FURI Proposal for Fall 2018

Interactive Adaptive Learning Systems: Algebra Made Wonderful 2.0!

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Main Goal. The primary goal of this work is to implement a fun and engaging tool that would help effectively teach a critical front-of-the-engineering-pipeline course: algebra. The proposed work will build upon our Spring 2018 FURI 1 work.

Features Implemented During FURI 1. During the Spring 2018 FURI 1 work, we designed and implemented our Algebra Made Wonderful iOS learning application. The purpose of the app is to seamlessly bring fun interactive gaming and research-based learning principles together to provide an enhanced learning experience that can be accessed anywhere in the world at any time.

So far, the app has the following capabilities:
- User individualized login/password
- Three main menu options:
  - WORK: this portal permits students to learn and practice their skills through online media and quizzing; tokens can be earned as students progress through the material;
  - PLAY: this portal permits students to play games and navigate through different levels - earning tokens as they progress;
  - SHOP: this portal permits students to use the tokens they have earned through the WORK and PLAY portals to buy incentives; e.g. advanced characters with significant powers (e.g. aerospace engineer, chemical engineer, biologist, etc.), valuable weapons, etc.;
- Notifications/Alerts: students can set notifications to practice skills and schedule alerts to be sent to their phone. Spaced practice is critical for “making it stick” [2], [4], [8], [11].

Proposed FUR 2 Work. This proposed FURI 2 project (Fall 2018) aims to grow the application and expand its reach. Currently, the Algebra Made Wonderful learning app covers (1) systems of linear equations and inequalities and some (2) quadratic functions and equations [9]. We intend to increase this coverage by adding polynomials and factoring. Additional features will be added to further integrate the research-based learning ideas from [2], [4], [8], [11].

Objectives: Guiding Principles. Toward the above goals, we will continue to follow core guiding principles that incorporate effective research-based learning principles [2], [4], [8], [9], [11]:
1) Motivation - Capture Imaginations: Concepts will continue to be well motivated - students are encouraged to earn tokens and buy new characters with unique capabilities; while doing so students are introduced to how the concepts they are being taught will translate to potential STEM careers;
2) Level Assessment: Self-regulated quizzing will encourage the student to test their level of achievement and they will be rewarded with tokens for their investment in their learning. As the student passes quizzes and earns tokens they will be able to buy more advanced characters (and capabilities) that will extend their reach within the game;
3) Quiz-Based Modules: Students will be able to choose to go to WORK and earn more tokens which can be used to buy items and characters from the STORE within the app. During their WORK, they will go through modules where they will be taught valuable techniques to help them learn new algebra concepts through on-line resources (e.g. Khan Academy, etc.) and shortly after, they will be quizzed on their ability to retain these concepts;
4) **Thorough Finest-Grain Coverage:** Central concepts should be covered thoroughly - a finest grain approach so “nothing important is overlooked;”

5) **Feedback:** Student quiz results will provide targeted feedback to the student after “goal-directed practice” [2], [4], [11];

6) **Interactivity:** Modules should be interactive multimedia; learning should be active whereby students are “doing” - not just reading; here, interactivity and multimedia are intended to adequately address distinct learning styles; e.g. (1) visual, (2) auditory, (3) verbal, (4) physical (using arrow keys), (5) logical (sequential), (6) social (group), (7) solitary;

7) **Spaced Quiz-Based Practice:** Learning will be primarily based on interactive “spaced” quizzes as discussed within the research-based foundational publication: Make It Stick: The Science of Successful Learning [4]; here, the term “spaced” is intended to allow a little time for forgetting in order to force students to try and recreate what was forgotten, strengthen neural connections and transfer knowledge from short- to long-term memory [4]; quiz-based calibration helps realign and consolidate learning; it helps one focus on central precepts; identify weaknesses, arrest forgetting and pursue mastery;

8) **Interleaving (Mixing) Relate Topics:** Reviewing a mixture of topics rather than “blocked practice” helps one better prepare for the real exam – just like taking random pitches during batting practice helps one better prepare for hitting during a real baseball game;

9) **Career-Steering/Shaping Projects:** Each module should point to relevant career-steering/shaping projects that students can pursue; this permits students to explore how the material is applied in practice;

10) **Critical Reminders – Time Management:** Students are reminded what to do and when to do it – consistent with teachings in Dr. Donna O. Johnson’s Guaranteed 4.0 Learning System [8]; this includes reading ahead and bullet pointing what you’ve read; reading ahead opens up your mind to the subject when the material is covered; it also includes: summarizing a module with bullet points; summarizing a graded quiz – why items were correct and wrong – emphasizing key concepts;

11) **Climbing Bloom’s Learning Pyramid:** We want all learners to climb Bloom’s taxonomy pyramid (1956) [10]. A bottom-up mnemonic for this climb is RESTED: (1) Remember, (2) Explain, (3) Solve, (4) Test, (5) Evaluate and (6) Design.

**Technical Details.** All programming will be in Swift/Xcode [12].

**Partners Across Arizona: Planned Surveys.** Currently, Dr. Rodriguez is the principal investigator (PI) of a 5 Year, $5M NSF S-STEM funded Academic Success and Professional Development (ASAP) scholarship program. I am a scholar. Each scholar is required to work on a career-shaping project. The partnership directly involves the following 9 community colleges (CCs): Mesa, Phoenix, Estrella, Glendale, Central Arizona, Cochise, Eastern Arizona, and Yavapai. Partners on another NSF learning-based effort include the above and the following CCs: Arizona Western, Pima, Scottsdale, Paradise Valley, and Chandler-Gilbert. At each of these schools, we have 1-3 algebra instructors that will provide significant feedback. Surveys will be collected from students at ASU and from the above 14 partnering CCs. Dr. Rodriguez and three graduate students are IRB CITI certified.

**Final Demonstration and Reporting.** The final demonstration will involve exhibiting essential app characteristics and presenting survey results from scholars in Dr. Rodriguez’ NSF ASAP program. All project results will be documented within a final comprehensive report and on the required final poster. The work will also be submitted for publication within the proceedings the Frontiers in Education (FIE) Conference. Other publishing venues will also be considered.

**Career Relevance and FURI Advisor.** The proposed project will serve as a step toward my immediate goal of earning a BS in CSE and then an MS so that I can pursue an educational software development career. Dr. Rodriguez has supervised over 50 graduate theses – many in the relevant area of interactive learning and visualization. The proposed FURI will permit me to work with Dr. Rodriguez alongside a team of highly motivated graduate and undergraduate students – many working on problems related to learning. I look forward to working close with him and his students over the next few years.
References:


[3] Barbu, Marian; Vilanova, Ramon; Lopez Vicario, José; Pereira, Maria João; Alves, Paulo; Popdora, Michal; Ángel Prada, Miguel; Morán, Antonio; Torreburno, Aldo; Marin, Simona; Tocu, Rodica (2017) - Data mining tool for academic data exploitation: literature review and first architecture proposal. Bragança: Instituto Politécnico. ISBN 978-972-745-228-6


The following timeline will be followed to guide the proposed Fall 2018 FURI project developments.

Week 1 – 3  Complete background research i.e. books, academic journals, theses, etc.

Week 2 – 9  App/Software design and programming on Xcode Apple Developer

Week 9 – 10  App Initial Quality Assurance Testing by advisor Dr. Armando A. Rodriguez (Professor of Electrical Engineering)

Week 10 – 15  Further App/Software design and programming on Xcode Apple Developer

Week 12 - 13  Final App Quality Assurance Testing

Week 11 – 15  Prepare poster for presentation at FURI symposium
Document all results in final comprehensive report