Board #439: Work in Progress: Notebook: An AI-Based Personalized Learning Resource Tool

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Work in Progress
eNotebook: An AI-Based Personalized Learning Resource Tool

Abstract
Online STEM learning environments present novel learning challenges and require self-regulation of learning. To self-regulate learning, students must develop notetaking study strategies. Yet 49% of online students don't take notes, and roughly 70% don't complete course readings. eNotebook is a comprehensive online notebook app that enables students to develop study strategies and evaluate their performance for corrective measures. This study proposes to 1) pilot test eNotebook's AI-enhanced study features and 3) investigate how well eNotebook enhances self-regulatory efficacy in Ecampus and hybrid STEM courses. eNotebook was designed and developed by the PIs and EECS collaborators based on the prototype feedback of 140 University students during the Fall 2022 term. The results of this study are expected to inform AI-enhanced study methods and self-regulatory efficacy in Ecampus and hybrid STEM courses.

Keywords: AI-study app, STEM, personalized learning

Introduction

Although face-to-face STEM education has a 60% retention rate [4,5], online and hybrid education presents additional challenges due to significantly reduced interaction and feedback [1, 2, 3]. During the second week of Fall term 2022, we organized and hosted a "Learning how to Learn" event at the University. We invited a learning science specialist with over 25 years of experience to teach their study method to 220 University students. Although the students applauded the method, our post-event survey showed that very few students had adopted and applied the method. Students had found it time-consuming and difficult to apply or understand. The survey also revealed that successful students used various study methods and apps. The study method has changed little since its creation 25 years ago. Today's students now have Internet-based education apps, videos, social media, and access to a reservoir of books, prior homework solutions, publications, tutoring services, and AI-based tools. Regardless of the study method, a common denominator is the lack of student support for self-regulation of learning. Self-regulated learning involves developing and using learning strategies [6]. Students can self-regulate their thinking and learning through self-observation, self-evaluation, and self-reaction [6]. Self-regulation of learning influences a student's motivation strategies for sustaining or continuing engagement in learning [7]. Paul Pintrich, the leading figure in the field of self-regulated learning, believes that "self-regulatory activities mediated the relationship between the learner and their environment and influenced learners' achievements" [8, p. 86]. While remembering that one study app or method does not fit all needs, students must learn the principles of self-regulated learning and how to study to foster deep understanding. Although this initial pilot study was done within an in-person course, these problems are only compounded for online courses due to reduced personalized guidance, interaction, and feedback. Intentional thinking involves analyses of one's thinking. Students develop strategies or ways of thinking about the task at hand and the processes or strategies necessary to complete the task.

COVID-19's dramatic shift to remote learning left many students struggling in online learning environments. Online learning environments present novel challenges to students' self-regulation of learning [9, 10, 11]. Self-regulation of learning, among other things, requires that students

employ organized study methods such as notetaking [12, 13, 14]. Yet 49% of students reported NOT taking notes during online learning [15]. Furthermore, in a recent video published by The Higher Times Education (2020), Dr. Steven Mintz of the University of Austin stated that "roughly 70% don't complete the course readings." Such realities starkly contrast the positive correlation between self-regulated learning and student success in online learning environments [12, 13, 14].

This research aims to 1) pilot test eNotebook's study strategy features and 2) investigate how well eNotebook enhances self-regulatory efficacy in Ecampus and hybrid courses.

eNotebook

We have developed an online app called eNotebook as an AI-based learning resource that especially benefits students taking online or hybrid courses. Our eNotebook research group has exploited their experiences in online, hybrid, and face-to-face learning (and teaching) to implement eNotebook features that address some of their most pressing needs for learning and research. Listening to the wants and needs of 100+ University students who have taken online, hybrid, and face-to-face courses, including students who utilize Disability Access Services (DAS), we created an eNotebook to include a tutoring AI feature that students could talk to along with their favorite study methods. eNotebook provides a general platform for nearly all of today's study methods and materials students use to create and customize for efficient access and assessment. For example, we have implemented a two-way talking conversation feature called Jarvis, which is an audio-to-text / text-to-audio feature with a ChatGPT engine with AI-specific aids to improve the quality of AI responses. We have embedded weblinks to over 50 of the most popular study apps easily accessible through a pull-down menu, where favorites appear at the top of the list. We have implemented a feature that converts handwritten notes into typed text. Images, audio, videos, webpages, or other media types can be cloud-stored. Login is required to access eNotebook to enable tracking for present and future research education studies, such as surveying and correlating usage statistics with course performance. Since eNotebook is web-based, it is easily accessible through any web-enabled device, such as a PC, Mac, Smartphone, Tablet, etc.

From students' perspectives, eNotebook adds a whole new level of efficiency that combines all their apps and learning methods under one roof. For example, each term a new set of students who are learning the same material as students before had to go through the same process to find resources found by former students. However, eNotebook allows students to share their course materials with others using eNotebook now and in the future. This includes notes, homework problems, favorite instructional videos, study methods, etc. And students will be able to communicate with other students through eNotebook groups for questions, study groups, and team projects through embedded links to Teams, Discord, etc.

An example of how eNotebook is used as a personalized tutor for learning is as follows: After Jessica clicks the Listen button, eNotebook waits until it hears the activation word 'Jarvis' before it starts converting audio to text and then answering by converting text to audio. Jessica can choose a different voice for Jarvis or change the activation word if she isn't an Iron Man fan. **Figure 1** shows Jessica asking Jarvis for personalized help in catching up with calculus.

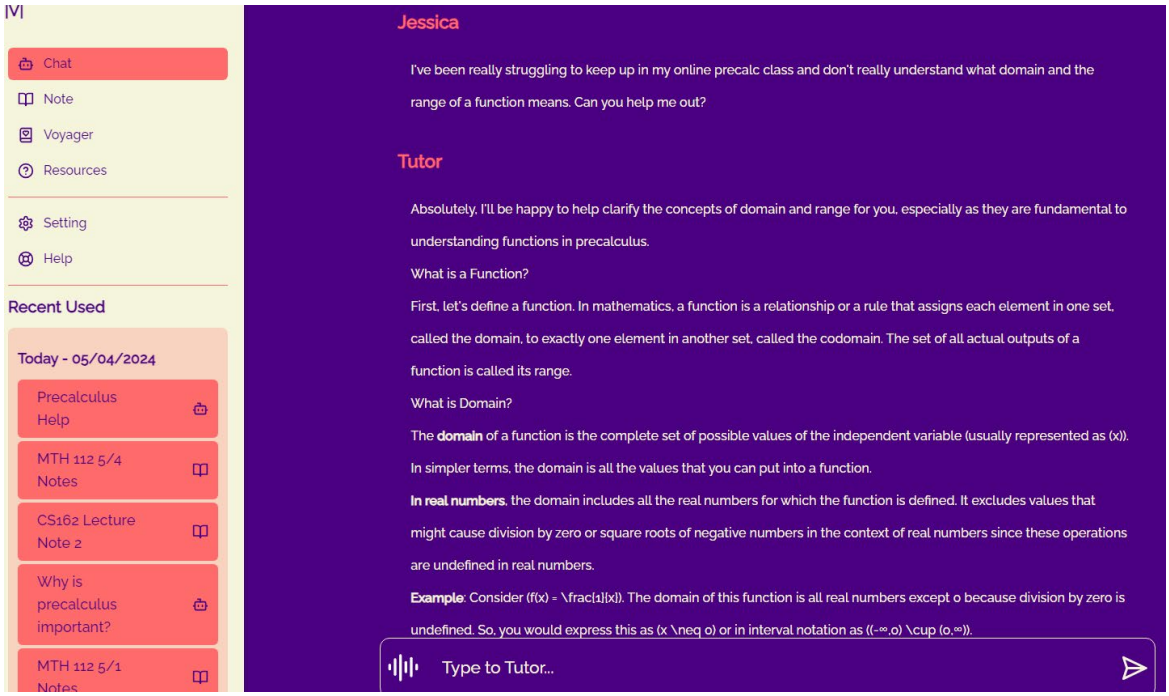

Figure 1: Tutoring example: A student using eNotebook to catch up with calculus. Note: Proper equation fonts are forthcoming.

While rote memory is useful and easiest to assess, true learning is often the most difficult to assess. eNotebook assesses if learning has occurred by assessing the student's real-time answer to how and why. This assessment is also timed and remembered by eNotebook for progress reporting and determining weaknesses. An example clip of an assessment taking place is played out in Figure 2. Figure 3 shows how we have implemented links to over 50 popular study apps identified by students. Students can extract their favorites or explore unfamiliar apps. Other AI-generated features like the Study Guide, Flash Card, and Practice Test are shown in Figure 4. Figure 5 also shows how eNotebook stores interactive communication, which is not available long-term in ChatGPT. This allows our tool to improve its personalization by keeping track of the student's interests and problem areas for full-term assessment and probing for long-term memory recall.

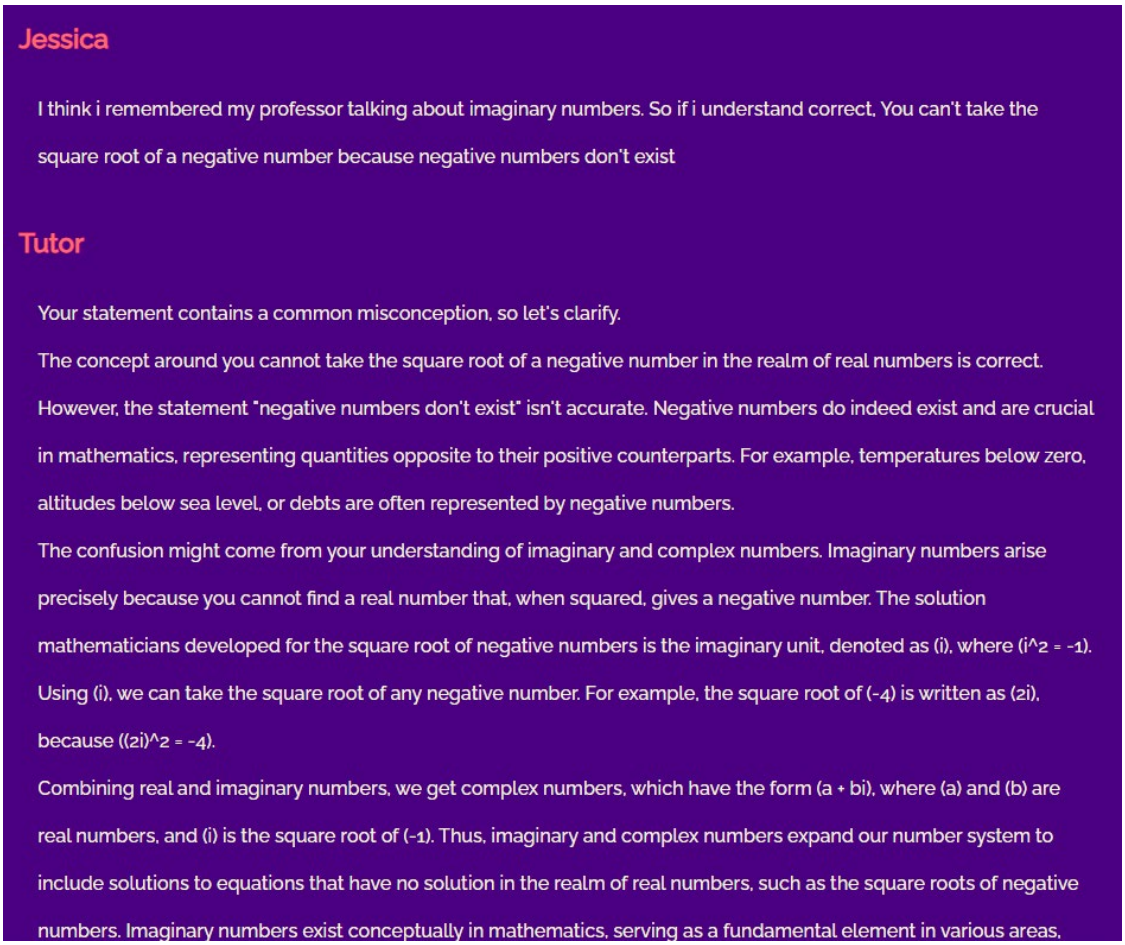

Figure 2: Learning assessment. eNotebook has the ability to test and assess if learning has taken place.

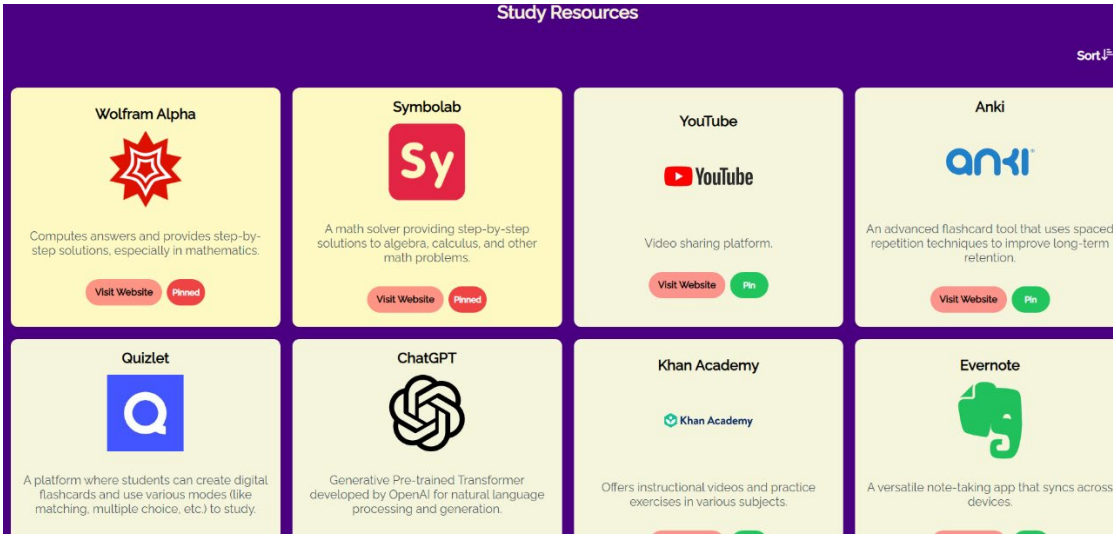

Figure 3. Embedded links. Favorites of over 50 popular apps that students have identified.

Question 1

Which operator is used to check if two variables are not equal in Python?
- A) =
- B) ==
- C) !=
- D) <=

Question 2

What is the correct way to start a for loop in Python?
- A) for i = 1 to 10
- B) for i in range(10)
- C) for (i=0; i<10; i++)
- D) for i in 10

Question 3

Which statement is used to handle exceptions in Python?
- A) handle
- B) error
- C) except
- D) check

Question 4

How do you install external packages in Python?
- A) npm install
- B) pip install
- C) brew install
- D) download

Question 5

What does the ** operator do in Python?
- A) Multiplication
- B) Power
- C) Division
- D) Root

Question 6

What module would you import to work with dates in Python?
- A) date
- B) time
- C) datetime
- D) timelib

Introduction to Python Lecture Notes

I. Overview of Python
- Definition and Background
  - High-level, interpreted language with a focus on readability and simplicity.
  - Created by Guido van Rossum and released in 1991.
- Why Python?
  - Versatility in web development, data analysis, AI, scientific computing, and more.
  - Strong community support and open-source libraries.
- Python 2 vs Python 3
  - Discussion on the differences and why Python 3 is the preferred version now.

II. Setting Up the Environment
- Installation
  - How to install Python on Windows, Mac, and Linux.
- Python IDEs
  - Overview of popular IDEs: PyCharm, VSCode, Jupyter Notebook.
- Hello World
  - Writing and running your first Python program.

III. Basic Syntax and Concepts
- Variables and Data Types
  - Integers, strings, floats, booleans.
  - How to declare and use variables.
- Operators
  - Arithmetic operators: +, -, *, /, %, **, //.
  - Comparison and logical operators: ==, !=, >, <, >=, <=, and, or, not.
- Control Structures
  - if, elif, and else statements.
  - Looping with for and while.

IV. Functions and Modules
- Defining Functions
  - Syntax, arguments, and return values.
- Importing Modules
  - How to use standard library modules like math, datetime.
  - Importing external libraries using pip.

V. Practical Examples
- Example Project: Building a Calculator
  - Step-by-step code to create a simple calculator.
- Example Project: Data Analysis
  - Using pandas and matplotlib to analyze and visualize data.

Study Guide: Introduction to Python

I. Introduction to Python
- Understand the basics:
  - Know what Python is, its history, and why it is popular.
  - Understand the difference between Python 2 and Python 3, and why Python 3 is preferred.

II. Setting Up the Environment
- Installation:
  - Practice installing Python on different operating systems.
  - Experiment with different IDEs (Integrated Development Environments) like PyCharm, VSCode, a
- First program:
  - Write and run a simple "Hello, World!" program in Python.

III. Basic Syntax and Concepts
- Variables and Data Types:
  - Learn about different data types (integers, strings, floats, booleans).
  - Understand how to declare and use variables.
- Operators:
  - Familiarize yourself with arithmetic operators (+, -, *, /, %, **, //) and their uses.
  - Learn about comparison and logical operators (==, !=, >, <, >=, <=, and, or, not).
- Control Structures:
  - Understand how to use if, elif, and else statements for decision making.
  - Learn the syntax and application of for and while loops for iterating over sequences.

IV. Functions and Modules
- Functions:
  - Practice defining functions with different parameters.
  - Understand the importance of return statements.
- Modules:
  - Learn how to use built-in modules like math and datetime.
  - Get comfortable using pip to install and use external modules like pandas for data analysis.

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Figure 4: AI generated Study Guides / Flash Cards. Embedded links of popular flashcard apps like Quizlet are also available.

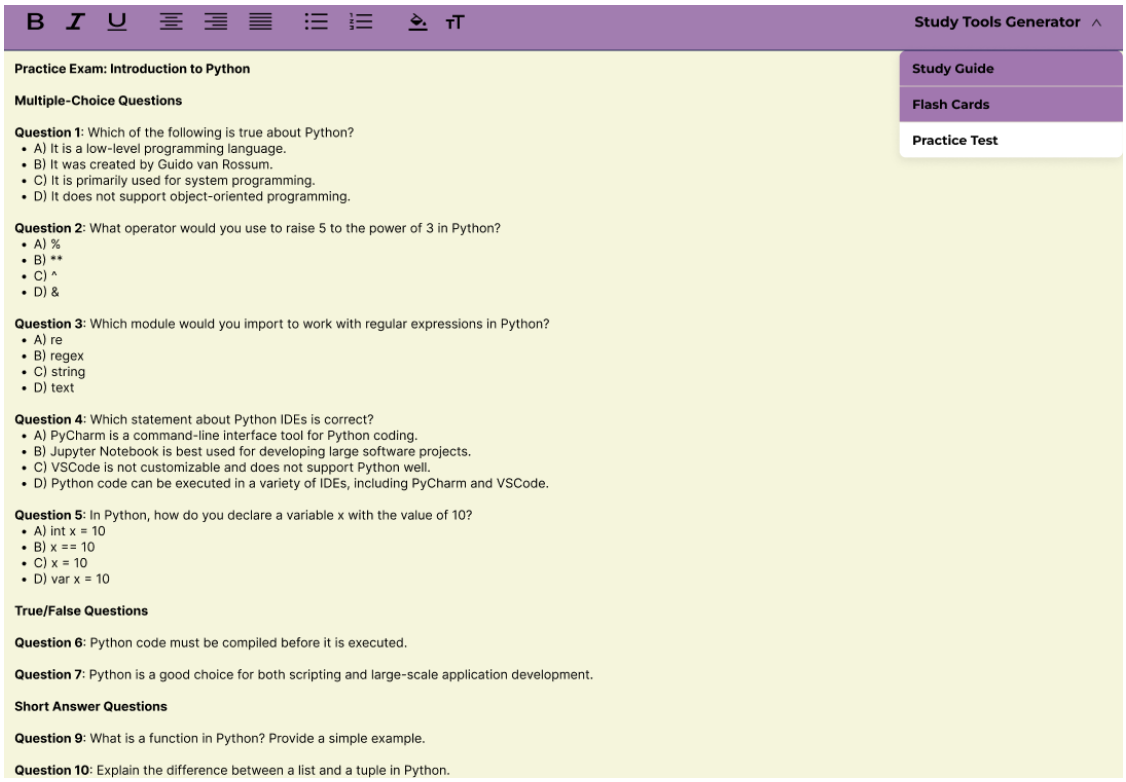

Figure 5: Practice test / Interaction memory. An unlimited number of practice tests can be generated over any range of dates within the term based on the student's interactions since the beginning of the term.

It is important to note that since not all students know how best to interact with AI-based tools, we have improved the process (behind the scenes) through the method of iteration and modifying the question posed by the user to achieve a higher quality answer, and loading relevant text along with the learner's question (such as a chapter's worth of material) to better refine the response to the student. We also implement frequent and customized Q&A buttons, such as simplifying a response, providing prerequisite information, providing a real-world example, etc. The customization buttons allow the user to provide their own frequently asked questions, such as "Explain it to me like I'm a 5-year-old".

Study impact includes feedback from eNotebook's usage analytics, where automated personalized quiz scores will be correlated with tracked study habits, and suggested changes will be offered by eNotebook to improve academic performance. Templates from various study methods will be available, as well as shared libraries of student-customized versions of eNotebook with or without course materials.

No known studies have investigated integrating self-regulated learning methods in an app such as eNotebook. No known app also offers templates of widely used study methods for encoding and storing study notes (two aspects of studying arguably most relevant).

Methods

Research questions are as follows: (1) What are some desired and effective features of eNotebook that can be used to incorporate eNotebook into Ecampus and hybrid STEM courses? (2) What are students studying pain points addressed by eNotebook? (3) How does eNotebook enhance self-

regulatory efficacy learning in Ecampus and hybrid courses?

Guided by Nielson's (1994) usability inspection methods, usability testing will be done through focus groups to explore participants' perceptions of the user interface design, identify design problems, and uncover areas to improve the user interface and user experience in Ecampus and hybrid courses (RQ1). A heuristics evaluation [16, 17] of the user interface will be conducted to ensure that usability principles are followed to provide a user interface with inclusivity and accessibility (RQ2). A Likert scale will be adapted from Bandura's (1989) Multidimensional Scales of Perceived Self-Efficacy [18] to explore participants' self-regulatory efficacy (RQ3).

Planned Intervention

The proposed study will combine elements of both exploratory and quasi-experimental research designs. The usability testing of eNotebook's user interface design and the piloting of eNotebook's study strategy features involve exploratory research elements. The investigation of how well eNotebook enhances self-regulatory efficacy in Ecampus and hybrid STEM courses will involve a quasi-experimental design where we compare the outcomes of two groups (a control group and an experimental group). Students who consent to participate in the study will be split into either a control or experimental group.

Participants

Participants will be undergraduate students enrolled in ENGR 100—Automating the Future I and ENGR 102—Automating the Future II. Based on previous participation by students taking these courses, we can expect nearly half (about 122) of the students to participate, which is more than an adequate sample size for all the measures proposed.

Expected Outcomes

The proposed study is expected to yield the following outcomes: (1) A tested prototype of eNotebook; (2) A user interface usability evaluation of eNotebook's user interface to include user inclusivity and accessibility design features; (3) Content to include Ecampus and hybrid STEM course learning materials that support self-regulated learning; and (4) Data indicating how self-regulated learning can enhance Ecampus and hybrid STEM students' efficacy in self-regulation of learning.

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