

## **Leveraging Online Games and Apps in Geotechnical Engineering Pedagogy**

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## **Abstract**

The usage of virtual tools in higher education is on the rise in engineering. With the recent modality shift due to COVID-19 restrictions, the necessity for virtual tools and technology enhanced application like online games and mobile apps are expected to grow. The learning algorithm of generation Z (Gen Z) is different from millennials where the former spends significant time on screen. To keep students more engaged during the learning process, the educators are now choosing various online tools like games and apps for effective understanding. The study used *Kahoot* platform to increase classroom engagement to boost motivation. *Kahoot* platform also provided instant feedback from students in the class during the *Civil Engineering Materials* class. In addition, the study also attempted to build mobile apps for few geotechnical engineering applications related problems. Moisture content, unit weight, permeability, bearing capacity etc. are some of the examples where the study developed apps for better understanding. While the programmable calculators and online engineering tools with excel files are abundant, the recent abundance of mobile devices offer seamless integration of convenience, connectivity, and processing power. Most of the students revolves around social media, photography, and shopping application whereas the inclusion of education within this platform remain largely unexplored. The apps will also assist the fresh graduate to have an estimation of the geotechnical properties based on the soil testing. Initially developed for android platform, the team will continue to create the same apps for iOS platform. The outcome of this paper will assist the educators to adopt such tools for their classroom teaching for more student engagement.

## **Introduction**

Formative assessment and summative assessment are the most used tool for student learning evaluation. Formative assessment is done during the class to improve their students' performance while the summative assessment usually is conducted at the end of the semester or course. There has been debate whether summative assessments are contributing to enhance the students learning or not as a final project or final exams are the forms of this assessment technique [1]. The result of this assessment is not capable of doing any immediate improvement but can be used in the subsequent courses for the faculties to enhance their efforts. As such, formative assessment is more appropriate to gauge the students' learning during the course. It can be helpful for the students as they get immediate feedback and for the teachers as they get an insight about the topic which need more emphasis and time allocation [2]. There are several methods of formative assessment of which gamification is gaining popularity nowadays. Game based learning methodologies has been surfacing around in the academia for a few years and is gaining more popularity day by day as the Generation Z is more inclined to use online and mobile platform. While the root of gamification dated back several decades ago, it has been used exponentially for the last one decade. Chorewars, FourSquare are some of the examples of using a smartphone app for household chores and location sharing with friends [1].

In order to make learning fun and more involved, game-based learning platform such as Kahoot has been adopted for supplemental pedagogical practice [3]. It is a free online program available both in mobile app and in website which is very easy to set up. They students need to enter a numeric code on their device to join the quiz and assess their learning. Moreover, this gamification feature of Kahoot is more popular with the teachers for formative assessment.

Programmable calculators have been in use for decades in the engineering school. Recent development of the online engineering tools is also available to the students. However, the proliferation of smartphone and tablets along with their seamless integration and connectivity processing power have motivated the educators to develop revolutionary educational tools. Although the majority of the students use the mobile device for entertainment purposes such as social media photography shopping, the opportunities to include educational content within this device remain largely unexplored [4]. The civil engineering educators are in an elevated position to guide shape and lead how that concepts taught in the classroom can be delivered in these devices. Bara et al. Documented the apps used in chemical engineering education developed for iOS, Microsoft Excel, R, COSMOL, MATLAB for use in chemical engineering classrooms. As such call mom there are room for civil engineering educators to produce such apps for more student engagement and effective learning of the concept. this paper describes step by step how to use online gaming platform Kahoot and develop apps for civil engineering classroom. This study will guide and assist the educators to develop such apps for their specific discipline and apply it in the classroom.

## **Background**

The use of Kahoot has been documented in several courses covering topics in physics, engineering, English, medicine etc. [5]. Ciaramella (2017) used Kahoot for vocabulary retention with learning impairment students [6]. The author described increase in vocabulary retention for the student using this platform. Coller and Scott (2009) used gamification in their mechanical engineering course where all the assignments were completed using video games [7]. For example, the students simulated car racing on a track using numerical method by writing programs by themselves. The authors concluded that the students had deep insight into the course in comparison with the students who are receiving conventional lecture approach. Borrell et al. (2017) employed Kahoot to generate pre-lesson quizzes for physical geography class where the authors monitored the students' progress to analyze the effect of this pre-lesson [8]. By performing a comparative study, the results indicated that the inclusion of this game based pre-lesson significantly improved the students' performance.

People are becoming increasingly interested in mobile applications due to the popularity of mobile phones and smartphones. In these devices, the Android operating system is the most widely used. There are different commercial and open-source tools available for developing mobile applications to fulfill recruitment. In order to create the mobile application in a professional manner, the development of the mobile application should be done using Android Software Development Kit (SDK). The application and software developers have been able to leverage the Android operating system and technology for creating mobile applications. This is a Google product that allowed users to connect their mobile devices with Google Services. Android is renowned as an operating system that can support over 1,000 applications. Android lays the groundwork for various applications. The Android operating system is becoming incredibly common in the electronics sector, especially in the smartphone market. This is favored by researchers since certain development tools are provided free of cost. Furthermore, this also enables the developers to employ multiple hardware platforms to actualize the ideas with minimum effort. All Android virgins are designed with more technological security measures that are clearly visible to the users and imply that they may be readily handled with the help of a user interface. for improving the security of the Android smartphone multiple methods can be used including password fingerprint and access permissions.

Android Development Tools (ADT) Eclipse platform, Java, and Android SDK are the most fundamental programming languages and programs for developing mobile applications for the Android operating system. Such systems have smooth operation and a great user interface. This also offers a great experience to the user. When creating the Android-based application in Eclipse a variety of tools are employed this effort. Firstly, many tools from the Android SDK were used these tools are accessible directly from the eclipse Integrated Development Environment (IDE) with the help of the command line or ADT plugin after finishing the installation of the SDK. The idle technique is to create with eclipse as it offers an immediate search for tools that are required for the application development.

### Implementing Kahoot in Civil Materials Testing Class

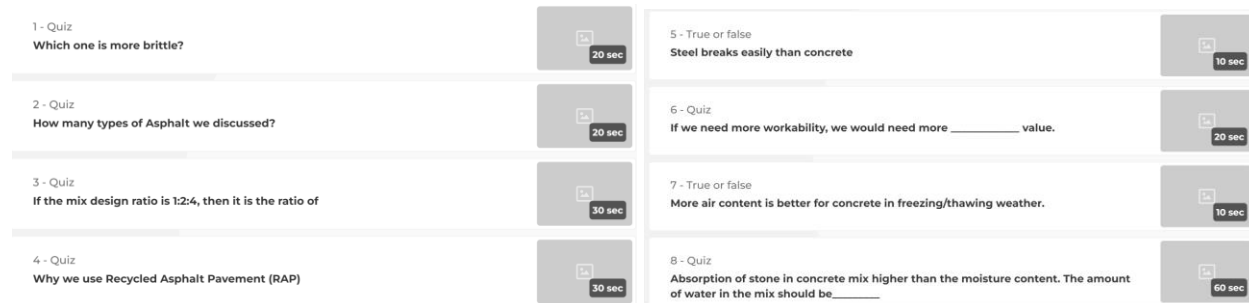
Kahoot platform is very simple to use and has multiple features which are effective in student engagement. Students are more motivated in this platform as it has some inbuilt features such as music, question time limit, score update, relative graphics etc. The instructor can choose several types of questions such as true/false, multiple choice, thought provoking, and critical thinking. Based on the question level and type, the instructor can choose the appropriate timing ranging from 10 seconds to 120 seconds. After each question, the correct answer is shown at the display along with the number of students with correct answer choice. As the instructor has the overall control when to move to the next question, it provides an excellent opportunity for instruction. For example, if the students failed to answer correctly in a critical thinking problem the instructor can go back to dig a little deeper in explaining that concept previously presented in the course. Figure 1 shows one thought provoking question in the class asking why the recycled asphalt pavement (RAP) are used in construction. The screenshot of the image is showing 18 seconds left for putting answer where the time allotted for this question was 30 seconds. The instructor also chose a Christmas snowy image as the holiday season was nearby while taking this quiz. It should be mentioned, upgraded and paid version is required to use some high-quality, relevant images and animation.



Figure 1: Sample question from Kahoot platform

## Lesson Learned from Implementing Kahoot

There was total 10 students in the class participated in the quiz. A total of 8 questions (Q1 - Q8) were asked to the students (Figure 2). Table 1 shows the percentage of correct answer recorded by the students in addition it also provides the feedback from the students participated in the game. As can be seen 100% of the student recommended the platform as they thoroughly enjoyed it. When asked about their feeling regarding the platform, 72% said positive while the rest of the student was divided in neutral or negative response. The 28% neutral or negative impact can be attributed to the students who were not able to secure good points at the quiz followed by feeling a little disappointed. In case of learning, 64% of the students were positive. From the following courses, the instructor will work more to infuse fun and learn simultaneously in selecting the questions.



**Figure 2:** Variety of questions used in the gaming platform

To use the Kahoot platform effectively, there are several issues that must be considered. At first, choosing an appropriate time for each question is crucial. Providing little time will do more harm than good leading to the frustrated students to give up and disengage. On the contrary, allowing too much time can lead the students feeling bored and lose the fanning atmosphere momentum created by the game. As such the instructor should be very careful to select the appropriate time limit for a wide range of students. Another important parameter is the question length. The quiz can lose its appeal if long questions are used. It has been seen that platform became less engaging if the students were asked to follow some table and performing some calculation to find an answer.

**Table 1:** Overall performance and feedback of the Kahoot game

Overall Performance			
Total correct answers (%)	46.88%		
Total incorrect answers (%)	53.13%		
Average score (points)	2873.63 points		
Feedback			
Number of responses	10		
How fun was it? (out of 5)	4.56 out of 5		
Did you learn something?	64.00% Yes	36.00% No	
Do you recommend it?	100% Yes	0.00% No	
How do you feel?	72.00% Positive	14.00% Neutral	14.00% Negative

Based on the experience of the instructor, student motivation and momentum are easily maintained if the questions are ranged from 10 seconds to 60 seconds with shorter questions. In addition, mix and match of various types of question such as true/false (Q5, Q7), fill in the gaps (Q6, Q8), multiple choice questions (Q1, Q2, Q3), one or two critical thinking question (Q4) are more appropriate for student engagement. In addition, each question in the quiz is fully customizable in the Kahoot platform. To design each question, the instructor needs to provide title, description, background image, language of the question. The instructor can choose appropriate background image relatable to each question to engage student more during the quiz. Real life pictures or cartoon, schematic figures also assist the students to engage more.

### **Developing App for Civil Engineering Applications**

The term "Android" refers to the mobile operating system, which is used in various gadgets like smartphones, tablets, and so on. For the developers of Android applications, Android SDK is necessary. Prior understanding of Java programming languages is required along with the Android SDK class library for implementing Android SDK for any application. The Android programming concepts are used in this study for developing the mobile application.

#### ***Android SDK***

This refers to the set of software development tools and libraries that are necessary for creating applications that are based on the Android operating system. This includes multiple tools and technologies that ensure that the process of mobile application development flows smoothly from development to the debugging stage. For the creation of the Android-based application, eclipse IDE is often used along with the Android SDK as well as accompanying technologies. The ADT bundle includes everything that is required for getting started with the development of applications. The ADT bundle includes the basic components of Android SDK along with the version of Eclipse IDE for the simplification of the process of Android development.

#### ***Android SDK Tools***

This includes the Android SDK tool which is made up of a package of different utilities and tools that are essential in the creation of Android applications. This includes the entire collection of Android development tools and debugging tools. There are mainly four stages for developing the application using Android SDK which is described below:

- 1. Configuration:** the first stage is related to installing and configuring the application development environment. This also includes the development the Android virtual devices and creates a link with the physical devices in which the applications will be installed.
- 2. Development:** The planning and development of the Android project are now under progress. This includes source code as well as resource files of the application.
- 3. Testing and Verification:** This includes the creation of a dot APK package for the mobile application that will be running and installed on the emulator for enabling the process of debugging.
- 4. Publishing:** This is the last stage of mobile application development that is based on releasing the application and delivering it to users.

## ***Android Studio***

Android studio refers to an IDE that supports the development of Android applications. This adds new tools that help in boosting efficiency during the development of Android applications. This is based on a versatile gradle-based build mechanism that includes a feature-rich emulator that is helpful in the testing of the app. This offers a unified environment that supports the creation of applications for different Android-supporting devices. This allows changing the resource code without restarting the code [9]. This offers a range of frameworks and testing tools that are showing compatible with NDK & C++. Due to compatibility with the Google cloud platform, this simplifies the integration of the app engine with Google Cloud messaging.

### ***Android studio project structure***

The Android studio-based project can have more than one module that include the source code files and resource files. Library modules, Android app modules, and Google app engine modules are a few examples of the various sorts of modules. In Android Studio a project includes everything that is helpful for the application workspace including assets that are required for testing the code, source code, and build options. Android studio produces the appropriate structure for the files and displayed it in the project pane. The project files in the Android studio are by default displayed in project view which is made up of different modules that support easy access to the important source files of the project.

### ***Modules***

A module can be understood as a combination of build parameters as well as source files that allow for breaking the project into different functional components. These are used by Android studio for making the application supportive of different types of devices. The project can have one or more than one module that may be tested, built, and debugged individually. Each module includes the required files as well as the code templates suitable for the device type and application. The other one is the same Modules are handy for generating the code libraries for developing different sets of resources and code for the type of devices while keeping the files within the same project.

### ***Gradle build System***

The Gradle build system can be referred to as the backbone of the Android Studio's build mechanism. This makes advantage of different Android-specific features that are supplied by the Android plugin which operates independently of the Android studio interface and command line. This has the ability to perform the configuration, personalization, and extend the process of building. The same project and modules can be used for generating numerous APKs with different features.

### **Application description**

The study developed 4 applications in the area of geotechnical engineering. Determination of soil moisture content, soil permeability, unit weight, and bearing capacity of soil were the specific four apps developed during the study.



*Soil Moisture:* The gravimetric methodology which is a direct measurement technique for measuring soil moisture content is used as a reference method for determining the soil water content. This is also known as the drying method which assesses the moisture content with the help of drying the sample of soil. This measures the difference between wet soil and dry soil samples. The procedure is trustworthy and accurate, and it is best suited for experimental work. The data relating to the density is required for converting the weight into volume calculation. The weight of the soil is measured prior to and after drying the soil at 105 degrees Celsius for 24 hours in this procedure. By dividing the weight of the water by the weight of the dry soil, the water content is computed.

*Soil Permeability:* The property of soil for enabling water to flow via soil is referred to as soil permeability. This is a critical aspect for constructing the structures that come into touch with water could storm the flow of water in soil occurs through a length of empty spaces or pores water flows along a curving course rather than a straight line [10]. The following equation (1) is used for calculating soil permeability for the Android application:

$$k = qL/Ah \quad (1)$$

Here,  $k$  is the coefficient of permeability,  $q$  is discharged water,  $L$  is the length of the specimen,  $A$  is the cross-sectional area of the specimen and  $H$  is constant head causing flow.

The value of the permeability coefficient is affected by the size of the particle and other factors. The complete cross-sectional area of soil mass includes different sectional reasons due to this; the flow cannot occur via the solid sectional areas. The seepage velocity or the velocity of percolation effort to the actual velocity or rate of percolating water discharge.

*Soil bearing capacity:* The ability of soil to support weights placed on the ground above is referred to as its bearing capacity. This is usually determined by the soil properties including density and shear strength. The bearing capacity of soil is also affected by the depth of the load's embedment. The deeper it is identified, the larger the bearing capacity would be. This mobile application makes advantage of Terzaghi's Bearing capacity equation (Equation 1). The soil is thought to be homogenous and isotropic. The ground surface is also considered to be horizontal.

$$q_u = CN_c + \gamma D_f N_q + 0.5B_\gamma N_\gamma \quad (2)$$

Here,  $q_u$  refers to the ultimate bearing capacity of the soil,  $c$  refers to cohesion,  $D_f$  is the depth of foundation below the ground, and  $\gamma$  is the unit weight of soil above and below the level of footing. These measurements and calculations are carried out on projects including underground pipes and bridge foundations.

### ***Project files***

The Android Studio displays the files of the project in Android view by default. This does not correspond to the structure of the file on the disk and it is structured by type of file and modules to make it easier the navigation between the important source files while concealing any folder or file that is rarely used in the project. The top-level Gradle script group displays all the build-related configuration files. This also displays the manifest file for every module that belongs to

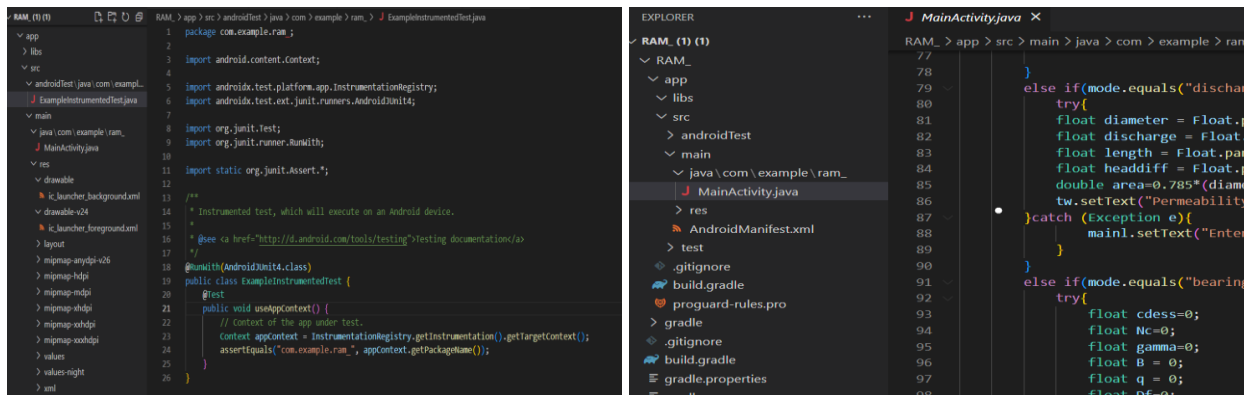
the module-level group. This is also accountable for displaying all the other alternative resource files instead of individual directories for each resource.

**Build/:** this includes build output.

**Libs/:** this consists of private libraries used in the soil moisture content calculation application.

**Src/:** this consists of all the resource files and code files within the subdirectories.

- **androidTest/:** this includes code for the instrumentation test. The Android studios intended to make the process of testing as simple as possible with the help of several capabilities which make it easier to write and execute as well as evaluate the tests. This allows the creation of tests that can be performed on the local system as well as instrumented tests that can be run and executed on a device [11]. The results of the test are displayed in the Android studio. For testing the proposed application, an instrumentation test is conducted. The test is located at the RAM\_/src/androidTest/java/ExampleInstrumentedTest.java. The taste is performed on the emulator. Due to the excess ability to instrument API, access to information on the application is provided. This test is used due to Android dependencies for which the test duplicates cannot be constructed. The test runner is used for results consistent.

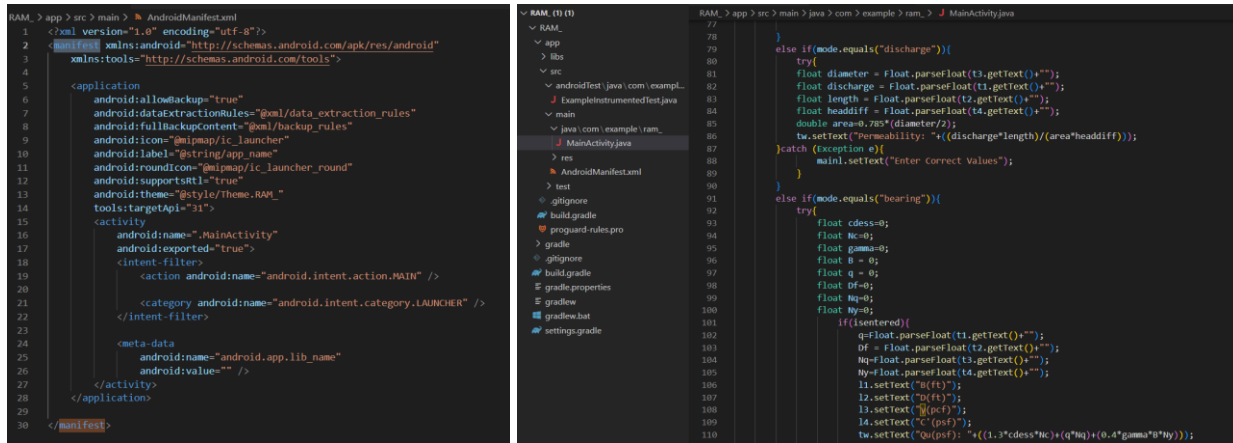


**Figure 3:** Instrumented Test and test file

- **Main/:** This directory includes the main source set files including resources shared by the versions as well as Android code.

**Manifests/:** The AndroidManifest.xml file is contained in this for the soil moisture content calculating application. The application project includes this file in the root directory. This is accountable for informing the Android build tools with the critical details about the application. For the soil moisture content calculator application, the manifest file includes all the components of the application such as broadcast receivers, services, activities, and other content sources. Basic attributes including the name of the Java class and Kotlin class are also defined by each component [12]. This state the capabilities of the application including the device configuration, which is supported by this, and how the component will be launched. The manifest file also contains the rights that the program needs to access the system's restricted regions. This announces any permissions that are necessary for other applications to access any data information from this app this also consists of the software

and hardware requirement of the application that influence which devices are able to install the application from Google play.



**Figure 4:** Android Manifest.xml and Java File

**Java/:** This consists of Java source code files and kotlin files that are organized by name of the package along with the Junit test code.

**Re/:** Layout definitions, bitmaps user interface, and other static materials are examples of resources that are used in this application development project. This includes the UI strings, XML layouts, and bitmap images that are organized into subdirectories. These resources are externalized for maintaining them independently [13]. Each type of resource is placed in its own subfolder within the res/ directory. Following is a hierarchy and description of each resource used in this project:

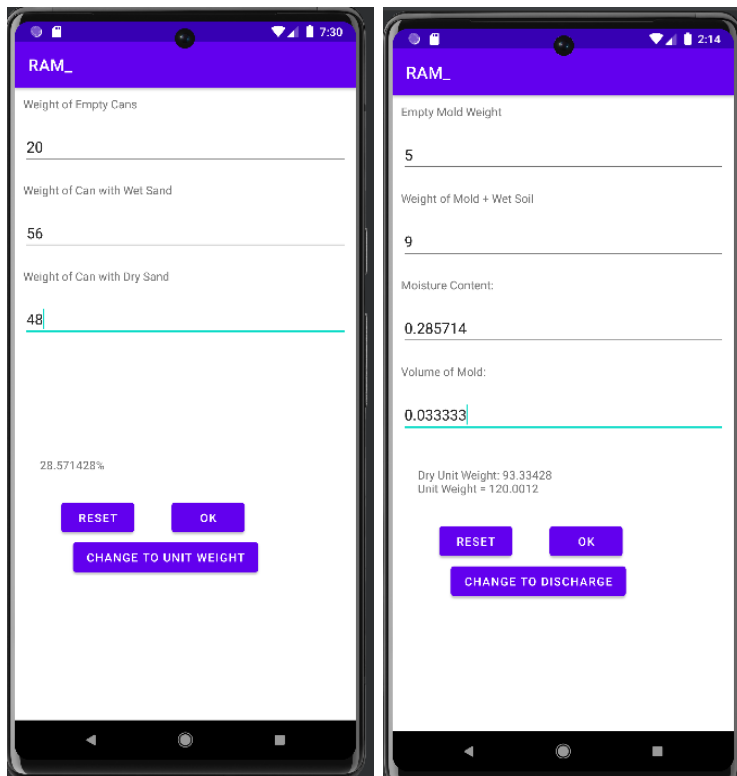
- **Drawable:** this is used for bitmap files and XML files. This refers to a graphic that can be created on screen.
- **Layout:** This refers to the XML files that describe the layout of the UI.
- **Mipmap:** This refers to doable files for various densities of launcher icons. The density-specific copies are offered for the application icon. Usually, the app launcher displays the icon of the application up to 25% bigger in comparison to the density bucket recruitment of the device [14].
- **Values:** this refers to the simple values including colors, characters, and numbers which are stored in XML files. Each subcategory of the resource element is accountable for defining a single resource within the file directory. Since every resource is described with the personal and specific XML element, any name to the file can be given and many resource types can be included within the same file. Although for clarity separate distinct resources are kept in two individual files
- **XML:** this refers to the arbitrary value of examine files that can be accessed during runtime. This is used for storing configuration files.

## Checking the Apps

### *Moisture content calculation*

In order to calculate the soil moisture content different values are provided as input to the application including the weight of the empty can, the weight of the can with wet sand, and the weight of the can with dry sand. Using the formula, the application provides the total weight, moisture content, and volume of soil. For providing the input values Firstly, the weight of the can is measured and denoted as  $W$ . After this, the sample of soil is put into the can and then the weight of the can plus wet soil is measured and denoted as  $W_1$ . Then the soil is dried in the oven at 105 degrees Celsius [15]. Then this sample is weighed along with the dry soil and named  $W_2$ . The user is also allowed to reset all the values or change the values into moisture content. The program uses these input variables to determine the amount of moisture in the soil. The application calculated the moisture content using the formula given below, to provide the outcome:

$$\text{Moisture content} = (W_1 - W_2) / (W_2 - W) \quad (3)$$



(a)

(b)

**Figure 5:** (a) Moisture content and (b) unit weight calculation in the App

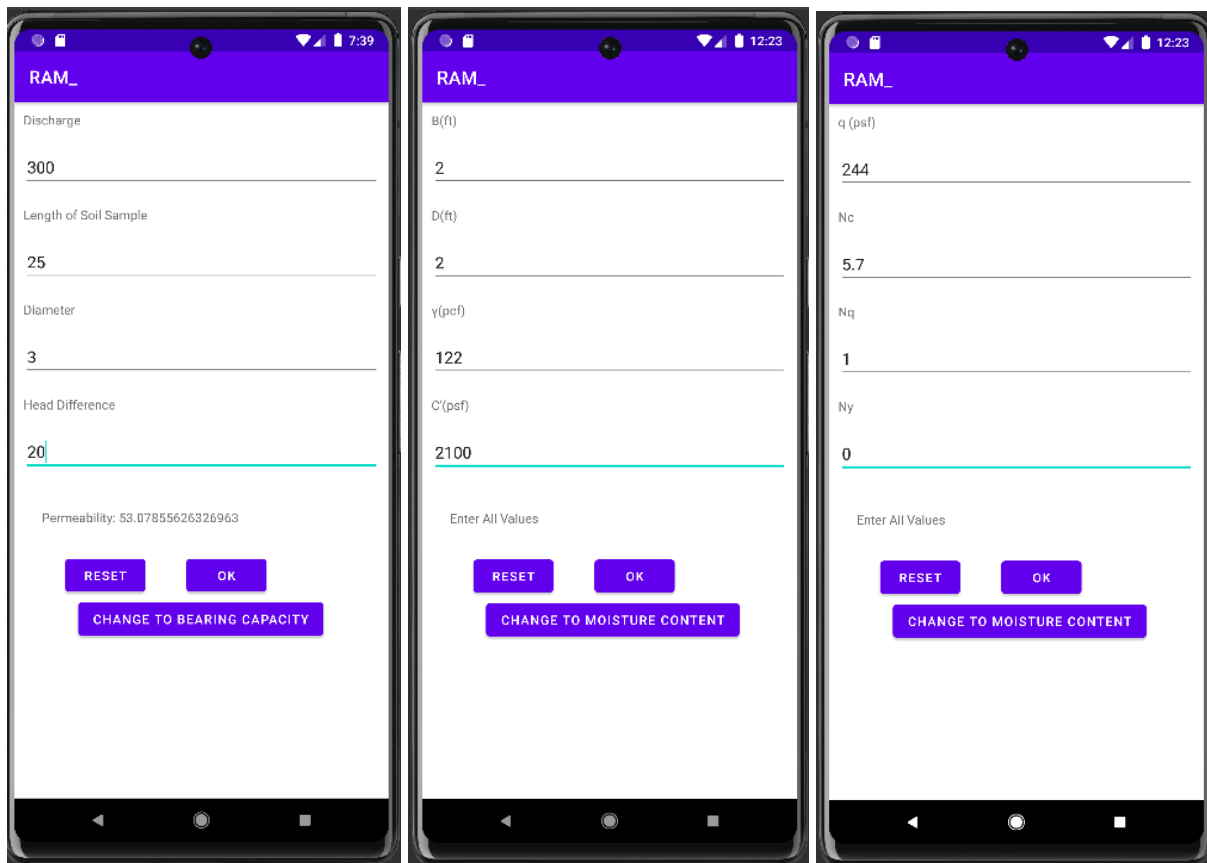
As can be seen that, the moisture content was calculated as 28.57% (Figure 5a). This same moisture content was used to calculate the dry unit weight from the wet unit weight calculation in the following section.

### Unit weight calculation

For calculating the unit weight of the sample, the input values are provided for the weight of empty mold (5 lbs), weight of mold along with wet soil (9 lbs), the weight of soil, volume of mold (0.0333 ft<sup>3</sup>). The weight of the wet soil was 4 lbs after subtracting the mold weight. By incorporating weight/volume for the unit weight, the value was calculated to be 120 lb/ft<sup>3</sup>. Using the 28.57% moisture content from the previous application, the dry unit weight was calculated to be 93.33 lb/ft<sup>3</sup> (Dry unit weight = Wet unit weight/1+moisture content). The results are displayed in Figure 5 (b).

### Permeability calculation

For calculating the permeability of soil, the input values are given for discharge, length of the soil sample, area of the permeameter, and difference of head which provided the result in form of permeability value. The value of the permeability coefficient is controlled by other factors and the size of the particle. For the sample check of the application, the discharge (q) value was taken as 300 mL/sec with 25 cm soil sample length (L). The diameter of the specimen was 3 cm leading to an area 7.056 cm<sup>2</sup> with head difference 20 cm (h). Using the equation (1), the permeability of the soil sample was calculated as k=53.15 cm/sec (Figure 6a).



(a)

(b)

(c)

**Figure 6:** (a) Soil permeability; (b) and (c) bearing capacity calculation in the App

### ***Bearing capacity calculation***

The ultimate bearing capacity of the soil, cohesion, depth of foundation below the ground, and unit weight of soil above and below the level of footing is provided as input for calculating the amount of bearing capacity [16]. The test findings are used for determining how much weight the soil can safely support. Starting with the weight needed for shearing the soil, a safety factor is added to ensure that the structure never bears sufficient weight for the distortion of soil. To keep within that value, the depth of the foundation or footprint can be changed [17]. According to the results, the soil can be compressed for boosting its strength. The method for measuring the soil bearing capacity includes the establishment of the maximum pressure that can be applied by the foundation on the soil in such a way that shear failure is less in comparison to the foundation. In Figure 6(b) and Figure 6(c), one sample calculation for the bearing capacity is shown with the following data shown in Table 2 using equation (2). As the number of input parameters were 8, the app had to take input in two screens.

**Table 2:** Bearing capacity parameters for app development

B (ft)	$D_f$ (ft)	$\gamma$ (pcf)	c (psf)	$\phi$	q	$N_c$	$N_q$	$N_\gamma$	$q_u$
2	2	122	2100	0	244	5.7	1	0	15805

Where B is the width of the foundation,  $D_f$  is the depth of the foundation,  $\gamma$  is the unit weight of the soil. The soil has a cohesion of 2100 psf with friction angle zero degree and some other bearing capacity factors (N values). The bearing capacity values were calculated to be 15805 psf.

### **Limitations of the Study**

In the current study, Kahoot platform was used for formative assessment and several android applications were developed for the assistance of the students. In the future, while developing the questions in Kahoot, the instructor will frame the questions at various levels of Bloom's Taxonomy which was absent this time. The questions will be mapped to knowledge, comprehension, and applications levels of the taxonomy. In the app development, it was only limited to android phone users. As the number of iOS operating system users are on the rise, next attempt will be focused on app development for iPhone, iPad users. In addition, no feedback was recorded from the students regarding this app development. The overcome of this limitation will improve the apps' effectiveness in the future.

### **Conclusions**

The rapid development of the technology and modality change of education due to the pandemic has forced the educators to think outside of the box to make students more engaged in the classroom. In addition, the generation gap between the educators and the students is also a challenge for effective knowledge transmission. The current generation Z is more smart device users for which educational tools related to screen time would be more beneficial. This current study exhibited step by step how to use Kahoot platform for the classroom adoption. The lesson learnt part would also help the educators for effective quiz orientation of Kahoot. In the app development part, step by step procedure was described so that any other educator could build

such kind of student friendly apps for the android smartphone devices. The paper described the software development kit along with the android studio and modules for the convenience of the audience of this paper.

### **Data Availability Statement**

The code used to develop the applications will be available upon request to the authors.

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