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| How does “Defence of Calculot” do things differently? |  |

A medieval-themed collection of interactive tools to help users learn lower-level university calculus

Defense of Calculot

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PART A: CONTEXT

**Background Information**

**Domain:**

Entertainment: Educational Mathematics Game

**Topics:**

Linear Algebra – Vectors, Matrices

Pre-Calculus – Trigonometry, Complex Numbers, Polar coordinates

Calculus – Theorems, Limits, Derivatives, Integrals

Theme – Medieval Fantasy

**Problem:**

Some students have problems grasping an understanding around post-secondary mathematical concepts. This is because of a lack of fundamental structure around pre-calculus and calculus.

**Sub-problems:**

While some applications provide insight on this problem, these applications provide a stale implementation around the topic. This can be detrimental to the learning process. Boredom can lead to procrastination which prevents effective learning.

**Purpose & Audience:**

High school and University students taking Pre-calculus, calculus, or linear algebra can use this app as a helpful tool to test and better understand the fundamental concepts in mathematics while providing an interesting thematic approach to the topic to keep things fresh.

**Storyline:**

User Requirement Definition:

The <app> should provide tools for learning concepts in the three subjects linear algebra, pre-calculus and calculus as well as test them in an enjoyable way. App should distinguish different students profile, allowing multiple users to save learning progress.

**Required Functionality – Functional Requirements**

PART B: REQUIRED FUNCTIONALITY

**Login System**

* **Upon runtime, this system shall display all the registered users in the database.**
  + All usernames must be clickable and will lead the user into the password entry activity, which they will enter the password to continue.

**Password Entry System:**

* T**he system shall log the user into the game upon entering valid user information**
  + The user must be registered into the system.
  + When the user enters information that is not in the database, they will receive an error dialog that prompts them to “register” or to “try again” which brings them to either the registration activity or cancel the dialog message.

**Registration System**

* **The system shall place the user information into the user database, if the information is ‘valid’.**
  + Validity is defined as such:
    - The user has not already been registered into the system.
    - The first name entered only contains alphabetical characters (A-Z, a-z) in their first name. All other characters invalidate the username.
    - The username only contains alphanumeric characters and underscores.
    - The password must include: At least 1 Uppercase letter, 1 Lowercase letter and 1 number. All other characters, or the exclusion of any of the characters listed will invalidate the password.
  + If all the inputs are “valid”, the system will notify the user via a “Toast” message that will tell them that the system has correctly placed their information in the database.
  + If one of the inputs are “invalid,” The system will display a dialog message notifying the user which of the fields have the invalid input, and will prompt the user to either go back to the main menu, or try again (dismiss the prompt).
  + If the username, and first name already exist in the system, but under a different password, a dialog will appear that will ask the user if they want to switch passwords. This will be a yes-or-no dialog and choosing yes will activate a prompt to enter the “old” password and “a new password”
    - If the old password is in the database under the username, the stored password will be changed to the new password, and a dialog will notify the user that their password has been changed.
    - If the old password is incorrect, or the password is invalid, the system will display a different dialog that will notify them that the password change has been unsuccessful. The dialog will prompt them to either try again or go back to the registration menu.

**Learning System**

* **This system shall provide a list of clickable topics which brings up information about the topic as (videos, images, etc.)**
* **The system shall provide a set of examples, in which a few are filled out and the few are blank.**
  + Upon the user filling out all the blanks and switching screens or clicking the ‘solve’ button, the system shall check if the examples entered by the user are correct.
  + If the system deems the solutions to be correct, the topic will indicate change (in the form of either text color, borders, background or icon)
  + If the system deems the solution to be incorrect, no changes will be made.
* **Clicking the android back button from a specific topic page shall bring the user back to the list of topics, which they can choose another topic or return to the menu screen.**

**Practice System – Multiple Choice Infrastructure**

* **Upon clicking the ‘practice’ button,** **the system shall load up a set of questions related to the topic.**
* **After clicking one of these choices, the system shall launch the game.**
* **The game shall display a question, the lives of the user, 4 possible answers, and the experience gained from the current playthrough.**
  + When the user clicks on the correct answer, the user shall gain experience, and a new question will appear.
  + When the user clicks on a wrong answer, the user shall lose a life, and a new question will appear.
  + If the user takes too long to respond, the user shall lose a life, and a new question will appear.
  + Example Question: Differentiate / Answers: , , ,
* **When the user reaches 10 answers, the system shall end, rewarding the user with experience to be stored in their profile.**
* **When the user loses all their lives, the system shall display a dialog which displays how many questions they have answered correctly and how many experience they have achieved from the playthrough of the game.**
  + The user shall only receive a quarter of the experience, due to the loss
  + A dialog shall appear and prompt the user to either: go for another round or go back to the practice menu.
* When the user clicks on the android back button, **a dialog shall appear that asks the user if they want to quit. The system shall prompt the user to either continue the game or save the progress and return to the practice menu.**

**Profile System**

* **The system shall display the player character of the user, the username, and first name entered during the registration page.**
* **The system shall display 3 different fields for experience: Total XP, differentiation XP and Integration XP, Algebra XP, and Trigonometry XP.**
  + Total XP is defined as the sum of all the experience of the topics.
  + There will be a bar that shows the graphical interpretation of the XP bar.

**Achievement System**

* **The system shall display a list of achievements in the profile page, and will display all the ‘locked’ achievements as the grayed-out version of the achievement.** 
  + When an achievement is ‘locked,’ it means that it has not been achieved. After the achievement is unlocked, the achievement will be unlocked.
  + Any achievement that has been unlocked will display a message that notifies the user that they have unlocked an achievement.

**Non-Functional Requirements**

* **Dependability Requirements**
  + The application shall handle errors gratefully. No user input shall cause the system to crash.
* **Efficiency Requirements**
  + Performance: The system shall respond smoothly to user input.
    - It shall not respond longer that 1-2 seconds for the system to respond after receiving the users input
  + Space: The system shall consume a small amount of memory space for installation.
    - The application shall not consume more than 200 MB of memory on the user device.
* **Usability Requirements**
  + Users shall have the ability to use the application whenever they desire.
  + The interface shall provide an easy-to-use interface and high-level instructions.
  + All components shall be simple for understandability reasons.
* **Security Requirements**
  + The system shall first ask the user to register or sign in an already existing user account.
  + The user must be unique in all cases and the user progress must be unique only to that user.
  + The user profile must only be accessible through the credentials that the user has entered.
* **Organizational Requirements**
  + Operational: The system shall:
    - Store user accounts in the database.
    - Allow user to sign into their account in the database
    - Provide the user questions on the selected topic.
    - Collect user answers to the question and verify if it is correct and inform the user if the answer is correct or incorrect.
  + Development Requirements
    - The system shall be developed using the Java Language
    - The system shall be developed using Android Studio exclusively
  + Environmental Requirements
    - The application shall work on all android operating systems running on API 16(Android 4.1 Jellybean)
* **External Requirements**
  + Ethical Requirements: The application shall provide correct information about math topics to not confuse users.
  + The application shall not display, or distribute any user information to external sources.
  + The application shall give credit to all sources used through a reference page.

PART C: DESIRED FUNCTIONALITY

PART D: TOPIC SPECIFICATION

**Topics Covered**

Taken from:

Calculus: Early Transcendentals Textbook, 7E. by James Stewart

Contemporary Linear Algebra 9E by Anton Busby

|  |
| --- |
| **Part A: Trigonometry (Appendix D)** |
| Basic Trigonometric Identities (sine, cosine, tangent, cosecant, cotangent, etc.) |
| Trigonometric Identities (Double Angle, Addition formulas, product formulas) |
| Trigonometric Identities of the Unit Circle |
|  |
| **Part B: Differential Calculus (Chapter 2 and 3)** |
| Limits & the Definition of a Derivative |
| Differentiation Rules of Basic Functions |
| Chain Rule |
|  |
| **Part C: Integral Calculus (Chapters 4 and 5)** |
| Definite Integrals |
| Indefinite Integrals |
| Substitution Rule |
| Integration by Parts |
|  |
| **Part D: Linear Algebra (Chapter 1 of Busby Textbook)** |
| Vectors |
| Vector Operations |
| Norm and distance for a vector |
| Dot product |
| Orthogonality & Orthonormality |
| Matrix Operations |
| Matrix Row/Column Elementary Operations |
| Inner Product of a Matrix |
|  |
| **Part E: Subsections (Various)** |
| Polar Coordinates |
| Complex Numbers |

**List of example questions**

|  |  |  |
| --- | --- | --- |
| Question | Possible Answers (for Multiple Choice) | Correct Answer |
| Which ratio gives the following trigonometric identity: |  |  |
| True or False: | True, false | True |
| Answer the following: | Various |  |
| True or False:  The tangent at point a represents the derivative as the limit of x approaches a. | True, False | True |
| Differentiate: |  |  |
| Integrate (assume there will be a constant): |  |  |
| Evaluate: |  | 11 |
| Compute: |  | 1 |

\*Note: These questions are only for discussion and verification purposes. The final product may or may not have these questions included.

APPENDIX A

Applications that contain similar systems to “Defense of Calculot”

**HKU Calculus –** HKU Calculus provides a similar idea to help students learn, and track their progress. They include text and video resources to aid the student in learning how to approach the topics being discussed.

Along with this, HKU Calculus also provides a Multiple Choice game to allow users to practice the theorems and methods they have learned from the application.

Google Play Store Link:

<https://play.google.com/store/apps/details?id=com.hkuscifac.hkucalculus&hl=en>

**Test Your LIMITS –** Test your limits include a Multiple Choice game around a theme of racing. This application focuses around the same topics as “Defense of Calculot” to help users practice calculus.

Google Play Store Link: <https://play.google.com/store/apps/details?id=com.jcweaver.calcLimits&hl=en>

How does “Defense of Calculot” differ from these applications?

**HKU calculus**

* While there are text and video resources for *HKU Calculus*, “Defense of Calculot” shall apply a more hands-on approach to the learning resources. There will be examples that will have a blank answer in which the user will input what they believe is the right answer.
  + Upon clicking the “finish” button, the android back button, or the implemented back button, the system shall check if all examples are correct.
  + If the examples are correct, the system will place a checkmark in in the topic outline, to signify that the user has “completed” the learning experience.

**HKU Calculus & Test your LIMITS multiple-choice Game**

* *Defense of Calculot* will be a more thematic approach to the multiple-choice game genre. While the core of the *Defense of Calculot* is a multiple-choice game, the implementation will provide a graphical and more interesting approach to the multiple-choice game genre.
  + Example: In “Adventure Mode” There will be monsters that will approach the user’s character. The user must click these monsters and answer the multiple-choice question. This interactivity provides an interesting approach to the genre.