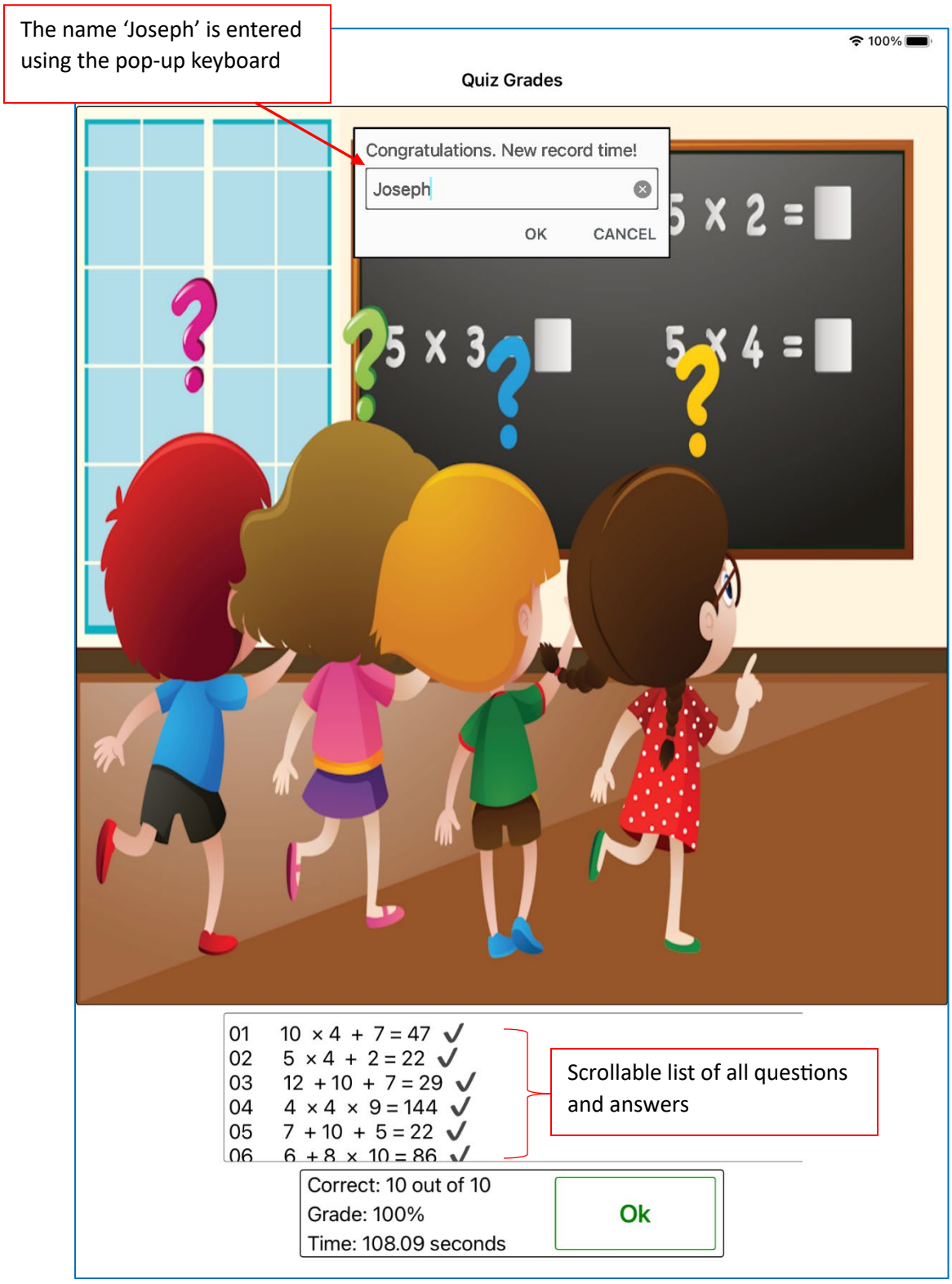
Timer running

Question Number

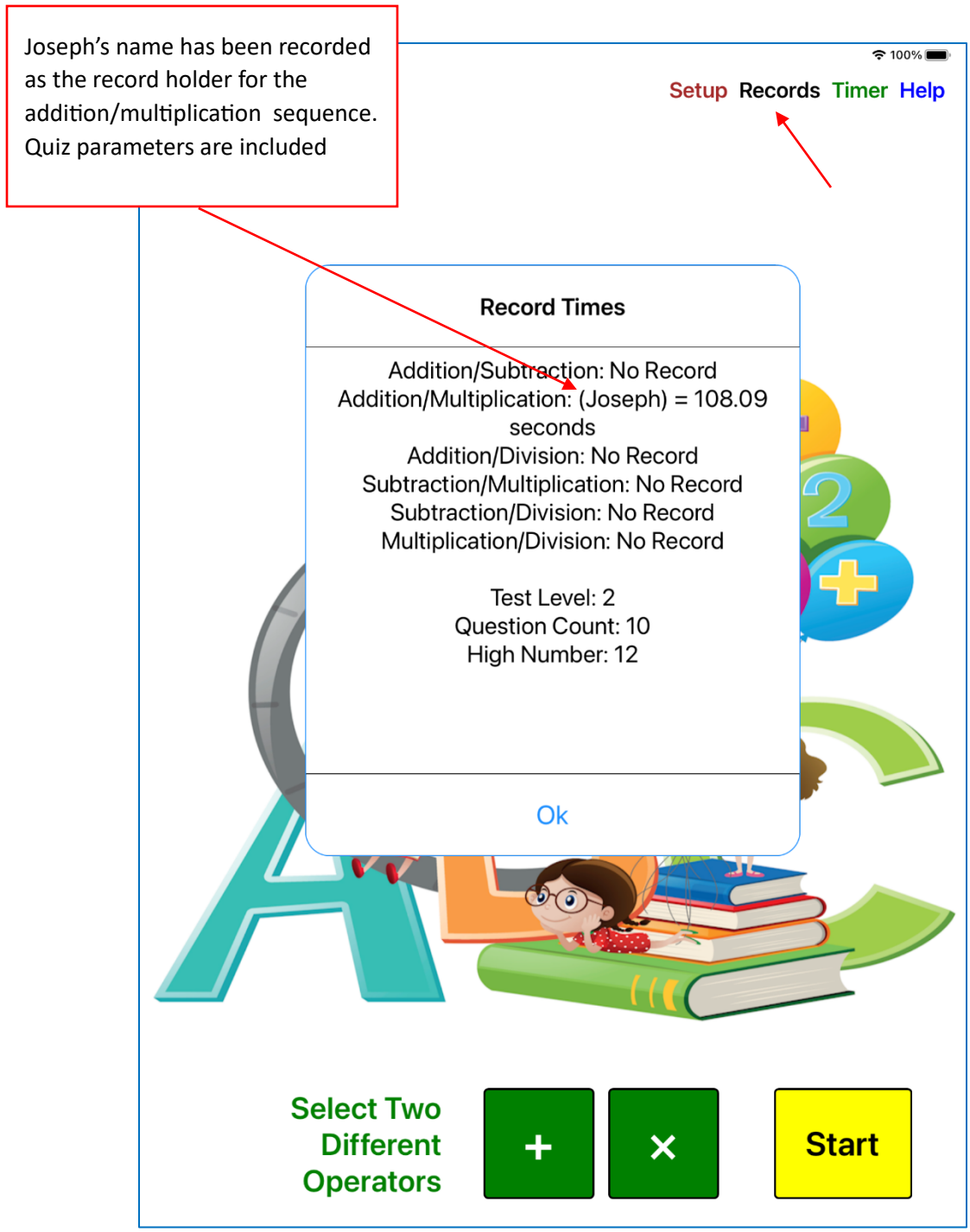
Press **NEXT button** to save the answer and advance to the next question.

After an answer is saved, the next question is shown. When the last question has been answered, the Timer is stopped (if enabled) and the SCORING PAGE is presented.

All answers in this example were correct and the results are shown below. A comparison was made to the previous record low time for this operator pair (addition/multiplication). The comparison showed this test time was lower. The student is asked for a name to enter into the record books.

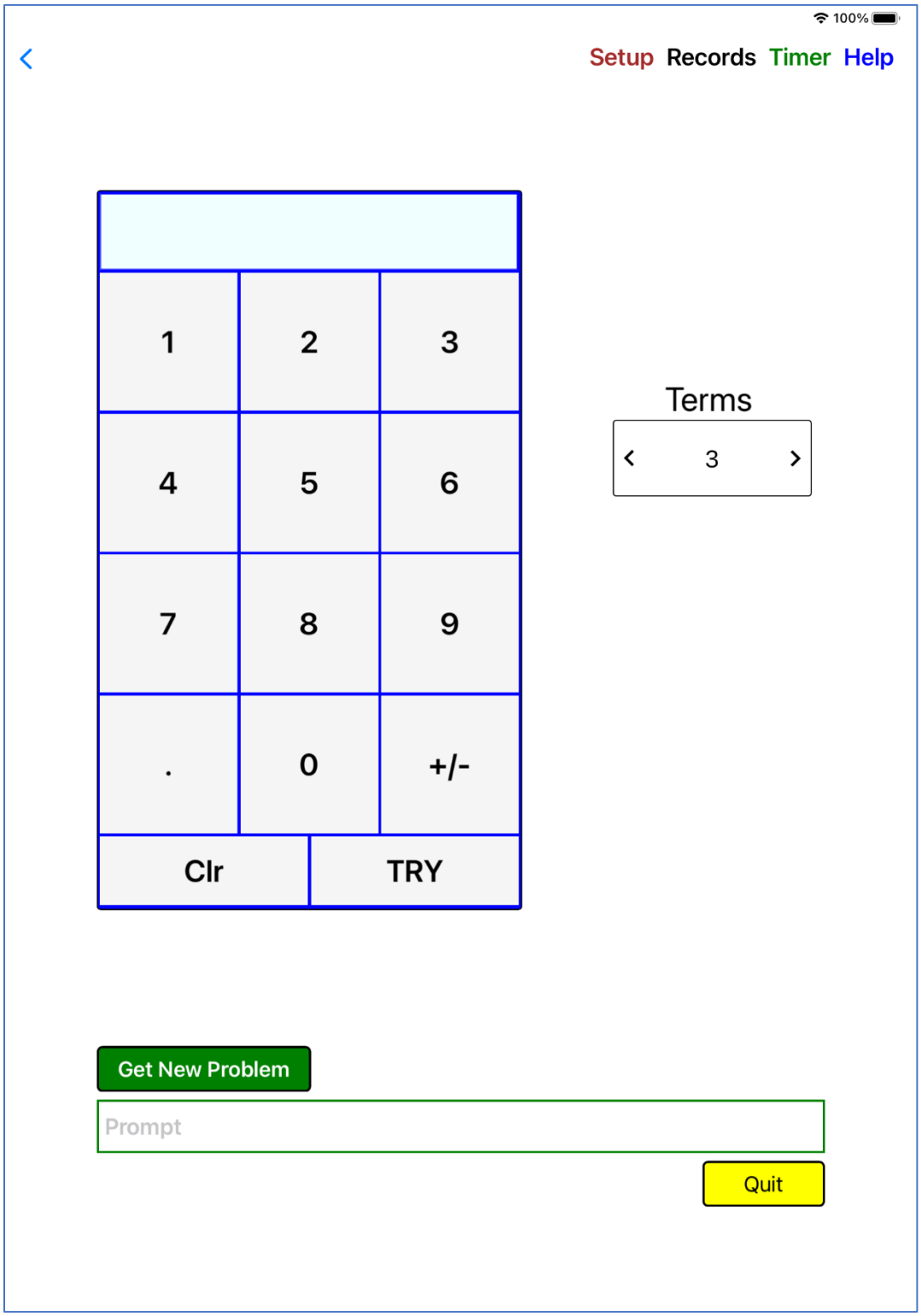


Return to the Middle School Quiz home screen and select Records menu item, the select Show Records

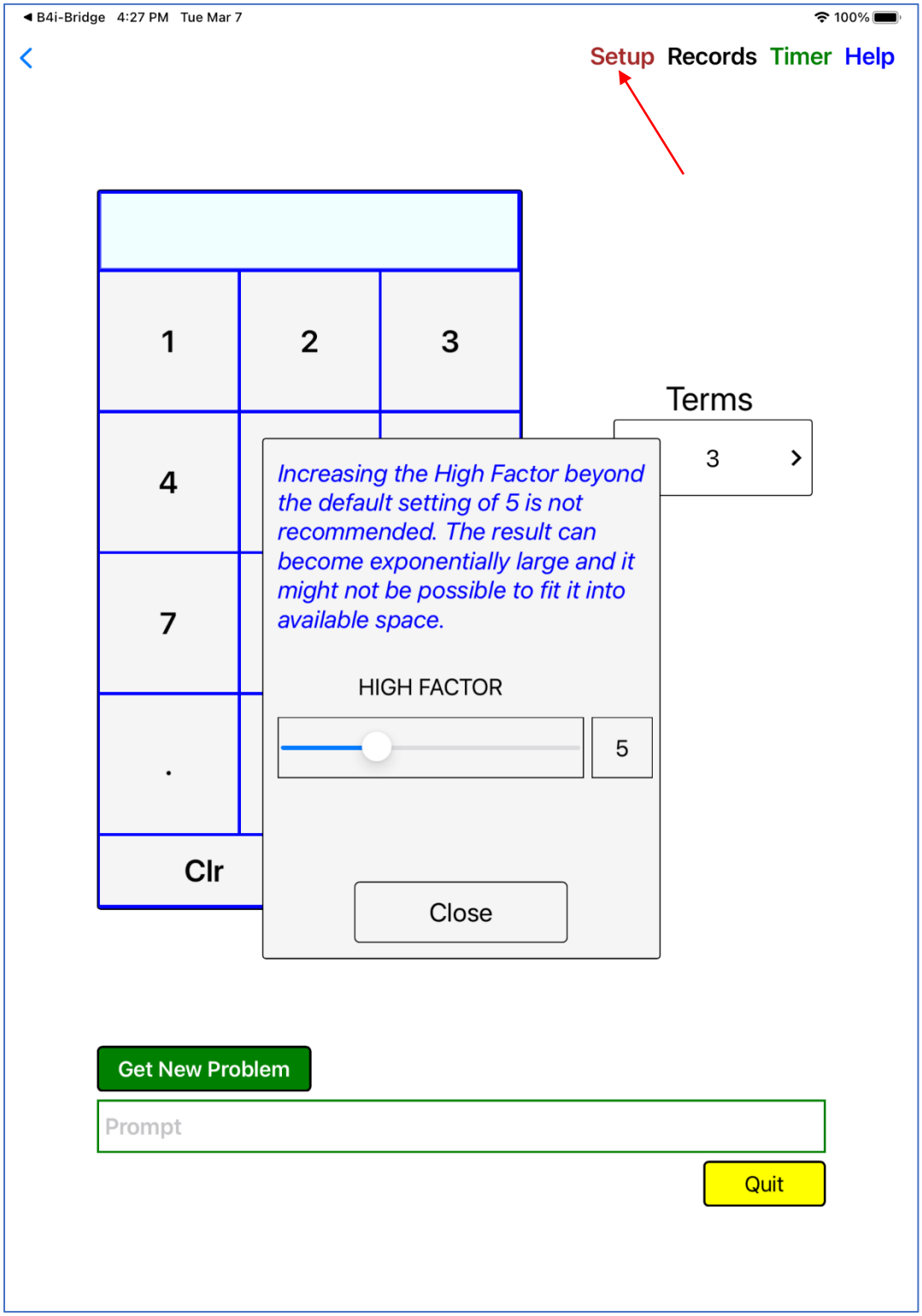


C. Junior High School Level (polynomial expressions, order of operation).

The opening screen:

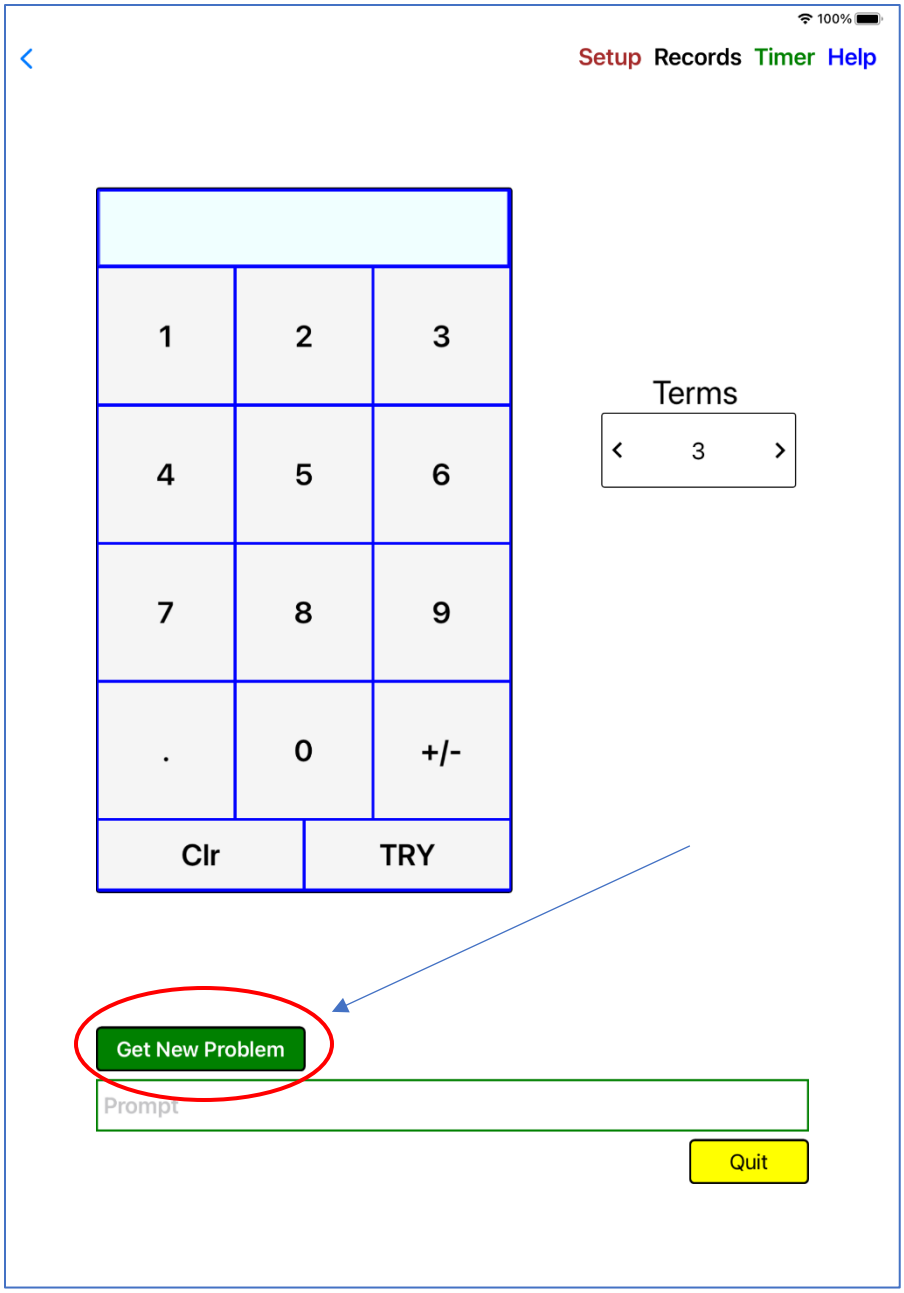


Before starting a quiz, use the Options menu at the top of the screen to set up the one parameter governing the quiz, the High Factor.



It is advisable to leave the High Factor set at 5 or less. After all, the point of the quiz is to test Order of Operations knowledge, and not to just generate extremely complicated math problems, the answers of which might not fit into available screen space.

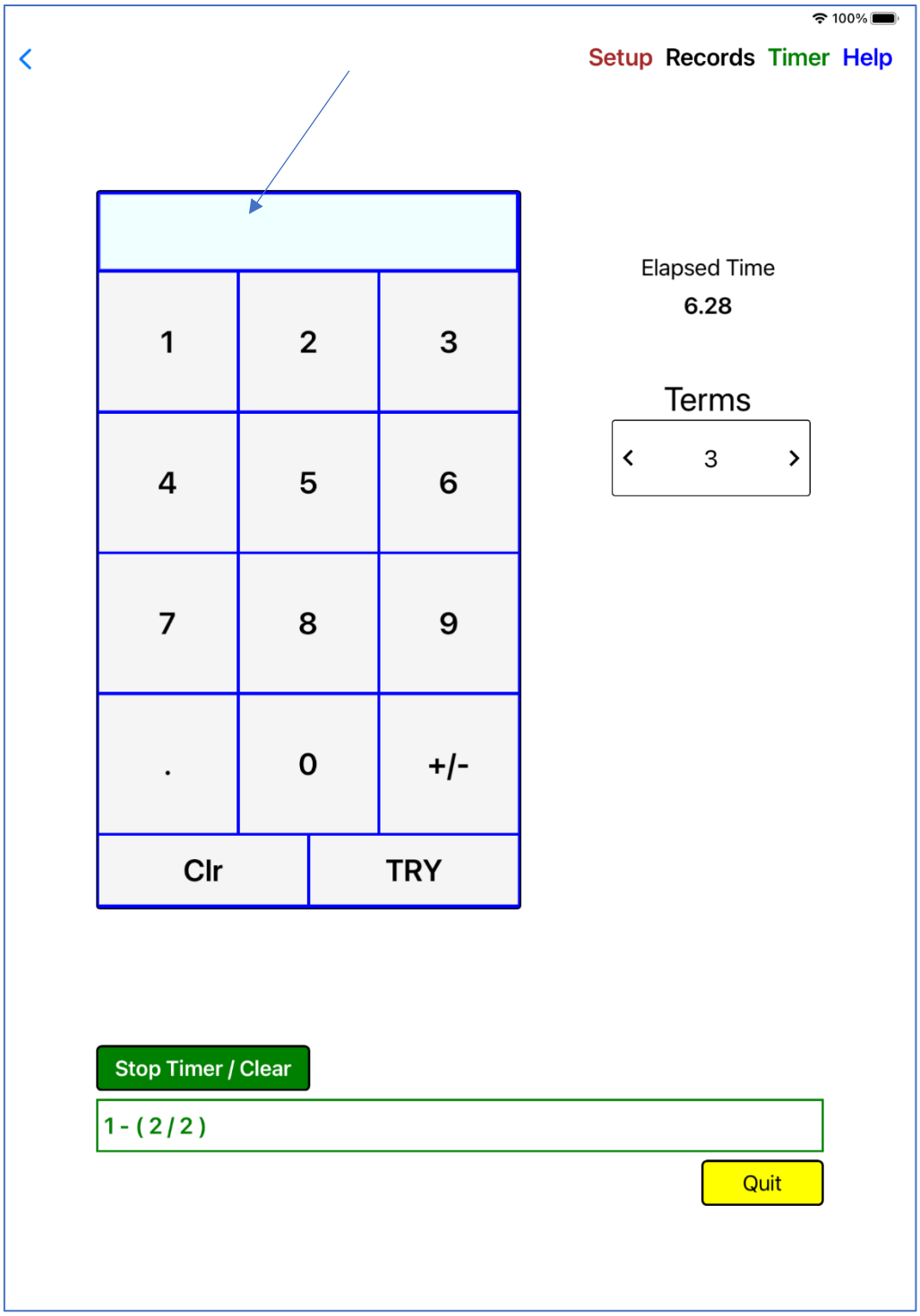
When ready to start the quiz, press Get New Problem button.



A polynomial expression will be auto-generated containing the number of terms selected using the left/right TERMS selector.

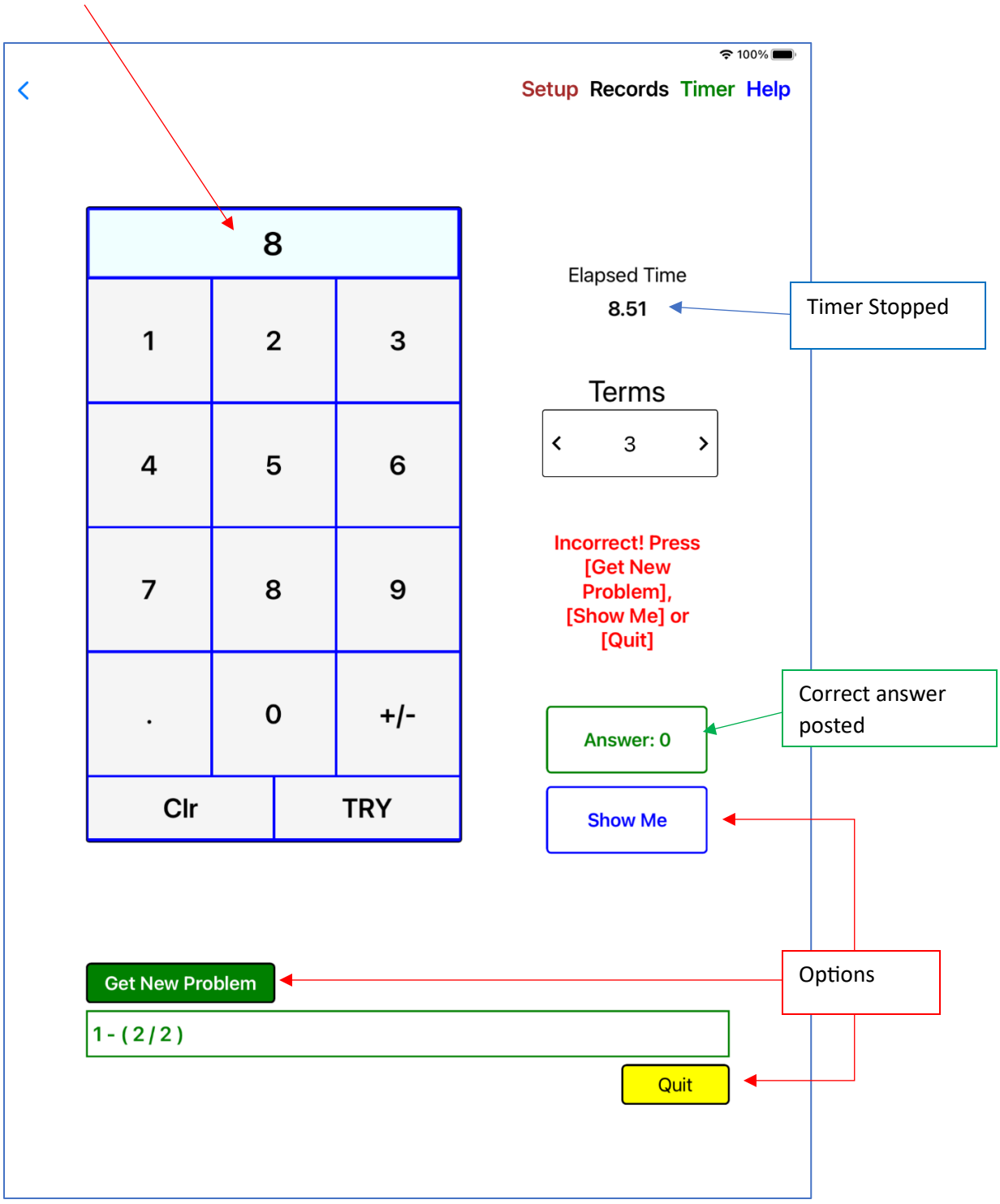
The maximum value for any term is determined by the High Factor setting.

If the Timer status is ON, then pressing the Get New Problem also starts the timer, which will be used to determine if the time needed to find the solution is lower than the time on record for quizzes with the same number of terms.



Step 2. Use the keyboard to enter the value of the expression.

Here, a wrong answer was entered and the TRY button pressed.

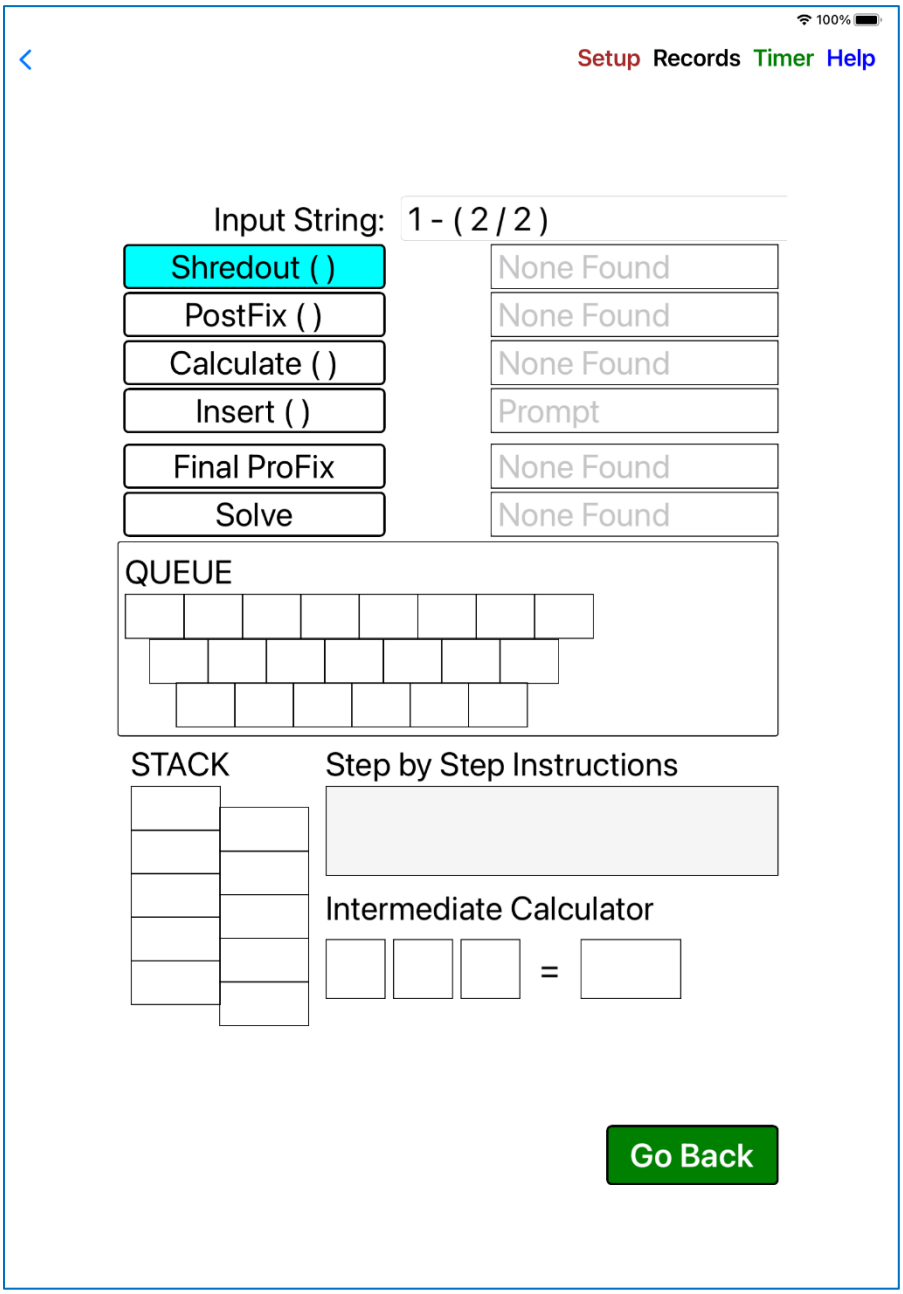


As a result, the timer is stopped, the correct answer is posted and the student has 3 options:

- Get a New Problem
- Show Me
- Quit

The SHOW ME option.

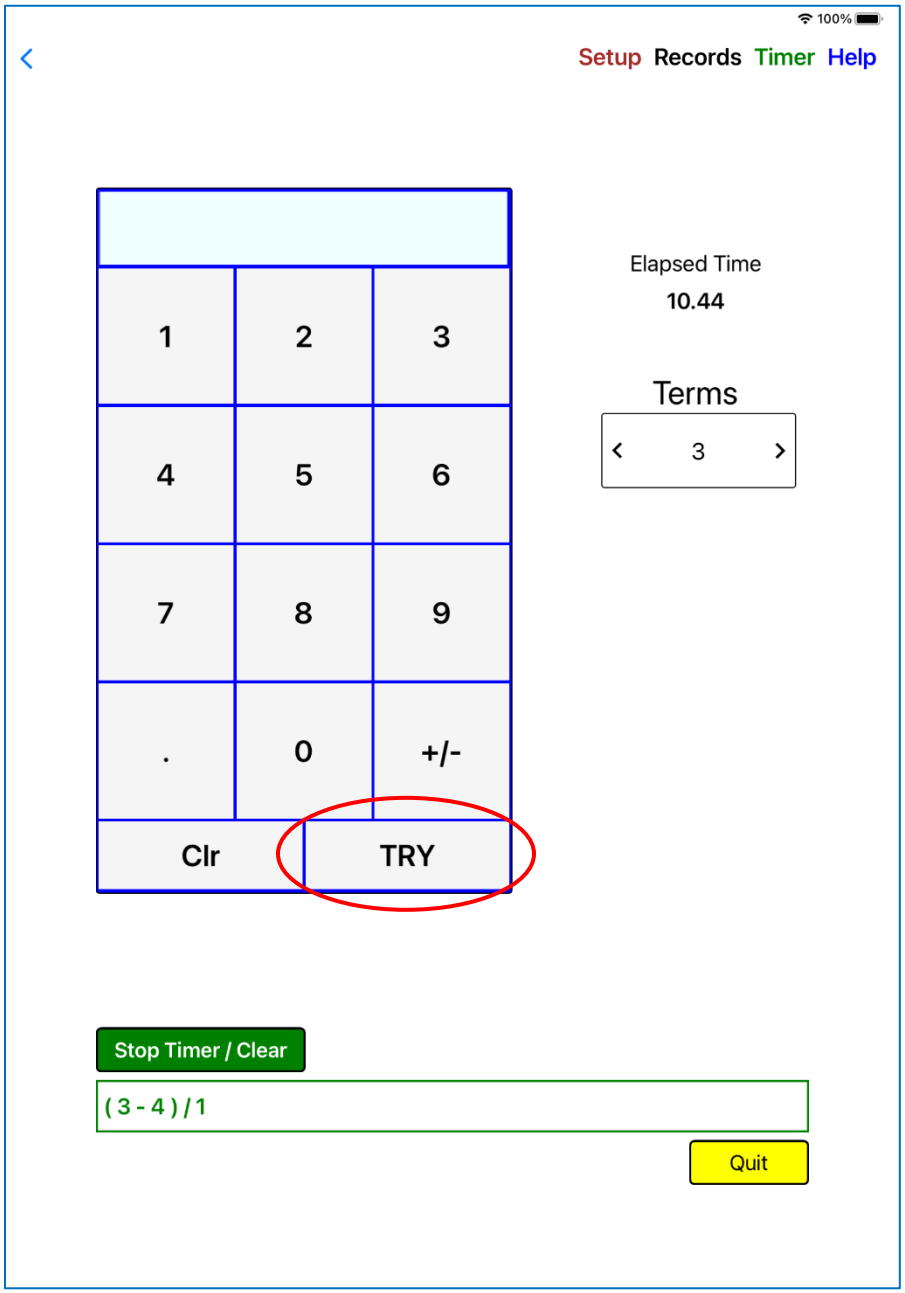
(Refer to the Junior High Practice section for an explanation of how this tool is utilized).



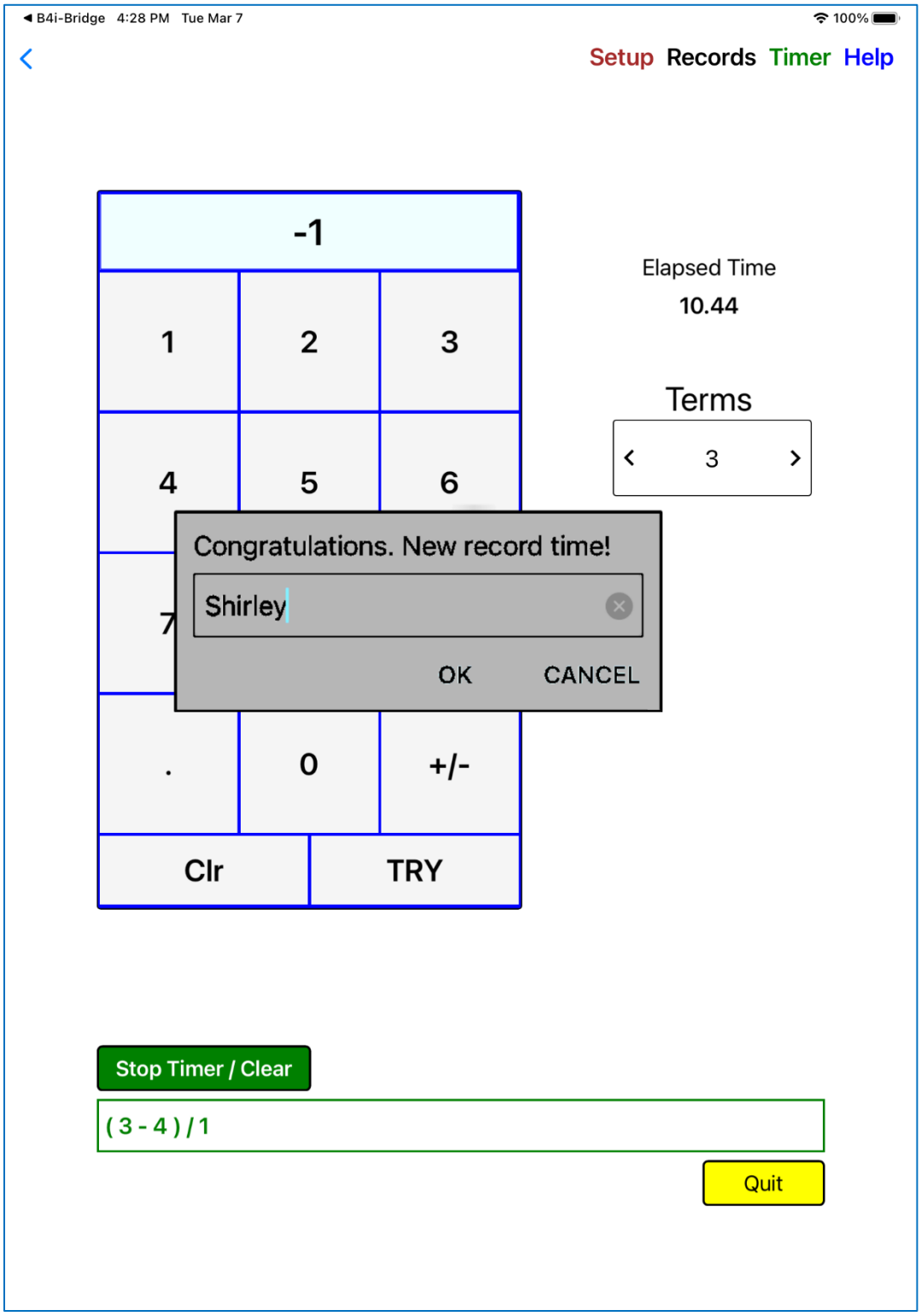
Let's assume that the Get a New Problem button is pressed. This results in the following:

- The answer window is cleared,
- A new expression is presented,
- The timer is reset and
- The keyboard is opened for input.

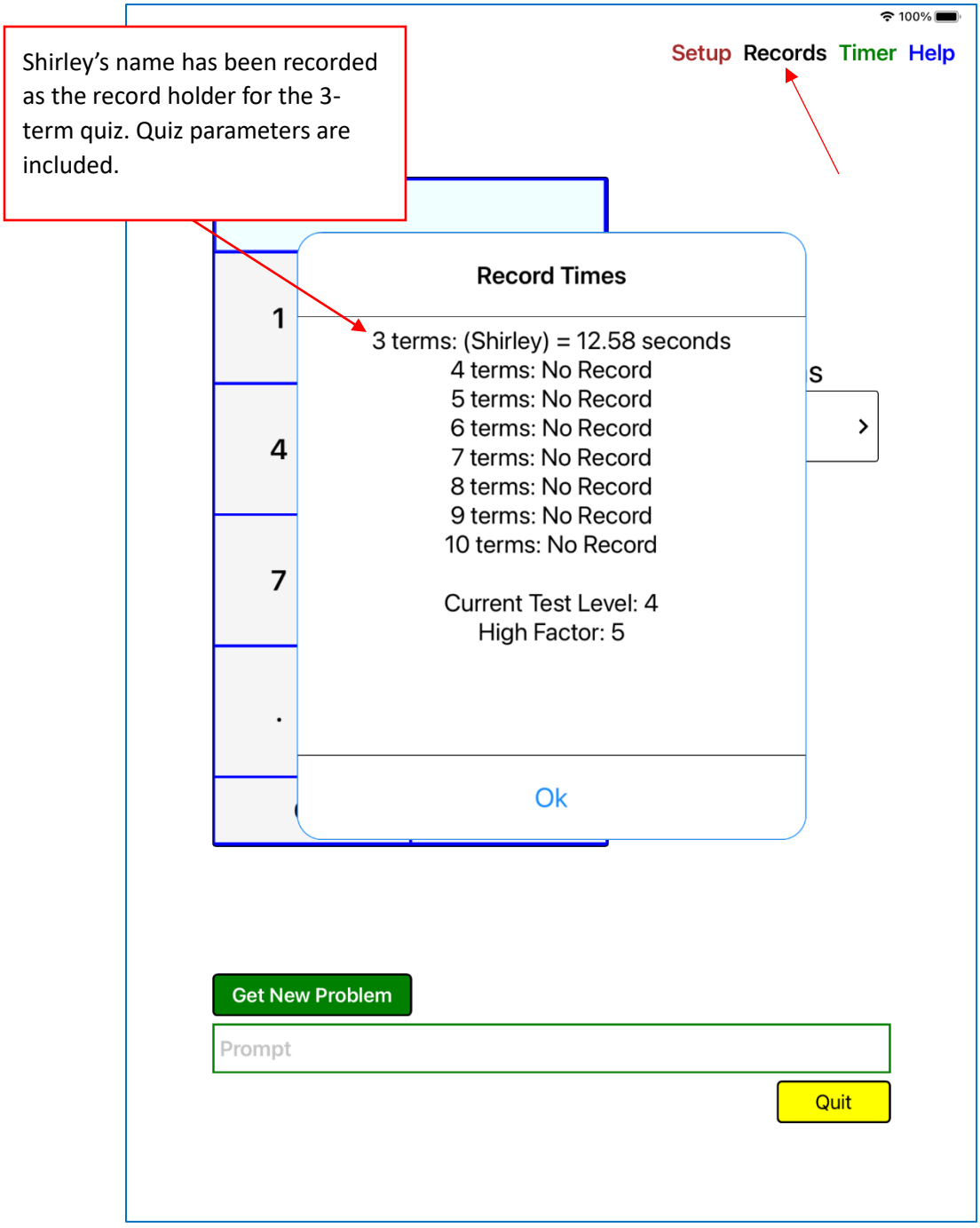
Enter the answer (-1) using the keyboard. Use the +/- key to enter a negative number. Then press the TRY button.



In this example, when a comparison was made to the previous record low time for this expression length (number of terms), the comparison showed that this test time was lower. The student is asked for a name to enter into the record books.



Return to the Junior High School Quiz home screen and select the Records menu item, then Show Records



Unlike the Elementary and Middle School quizzes where there are usually many questions in a quiz, the Junior High School quizzes consist of a single question. The complexity increases as the number of terms increases, which is what the Record levels are based on.

Appendix M

Menus and Controls

The Apple iPad opening screen is shown above. The menus and controls are functionally identical to the Windows, Android and iPhone versions. The Windows and Android differences are addressed in the Appendices W and A.

Mode Selections: Practice and Quiz

Guide: Print or View the User Guide

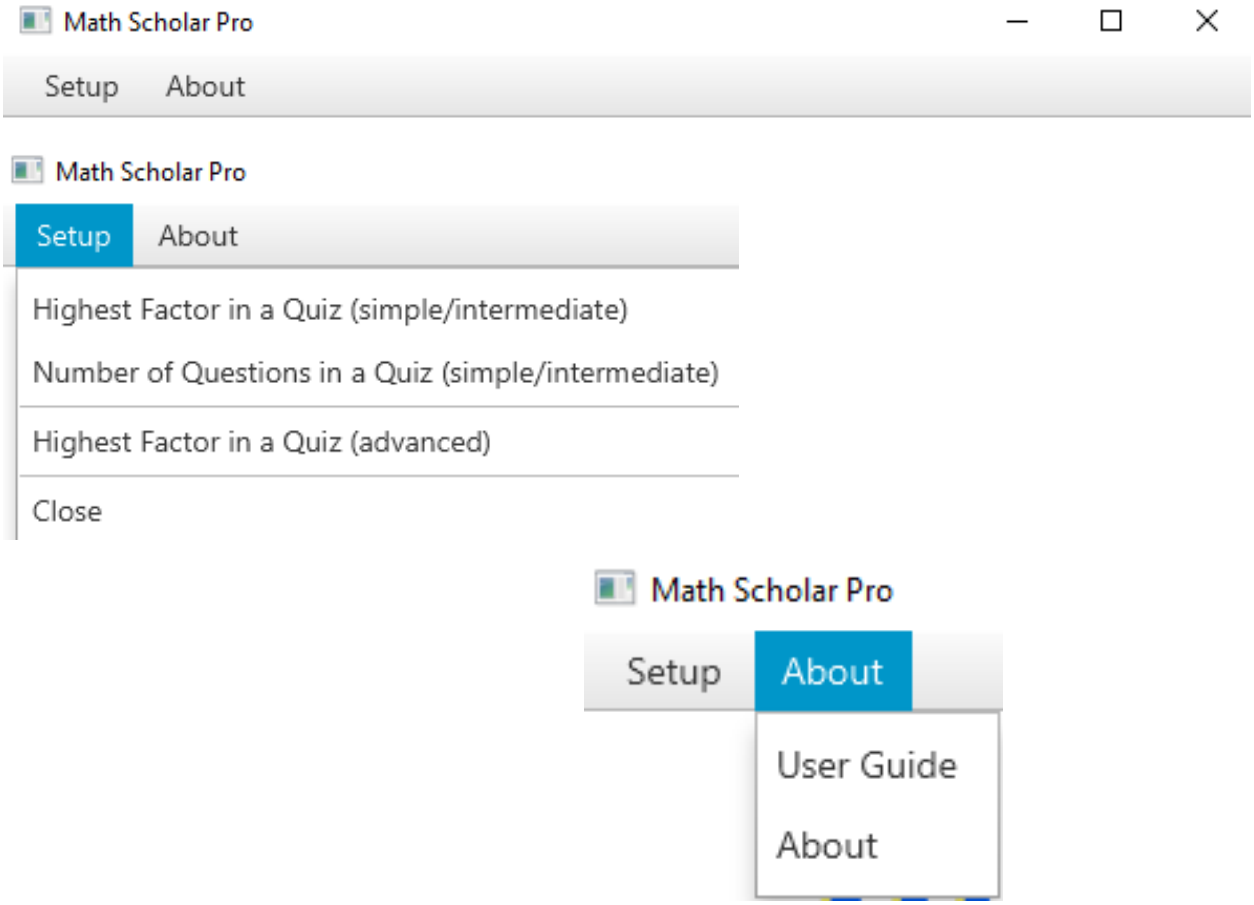
Help: Scrollable instructions available anytime they are needed

QR: QR Code to quickly access the TurboSoftSolutions.Com website

About: Version, copyright. Option to Rate/Review the app

Appendix A.

Android Menu


Math Scholar Pro
Setup
About
Math Scholar Pro
Setup
About
Highest Factor in a Quiz (simple/intermediate)
Number of Questions in a Quiz (simple/intermediate)
Highest Factor in a Quiz (advanced)
Close
Math Scholar Pro
Setup
About
User Guide
About

Appendix S

Then SHUNTING YARD and POSTFIX Algorithms

The method used to solve Order of Operations problems involve two algorithms.

1) The first algorithm (SHUNTING YARD - credit: Dijkstra) translates our equation from "infix" notation, where operators fall in between the operands they're acting upon (e.g. 1 + 2 * 3) to "postfix" notation, where all operators follow their operands (e.g. 1 2 3 * +). This is important because when the machine is reading expressions in this format, it will never encounter an operator before the operands it's acting on, which means it won't have to go back and forth between operator and operands.

2) The second algorithm (POSTFIXEVAL) evaluates the Postfixed expression to produce the solution.

Both algorithms utilize arrays known as stacks and queues.

- A stack is analogous to a stack of dishes. You add a new dish to the top of the stack, and all dishes currently in the stack are "pushed" down one level. Retrieving values from the stack ("popping") retrieves the topmost value, just like you would taking a dish from the stack. In computer parlance, this is known as Last In, First Out or LIFO.

- A queue on the other hand resembles a group of people waiting in line for an event. As new people join the group, they take their place at the end of the line. Removing a value from a queue is analogous to the first person in line leaving the line to enter the event and others in line moving forward one place. In computer parlance, this is known as First In, First Out or FIFO.

Lastly, an Order of Operation Precedence Table is established, using the familiar PEMDAS rule:

1) Parenthesis

2) Exponent

3) Multiplication/Division (equal precedence)

4) Addition/Subtraction (equal precedence).

A well-known pneumonic for this rule: "Please Excuse My Dear Aunt Sally".

Because parenthetical content is the highest priority, the program first scans for a parenthesis pair. If found, its content is translated with SHUNTING YARD, then solved with POSTFIXEVAL. The resulting value is substituted back into the original expression, taking the place of the parenthetical information, leaving a parenthesis-free expression, which can then be solved using the same SHUNTING YARD/POSTFIXEVAL methodology as before.

SHUNTING YARD Steps:

1) Parse expression left to right, element by element.

2) If element is

2.1) an OPERAND, immediately add to Queue; parse next element

2.2) an OPERATOR, then:

2.2.1) if stack is empty, immediately push operator onto the stack; parse next element

2.2.2) if stack is not empty, then:

2.2.2.1) if incoming operator has HIGHER precedence than top of stack, push incoming operator onto stack; parse next element

2.2.2.2) if incoming operator has EQUAL precedence to top of stack, pop top of stack and add that operator to the queue, then push incoming operator onto stack; parse next element

2.2.2.3) if incoming operator has LOWER precedence to top of stack, pop top of stack and add that operator to the queue then compare incoming operator with new top of stack and follow rule 2.2.1 above.

3. Once the entire expression has been parsed, pop all remaining operators on the stack and add to queue.

Example: 1+2*3^4

Rule 2.1:

QUEUE [1]

STACK [empty]

Rule 2.2.1

QUEUE [1]

STACK [+]

Rule 2.1:

QUEUE [1,2]

STACK [+]

Rule 2.2.2.1

QUEUE [1,2]

STACK [*]

STACK [+]

Rule 2.1

QUEUE [1,2,3]

STACK [*]

STACK [+]

Rule 2.2.2.1

QUEUE [1,2,3]

STACK [^]

STACK [*]

STACK [+]

Rule 2.1

QUEUE [1,2,3,4]

STACK [^]

STACK [*]

STACK [+]

Rule 3

QUEUE [1,2,3,4,^,*,+]

STACK [empty]

Final POSTFIX EXPRESSION: 1 2 3 4 ^ * +

Note that in the case of parentheses, the subexpression withing the parenthesis is isolated and evaluated using SHUNT YARD. That expression is evaluated (see below) and its result substituted for the parenthetical subexpression. This yields a parenthesis-free string which is then translated using the SHUNT YARD algorithm.

POSTFIXEVAL Steps:

Start with empty stack

1) Parse first token in PostFix expression left to right, element by element.

2) If element is

2.1) an OPERAND, immediately push onto stack

2.2) an OPERATOR, then pop off two operands from stack and save to temporary variables.

2.2.1) evaluate the expression:

EVAL = Temp1 [OPERATOR] Temp2

2.2.2) push EVAL to top of stack

3. Repeat until expression is empty. Solution will be lone stack value.

```
Example: 1 2 3 4 ^ * +  (Postfix expression from previous example)
                EXPRESSION [1 2 3 4 ^ * +]
                STACK [empty]
Rule 2.1:  EXPRESSION [2 3 4 ^ * +]
                STACK [1]
Rule 2.1:  EXPRESSION [3 4 ^ * +]
                STACK [2]
                STACK [1]
Rule 2.1:  EXPRESSION [4 ^ * +]
                STACK [3]
                STACK [2]
                STACK [1]
Rule 2.1:  EXPRESSION [^ * +]
                STACK [4]
                STACK [3]
                STACK [2]
                STACK [1]
Rule 2.2:  Operator = "^"
                Temp2 = pop 4
                Temp1 = pop 3
Rule 2.2.1
                EVAL = Temp1 [Operator] Temp2
                EVAL => 3 ^ 4 = 81
Rule 2.2.2
                STACK [81]
                STACK [2]
                STACK [1]
Rule 2.1:  EXPRESSION [* +]
Rule 2.2:  Operator = "*"
                Temp2 = pop 81
                Temp1 = pop 2
Rule 2.2.1
                EVAL = Temp1 [Operator] Temp2
                EVAL => 2 * 81 = 162
```

```
Rule 2.2.2
                STACK [162]
                STACK [1]
Rule 2.1:  EXPRESSION [+]
Rule 2.2:  Operator = "+"
                Temp2 = pop 162
                Temp1 = pop 1
Rule 2.2.1
                EVAL = Temp1 [Operator] Temp2
                EVAL => 1 + 162 = 163
Rule 2.2.2
                STACK [163]
Rule 3.         EXPRESSION [empty]
                SOLUTION = pop 163

[End]
```

Product Name: Math Scholar Pro

Company: TurboSoftSolutions.Com

Programmer: Neil Rohan