Simple Adaptive Learning: Explorative Paper

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(For peer review only)

A technical means to achieve higher quality at lower costs will soon be available in the form of adaptive learning, such as seen in the Knewton or ALEKS homework platforms. This paper explores the nature of future education. More students will develop a clear understanding of higher mathematics.

Adaptive learning should be by definition an inquiry-based process. Deep learning is individually focused though self-directed inquiry. Thus combining adaptive learning technology with deep learning methods is reasonable. This paper explores how adaptive learning, self-directed inquiry, Goal Oriented Guided Inquiry Learning, and deep learning might be simplified using common elements.

The study of inquiry-based programs involves us in differences between the disciplines; as well as differences between target sub-populations. For example, implementations of self-directed inquiry, of the R. L. Moore type, are unknown at two year technical or community colleges. Process Oriented Guided Inquiry Learning (POGIL) is specific to chemistry. Adaptive homework platforms are still experiencing software flaws.

Dr Lisa De Castro, at Florida Southern College, is developing pre calculus and calculus one content using POGIL. In fact the college as a whole has adapted various levels of inquiry pedagogy. This orientation suggests to me that integration of POGIL with some elements of R L Moore type inquiry methods is desirable.

My goal is to combine deep learning methods with inquiry methods for freshman courses. This objective faces layers of complex barriers. Commercial adaptive platforms support hybrid online and face-to-face courses for entry courses; mathematics, English, history and literature. These types of platforms are being extended to provide unique next generation learning environments for students in many undergraduate courses. So markets are attempting to move, at least within the constraints imposed when assessment is primarily based on measures of skill.

Adaptive learning platforms have layers of depth. Partially for this reasons, the initial use of these platforms is often incompletely accomplished. Reflect about why this is. Are there not deep philosophical differences between how adaptation to individual needs must occur, and traditional instruction in freshman mathematics courses? This explorative paper examines some of the consequences arising from these differences.

In particular, we explore concerns about instruction directed too narrowly towards skills without a balanced focus on conceptual understanding. Cultural considerations suggest a need for improved performance from traditional learning methods. Our theory suggests that conceptual understanding improves over all skills; reducing the difficulty some students have with required higher mathematics.

Simplifying Adaptive Learning

In most situations adaptive learning is first introduced to support STEM majors. This may be the easiest path since STEM courses involve a motivated audience. Even with this audience, adoption of adaptive learning for mathematics in colleges and universities is rare.

We make the argument that a significant cultural challenge lies in providing improvements to non-STEM courses. For example, increased conceptual understanding may be expected to increase enrollment in higher-level mathematics courses. Benefits arising from successful implementation in pre-calculus and calculus may also be something for future research to address.

Regardless the target audience, adopting a full platform is likely not a good first step. Adaptive learning software is not yet perfect, and individualizing aspects are a departure from how things are done today.

A process of familiarization is needed to acquire an understanding about methods and consequences. This process must occur over a period of some years.

Let us suppose that individualizing adaptive learning is to be adopted for freshman mathematics courses. Suppose further that a three-year adoption period is agreed to. After the first year, grant proposals are to be developed.

Supplemental Pedagogy within Social Media

Adoption of a simple adaptive component would involve several steps. Because of depth-of-change is involved, an academic committee must be formed and provide oversight.

The central questions for the committee are about how to bind together many sections of freshman core courses using adaptive methods while retaining traditional structure to how coursework is presented in the classroom.

Learning Objectives: Additional student learning objectives might be developed. Traditional objectives would be complemented with the following two:

1) ***Self-directed Inquiry:*** The student will be able to write descriptive narratives about three core concepts, of the individual's choosing.
2) ***Familiarity of Content:*** Students will be able to list the majority of core topics from memory.

These two additional learning objectives are consistent with the intent of adaptive learning theory and practice. Both require an internalization of content in a creative and individualizing fashion. Learning objectives such as these focus on measuring value added in appropriate behavioral dimensions.

Independence and Choice

Individual Choice: An explanation of a specific pedagogical method is illustrated in the following pages. The method requires individual choice as an enabling factor. The approach is social and should involve both digital and physical places where participating students might exchange moderated interactions.

The means through which guidance occurs is via handwritten notes scanned and sent via email. Introduction workshops are seen as necessary, but must be attended to during non-classtime hours. Separately scheduled deep learning workshops introduce students to note taking and study skills.

Participating students improve grades on skill-based tests. They have increased satisfaction[1]. But at least initially recognition of value is best achieved if the individual is free to say no, and work towards success using other means. Student expectation about what to expect in the math class is not only high, but is sometimes charged with anxiety.

The use of a course management system is proposed as a virtual home for students who choose to participate. Small study groups are also encouraged so that socialization is occuring outside the classroom.

Separated Function: Under the model suggested below, individualizing guidance is provided, outside the classroom. The model assumes a support role to traditional classroom instruction and that individual instructors are not receiving grading information from a supplemental resource.

This type of separation is similar to what we have in math labs, and in department sponsored tutoring sessions. The difference includes our use of handwritten topic descriptions and a simple form of social media.

[1] According to a poll for thirty-two students in a business algebra course enrolled spring semester 2016. See private data in Prueitt's data bases.

Sense of Location

Central to understanding deep learning methods are the concepts of 'sense of location' and 'action-perception cycles'. These concepts are found in a simplified adaptive learning program, discussed in the appendix. They are also central to commercial adaptive learning platforms and have a foundation in emerging theory about learning science.

Deep learning is advanced using four steps that produce topic trajectories. Other insights are included in presentations to students who develop trajectories. A private social media may be developed to support a cultural re-enforcement of these insights.

Not all students will want to engage in developing trajectories, but some will and for this sub-population we may see a significant improvement in skills based test outcomes.

A faculty member or mentor will look at handwritten expressions from students and quickly tell what type of exercises this student should look at next. Of course there are always choices; should I recommend this or that? These choices provide flexibility as the class collaborates in the development of descriptions of the topics in the curriculum.

Topic descriptions are handwritten and may be posted into private social media as the course proceeds, making the postings a type of volunteers' game. Peers will communicate with peers. It is reasonable to expect that twenty percent of students will immediately want to participate. Success will be measured if seventy percent participate. Participation is voluntary for a variety of reasons.

Grades continue to be primarily earned by standard myMathLab generated tests. Again, the committee may discuss the reason for this feature. However, the nature of self-directed inquiry may be enhanced when a legitimization of learning for the sake of learning is part of the cultural experience.

We expect to see student enthusiasm similar to what was expressed by my students at Texas State University. Increased grades on more difficult standardized tests are expected.

If a student has taken responsibility for clearly communicating about what he or she is comfortable with and what not; then mentors will have a clearer understanding about how to help that individual.

Summary

Freshman mathematics courses present personal and cultural challenges that are difficult to overcome. A gap between student expectations and the reasonable expectations of university mathematics faculty members has been increasing.

A parallel and supplemental non-technical adaptive learning resource could be a game changer for freshman mathematics. However, cost constraints prevent across the campus implementation of supplemental programs based on the use of adaptive learning software. Deep learning methods are also not uniformly implemented due to variation in teaching styles.

We reflect a belief that freshman mathematics is a proper place to focus instructional models that use adaptive learning methods. However, we recommend that adaptive methods be first introduced as a supplement from outside the classroom. Additionally, we suggest that deep learning methods provided a means to make adaptation focused on individual decisions rather than on a top down regime of instruction and testing.

Inquiry based learning places primary responsibility on the shoulders of students. Asking a question and then answering this question is central to self-directed inquiry. Increases in standard testing outcomes are the surest way to demonstrate superior methodology. Thus participating students should not earn extra credit. The goal is to improve the individual's study habits through the use of adaptive learning methodology. The student must demonstrate skill in the traditional fashion.

A change in perception is sought.

Students are taught how to write about topics. Individuals more readily communicate with peers and teachers. These outcomes happen quickly with results that are demonstrative of a key belief.

Our students learn far more and retain longer core topics in college level freshman mathematics. They also change long held false viewpoints about the value of mathematics.

A proposed simplification involves learning to write about topics in the curriculum. Writing becomes a source of communication with the teacher and with peer mentors. How might adaptive learning involving higher quality communication might be implemented?

The following pages make the case that an inexpensive and feasible pathway exists.

Thank You ... PSP

Short Appendix

Creating Action and Perception Cycles

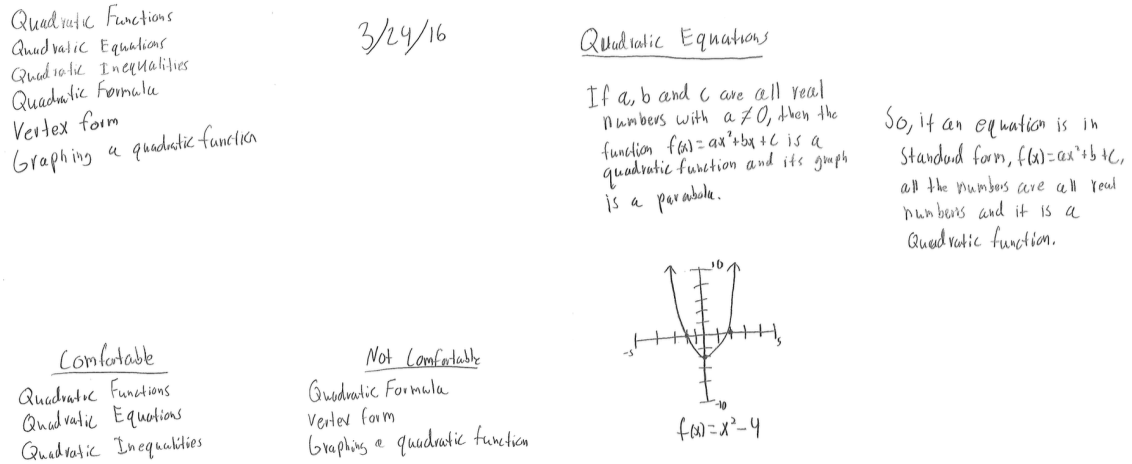
An action-perception cycle reflects some of the physical reality involved with human awareness. Technology in social media has been attempting to produce a digital technology that adaptively assesses what the individual wants, via his or her 'location' in some type of representation space.

A proper assessment creates a digital profile that is then useful in recommending to the individual something to buy, or to otherwise consume. However, as pointed out; mentors are easily able to make the type of assessment needed; if the student is able to communicate well.

Deep learning methods produces an internalization of elementary notions in a mathematics curriculum. Internalization occurs for those who are being successful, and not occurring for those who are not being successful in class.

Over the years, motivation has been to have a means whereby the individual, him or herself, could communicate where he or she is 'located' in a representation of the topics in the curriculum. The act of doing the first trajectory starts a process which if continues changes the success for that individual in math class.

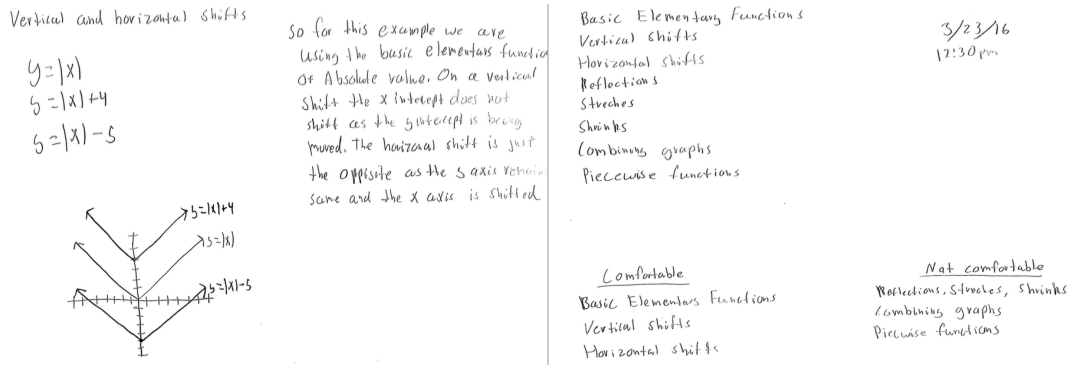
The following screen shots is from one topic trajectory series produced by students during the month of March 2015.



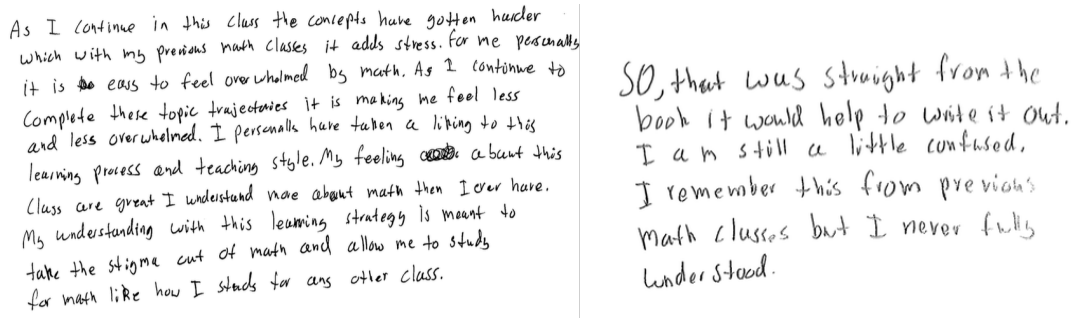
Illustrations of first and second step in creating a Trajectory

A student creates a list of topics, and then separates this list into two parts. Then, following instructions, this student wrote about what he is comfortable with.

The process of selecting the 'most challenging topic' has great pedagogical value, since the individual has to make the list on his or her own, and to make the selection based on his or her own realizations. By listing topics and making presentations there are repeated internalizations of parts of the curriculum.



A student then selects one of the topics he or she is not comfortable with and writes about this topic and concerns.



A blog type entry is made. Here he expresses how he feels, about math and about the class.

Asking the student about how he or she feels

In this final statement he, or she, again expresses a desire to learn, but also a sense of being hopelessly lost in math class. This sense is a common experience for incoming freshman students.

The expression of this sense of being hopeless may be therapeutic. Adaptive learning has the potential to create knowledge profiles compatible with platforms like the Knewton platform. The various senses about self and self-efficacy are not found from predictive analytics based only on multiple-choice tests. However, trajectories communicate a wider range of personality types, including feelings about math class.

A human review of trajectories quickly produce subjective understanding of common behavioral characteristics faced by incoming freshman students. This type of information is emerging from research in education and is being added to platforms like Knewton.

Subjective understanding is similar to what one would expect in a knowledgeable mentoring relationship. In many cases, a transformation is possible in how the individual sees his or her ability to orient towards topics under study.

Deep Learning and Technology

My definition of "learning media' is directed at producing individualizing recommendations based on a quick analysis of a student's submitted trajectory. The student him or herself is doing the work of a 'perfect' assessment/recommender software program – if such a perfect set of algorithms existed.

Now we come to an important point.

Our initial work does not depend on algorithms, or technology. Our architecture for receiving and responding to trajectories moves a short way along a pathway towards integration with the Knewton platform. How learning media might be set up is consistent with the internal workings of Knewton's knowledge representation spaces.

What algorithms might do is what mentors do easily. In fact if mentors are peers, the 'game' becomes exciting and novel. Part of the innovation that I am suggesting creates this peer-to-mentor dialog.

When a very simple social media is implemented and trajectories start to flow from individual students, faculty members produce recommendations about what the 'next assignment' is. Gradually part of the responsibility is shifted to peers and to mentors.

It is critical to make membership in learning media supplemental to attendance in face-to-face courses. We should also have digital and physical locations, where students might socialize. The two worlds, digital and physical, work together.

On the Horizon

Not yet in our long history might anyone from anywhere enroll in a college and be individually guided. A number of embedded issues are involved: how to measure learning, how to provide interventions when behavior is not positive learning behavior, and others. Individualized adaptive learning programs are the obvious answer, but there are costs concerns.

A deep learning model addresses cost concerns. The learner takes responsibility for learning rather then continuing to be a passive observer. This shift from passive to active learning is correct pedagogically, but also makes technology support requirements much easier to obtain.

Commercial adaptive learning's core enabling feature is a topic level representation of a curriculum. This representation is constructed to parallel the official outline of a course syllabus. An experienced teacher will have this representation in mind. Degree programs implicitly use a topic level representation to make the connections between different required courses.

Trajectories [2] [3] [4] are a means by which an individual student tells the instructor his or her location within a curriculum. Because the individual is doing the work, adaptive algorithms have far less to do; and proprietary software is not needed.

When freshman have difficulties with college level curriculum, there are often barriers to learning. Many of these are based on predictable consequences from past experiences. Part of required peer mentorship is recognition of barrier types. Knowledge of category type, as expressed in adapting profiles, enhances mentor capacity.

Enhancement takes on various forms. For example, realizing an individual has testing fear may be addressed trough specific adaptive methods. Methods include confidence building while holding expectations high. Success is found by being a member of a class of individuals who are each finding success.

Mentors play a key part. By providing training in deep learning methods and adaptive theory, advanced students demonstrate more than has been expected. Mentor contributions reduce workload on faculty while creating online monitored peer-to-peer social interaction.

Trajectories and peer mentoring individualizes learning as a supplement to regular traditional classroom instruction. Providing access to a solid conceptual foundation deepens learning. Due to these consequences, cost for provision of freshman mathematics instruction goes down.

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[2] Paul Stephen Prueitt (April 17th 2015) A New Data Source for Design-Based Research on Deep Learning Strategies, presentation to the Mathematics Education Seminar at Texas State University

[3] Paul Stephen Prueitt (Feb. 6th 2015) Deep Structure Architecture for Machines and Humans, presentation to the Mathematics Education Seminar at Texas State University

Paul Stephen Prueitt (February 2015) Deep Architecture for Human and machine Learning, seminar presented at Computer Science Seminar at Texas State University

[4] Prueitt. Paul Stephen (June 23, 2014) Individually Directed Inquiry. R L Moore Legacy Conference 2014, Denver CO.