

**Mastery of Mathematics**

**with**



**A White Paper**

**February 2007**

# **Table of Contents**

ALEKS: Research Brought to Life

Quantitative Data for ALEKS

Louisiana Technical University

Black Hills State University

Boise State University

The University of Memphis

ALEKS Course Products Available for Higher Ed Mathematics

## **ALEKS: Research Brought to Life**

### **WHAT IS ALEKS?**

ALEKS is a web-based, artificially intelligent assessment and learning system. ALEKS uses adaptive questioning to quickly and accurately determine exactly what a student knows and doesn't know in a course. ALEKS then instructs the student on the topics she is most ready to learn. As a student works through a course, ALEKS periodically reassesses her to ensure that topics learned are also retained. ALEKS courses are complete in their topic coverage, and ALEKS avoids multiple choice questions. So a student who shows a high level of mastery of an ALEKS course will be successful in the actual course she is taking.

ALEKS also provides the advantages of one-on-one instruction, 24/7, from virtually any web-based computer for a fraction of the cost of a human tutor.

### **HOW DID ALEKS ORIGINATE?**

ALEKS is a ground-breaking technology developed from research at New York University and the University of California, Irvine, by a team of software engineers, mathematicians, and cognitive scientists with the support of a multimillion-dollar grant from the National Science Foundation. ALEKS is fundamentally different from previous educational software. At the heart of ALEKS is an artificial intelligence engine that assesses each student individually and continuously.

ALEKS is based upon original theoretical work in a field of study called "Knowledge Space Theory." Work in Knowledge Space Theory was begun in the early 1980's by Dr. Jean-Claude Falmagne, an internationally known mathematician and Professor of Cognitive Sciences who is the Chairman and founder of ALEKS Corporation. See: [http://www.aleks.com/about\\_aleks/research\\_behind](http://www.aleks.com/about_aleks/research_behind)

### **HOW DOES ALEKS WORK?**

ALEKS avoids multiple choice questions and instead offers flexible and easy to use answer input tools which mimic what would be done with paper and pencil. When a student first logs on to ALEKS, a brief tutorial shows him how to use these ALEKS answer input tools. The student then begins the ALEKS Assessment. In a short period of time (about 45 minutes for most courses), ALEKS assesses the student's current course knowledge by asking him a small number of questions (usually 20-30). ALEKS chooses each question on the basis of the student's answers to all the previous questions. Each student, and therefore each set of assessment questions, is unique. It is impossible to predict the questions that will be asked.

By the time that the student has completed the assessment, ALEKS develops a precise picture of her knowledge of the course—which topics she has mastered and which topics she hasn't. The student's knowledge is represented by a multicolor pie chart.

The pie chart is also the student's entry into the Learning Mode. In the Learning Mode, she is offered a choice of topics that she is ready to learn (she has the prerequisite knowledge to successfully learn these topics). When she chooses a topic to learn, ALEKS offers her practice problems that teach the topic.

These problems have enough variability so that a student can only get them consistently correct by understanding the core principle defining the topic. If a student doesn't understand a particular problem, she can always access a complete explanation. Once she can consistently answer correctly on the problems for a given topic, ALEKS considers that the student has learned the topic and the student chooses another topic to learn. As the student learns new topics, ALEKS updates its map of the student's knowledge-- the student can observe the most current summary of what she knows and what she is ready to learn.

To ensure that topics learned are retained in long-term memory, ALEKS periodically reassesses the student—using the results to adjust the student's knowledge of the course. Because students are forced to show mastery through mixed question assessments that cannot be predicted, mastery of the ALEKS course means true mastery of the course.

### **WHAT ARE ALEKS' LEARNING RATES?**

ALEKS keeps a statistic to measure students' learning success – namely, how often students succeed at learning a topic that ALEKS offers them as "ready to learn." ALEKS Corporation keeps server statistics on the learning rates of students for topics in ALEKS. When ALEKS determines that a student is ready to learn a topic, the student is able to learn it a very high percentage of the time. In the small percentage of cases where the student is initially unsuccessful, the topic is presented again to the student later on. Because of the artificial intelligence of ALEKS, students are almost always successful at learning the material ALEKS offers them. (The level of instructor involvement doesn't affect this.)

The Average Historical Student Learning Rates with ALEKS are ~90%.

No other educational software keeps such data. If they did, what are the chances of this type of success?

### **WHAT ARE SOME OTHER FEATURES OF ALEKS?**

- ALEKS avoids multiple choice questions. All questions are algorithmically generated and require a free response.
- Whenever the student reenters the system after a break, she automatically returns to the place she was last working. This is true even if the departure was caused by unexpected loss of connectivity on the Internet or a computer crash.
- ALEKS offers a comprehensive message center that allows the student to communicate with her instructor about the content using subject-appropriate notation.
- ALEKS now offers Textbook Integration Plus for superior alignment with specified textbooks or custom syllabi. Textbook Integration Plus supports instructor chosen chapter ordering, dates for intermediate objectives, and easily managed homework and quizzes.

## **Quantitative Data**

**Louisiana Technical University**

## Implementation

ALEKS was used as a supplement for Calculus I and II. The Calculus courses at Louisiana Tech include precalculus material such as algebra and trig. Students are required to use the program outside of class for at least three hours a week and must make six percent progress in ALEKS each week. Student progress is checked weekly.

## Results

In Math 240 (Calc I), 91% of students who used ALEKS for 23 ½ hours or more during the term (107 students) received an A, B, or C. Only 9% of these ALEKS users received a D or F or withdrew from the course. Only 55% of students using ALEKS less than 23 ½ hours (218 students) received an A, B, or C, and 45% received a D, F, or withdrew from the course.

In Math 241 (Calc II), students who used ALEKS (30 students) were compared with students who did not use ALEKS at all (45 students). 90% of students who used ALEKS received an A, B, or C, and only 10% received a D, F, or withdrew from the course. Of the students who did not use ALEKS, only 53% received an A, B, or C, and 47% received a D, F, or withdrew from the course.

## Contact Information

For more information about this study, please contact Dr. Ruth Ellen Hanna, at (318) 257-2538 or [rhanna@coes.latech.edu](mailto:rhanna@coes.latech.edu)

A paper on this study was presented at the 2006 ASEE Annual Conference.

Please see: [http://www.me.nmsu.edu/~aseemath/2465\\_carpenter\\_06.pdf](http://www.me.nmsu.edu/~aseemath/2465_carpenter_06.pdf)

## **Black Hills State University**

### Implementation

ALEKS was used to replace traditional homework assignments in a college algebra course at the university. Four sections of the course used ALEKS (the experimental group) and four sections of the course were taught in a traditional manner (the control group). Students (a total of 251) were randomly assigned to one group or the other.

### Results

Three of the four ALEKS sections dramatically outperformed the control groups in gains between the pretest and the posttest. (The exception was one ALEKS section--the only "night" section in the experimental group--where students did not have sufficient computer access and were allowed to switch to a traditional format early in the course.) Furthermore, 14 months later, based on performance on a CAAP algebra test, ALEKS students retained their advantage and outperformed the non-ALEKS control group.

### Contact Information

For more information on this study, please contact Dr. Gary Hagerty, at (605) 642-6425 or [garyhagerty@bhsu.edu](mailto:garyhagerty@bhsu.edu)

Details are published in the following paper: Hagerty, Gary and Smith, S.; “Using the Web-based Interactive Software ALEKS to Enhance College Algebra” *Mathematics and Computer Education*, Fall 2005; Please see: [http://www.findarticles.com/p/articles/mi\\_qa3950/is\\_200510/ai\\_n15868747](http://www.findarticles.com/p/articles/mi_qa3950/is_200510/ai_n15868747)

## **Boise State University**

### **Implementation**

ALEKS was used as a key component in two new introductory engineering courses offered concurrently with the students' first mathematics course. One group of students (17 students) took Precalculus concurrently with Engineering 110 (using ALEKS), and another group (28 students) took Calculus I paired with Engineering 120 (using ALEKS). Grade performance of the students taking the ALEKS oriented courses was compared with that of students who took only Precalculus or Calculus I alone.

### **Results**

Of the students using ALEKS in Engineering 110, ~41% received an A or B in Precalculus, and ~59% received an A, B, or C. Among students in Precalculus alone (no ALEKS), ~27% received an A or B, and ~52% received an A, B, or C.

Of the students using ALEKS in Engineering 120, ~79% received an A, B, or C in Calculus I. Approximately 49% of the students in Calculus I alone (no ALEKS) received an A, B, or C.

“Although the data show a trend that appears to indicate that the ALEKS supplemental instruction is efficacious, a larger sample size is needed before concluding that this result is statistically significant.”

### **Contact Information**

For more information on this study, please contact Dr. Janet M. Hampikian, at (208) 426-5983 or [janethampikian@boisestate.edu](mailto:janethampikian@boisestate.edu)

A paper on this study has been accepted by ASEE and is awaiting publication. Please see: <http://coen.boisestate.edu/eswi/pdf/Final-Hampikian-ASEE-2006.PDF>

## **The University of Memphis**

### **Implementation**

This observational study focused on 548 undergraduate students who completed a statistics course under the same professor between the Spring 1995 and Fall 2005 terms. One hundred and thirty-seven students took the course in an online format using ALEKS, and 411 students took the course in a conventional lecture format.

### **Results**

This study compared the academic performance of students from online ALEKS-using sections of statistics to a retrospective comparison group comprised of students who took statistics under a conventional lecture format. A historical one-letter-grade gap between groups of students in this course at this university was eliminated when ALEKS was used. For more information, please see:

[http://www.aleks.com/highered/behavior/AERA\\_Paper.pdf](http://www.aleks.com/highered/behavior/AERA_Paper.pdf)

#### Contact Information

For more information, please contact Dr. Xiangen Hu, at (901) 678-3608 or [xhu@memphis.edu](mailto:xhu@memphis.edu)

A paper on this study has been accepted for publication by the American Educational Research Association.

## **ALEKS Course Products Available for Higher Ed Mathematics**

Basic Math

Pre-Algebra

Beginning Algebra

Introduction to Geometry

Intermediate Algebra

College Algebra

Trigonometry

College Algebra with Trigonometry

PreCalculus

Prep for the CSU - ELM

Math Prep for College Physics

Preparation for Calculus

Introduction to Statistics

Business Statistics

Statistics for the Behavioral Sciences

Business Math