# Testing the Efficacy of Reverse Learning as a Teaching and Learning Method Using an Interactive Multimedia Computer Program


*Gina M. McAndrews[1], Scott Chadwick[2], Russell E. Mullen*

*Department of Agronomy*
*Iowa State University*
*Ames, IA 50011-1010*



## Abstract

A Computer Interactive Multimedia Program for Learning Enhancement (CIMPLE) program was developed to enhance learning in an introductory agronomy course at Iowa State University. CIMPLE includes learner objectives, digitized tutorial video, key concepts, practice learning exercises, and self diagnostic quizzes. The self-assessment components are for students to quiz themselves over material presumably after having studied the material. Several students however started with the learning assessment programs, to test their initial level of understanding of material before studying, a process coined "reverse learning." To assess the concept of reverse learning, students were divided into one of three learning strategies: 1) students used the textbook, did not use CIMPLE and then took graded quizzes; 2) students used CIMPLE and the textbook and then took the graded quizzes; and 3) students first did the non-graded self-assessments on CIMPLE, then used CIMPLE and the text, and then took the graded quizzes (reverse learning). There was no significant grade difference across the three learning strategies. Grade performance was not influenced by learning style regardless of learning strategy. Students with different learning styles within a learning strategy had similar grade performance. While our results do not show that reverse learning is statistically better than the other learning strategies we tested, they do show that students using that strategy learn, on average, as well students using more traditional strategies.


## Introduction

At Iowa State University, the introductory course, Principles in Agronomy, serves as a foundation course in sustainable crop production to undergraduate students in several majors, including Agronomy, Horticulture, Animal Science, Ag Business, and Ag Education. Generally 300 students annually enroll in the three-credit Agronomy course (Agron 114). The primary focus of the course is to introduce material that will help students understand the science and strategies underlying crop-based agriculture and soil management. Consequently, the course covers a variety of subjects including; plant anatomy, plant classification and identification, physiology, climate, soil and soil water, tillage, plant breeding, seed/grain quality, weed, insect and disease management, and crop harvesting and storage.

Historically, the learning activities that have been used in Agron 114 included greenhouse experiments, a weekly discussion, and visual and hands-on lab displays. We recently completed the development

**Table 1. Description of the components of the computer program called CIMPLE.**

| Component Name | Description |
|---|---|
| Chapter Assessment | Extensive set of T/F questions for students to assess their overall knowledge of chapter material. After completion, students receive results of the number of correct and incorrect answers categorized by subunit so students may see which areas they may need to review. |
| Video | 20-30 minute digitized video that covers chapter material. Depending on the chapter, the video may include dissections of plants, demonstrate planting or breeding methods, or exhibit different tillage equipment and show the results of the implement's use. |
| Key Concepts | Educational material providing in-depth information on key topics of each subunit of a chapter. All key-concept units include several images, photographs and diagrams. |
| Practice | Interactive questions and diagrams for students to test their knowledge of key issues of each subunit of a chapter. Activities include matching images of plants, insects or equipment with the correct names, and labeling plant parts. |
| Self-Check | 3-5 multiple-choice questions over subunit material to help students assess their knowledge. |
| Practice Problem-solving | Asks students to apply chapter material to solve a practical problem that is presented |
| Environmental & Ethical Issues | Presents a current day environmental or ethical issue relating to the chapter that people encounter in everyday life and asks students to consider information on both sides of the issue with what the student knows, and develop an argument for one side of the issue, write it up and be prepared to discuss the issue in class. |


[1]1126 Agronomy Hall; Phone: 515.294.7832; Email: gina@iastate.edu

[2]Assistant Vice President for Academic Affairs, Director of the Office for Excellence in Teaching, Learning, and Assessment, Creighton University, Omaha, NE 68178

of an interactive computer program, the Computer Interactive Multimedia Program for Learning Enhancement (CIMPLE), to provide students computer-based learning programs to supplement students' lab experiences as listed above. The CIMPLE program is comprised of seven components (see Table 1).

While much attention has been placed on Web-based instruction, the use of computer-based tutorial systems has also been shown to effectively help students learn in a natural resource related course (Seiler, et al., 2002). Students use different learning styles in their learning process (Kolb, 1981, 1984). It is not known whether students who prefer specific learning styles benefit, or are hindered, by computer-based learning systems, or whether there is a preferred sequence of using computer program components.

The concept of reverse learning was coined during the initial use of CIMPLE when we recognized that students used the computer program components differently than we had anticipated. The self-assessment component of the computer program was developed so that students could quiz themselves over course material, presumably after they had studied the material through formal means (i.e. reading text, attending lectures, using computer aided instructional units). On several occasions, however we observed some students started first with the learning assessment programs, presumably to test their initial logic and level of understanding of material. During the first two semesters CIMPLE was integrated into the course, we observed students and received feedback from students, both of which revealed that several students preferred to use learning assessment components as the initial starting point of study. Students compared this phenomenon with receiving or purchasing an item that requires assembling; many people test their logic with trial and error to assemble the object and only as a last resort will consult the directions to complete the task. We termed this concept as vocalized by students, 'reverse learning' because students were bypassing formal teaching material and using quizzing programs to learn.

Meta-analytic research shows that computer-based instruction increases student test scores and positive attitudes toward technology and teaching (Kulik and Kulik, 1991). Other meta-analytic research shows positive effect-sizes for learning outcomes associated with the use of technology in learning compared to traditional instruction (Bangert-Drowns, et al., 1985; Khalili and Sashaani, 1994; Liao and Bright, 1991; Ryan, 1991). Theoretically, Mayer (2000) argues that it is important to understand the effects upon learning that integrating technology into a learning environment may cause.

We suspected that the use of reverse learning we observed in students stemmed from the advantages of older concepts in the literature such as student centered learning, active learning, exploratory learning and others. However, these traditional approaches may not have embraced making mistakes as an integral part of the learning process. Reverse learning allows students to make mistakes, removing the fear of failure, or in other words, embraces trial and error as an integral part of learning. We often teach to avoid mistakes when maybe we should encourage students to use assessment tools as a means to help them understand what they need to learn to understand the material. This concept of reverse learning embraces techniques that present material with tools that allow students to access course material to be learned and to repeatedly make mistakes while learning the material. Reverse learning may also offer greater challenges to the individual learner because they can initiate and continue the learning process by constantly testing their own knowledge and logic of subject matter as it

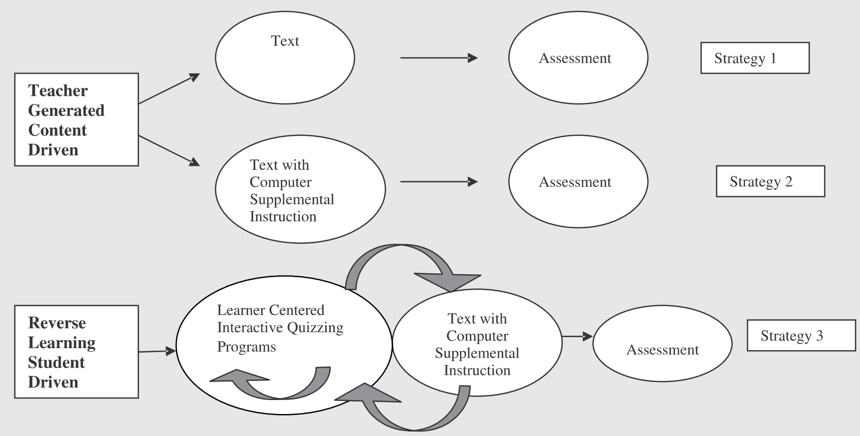

Figure 1. Diagram depicting three major approaches students use in Agronomy 114 course.

Table 2. Description of Kolb's Learning Styles

| Learning Style | Description |
|---|---|
| Accommodator | Prefer hands-on learning, benefiting from trial and error. |
| Assimilator | Prefer concise and logical presentations of information, from which they can build accurate and organized conceptualizations. |
| Balanced | Likely to use any of the styles, with no clear preference for any one learning style. |
| Converger | Prefer practical problem solving exercises. |
| Diverger | Prefer to be exposed to many points of view, listening, absorbing, and categorizing information from a variety of sources. |

Table 3. Tukey HSD of student total quiz scores compared to learning strategy group based on sequencing of reverse learning.

| Section (I) | Section (J) | Mean Difference (I-J) | Standard Error | Significance |
|---|---|---|---|---|
| Strategy 1 | Strategy 3 | -1.029 | 0.844 | NS* |
| | Strategy 2 | -0.305 | 1.041 | NS |
| Strategy 3 | Strategy 1 | 1.029 | 0.844 | NS |
| | Strategy 2 | 0.724 | 1.055 | NS |
| Strategy 2 | Strategy 1 | 0.305 | 1.041 | NS |
| | Strategy 3 | -0.724 | 1.055 | NS |

*NS is no significant difference.

Table 4. Average learning strategy group scores for three exams, total quizzes and final grade.

| Learning Strategy | Exam 1 (score of 50) | Percent | Exam 2 (score of 50) | Percent | Exam 3 (score of 75) | Percent | Total |
|---|---|---|---|---|---|---|---|
| Strategy 1 | 31 | 62 | 32 | 64 | 44 | 59 | |
| Strategy 2 | 33 | 66 | 33 | 66 | 45 | 60 | |
| Strategy 3 | 34 | 68 | 35 | 70 | 47 | 63 | |

is presented. Traditional structured methods of reading and presenting information with the assumption that understanding will follow and quizzing will verify learning, removes the challenge from the individual learner and contributes to learner boredom of subject matter during the actual process of learning.

The objective of this research was to investigate a concept of reverse learning as an effective pedagogical method of formal teaching in an introductory agronomy course, 'Principles of Agronomy' (Agron 114) at Iowa State University.

## Methodology

To assess the concept of reverse learning as an effective pedagogical method of formal teaching, we used a modified three group posttest- design. Based on information gathered during the initial use of CIMPLE, we determined that students employ one of three strategies of engaging the course content and computer-aided learning tools: 1) students used the textbook, did not use CIMPLE and then took graded quizzes; 2) students used CIMPLE and the textbook and then took the graded quizzes; and 3) students first did the non-graded self-assessment quizzes on CIMPLE, then used CIMPLE and the text to learn material, and then took the graded quizzes (reverse learning) (see Figure 1). Students using the first two strategies followed the traditional learning style of exposing themselves to content then performing an assessment. Students in the third category engaged in a process of what we called 'reverse learning.' There were three sections of students in Agronomy 114. We assigned all the students in section 1 to strategy 1, all the students in section 2 to strategy 2, and all of the students in section 3 to strategy 3 (Figure 1).

During the first week of the course, students completed an online Kolb's Learning Style Inventory to identify their learning style (Table 2). We measured the efficacy of "reverse learning" by comparing student learning outcomes, as measured by individual online assessments and final course grades, across the three groups. We assessed differences in grades across the different learning strategies used and among the sets of preferred learning styles.

## Results and Discussion

This study sought answers to the following research questions:

1. Do students who use "reverse learning" in a computer-assisted learning environment learn more (as measured by course grades) than students who do not use "reverse learning?"
2. Within a computer-assisted learning environment, do students of particular learning styles learn more (as measured by course grades) than other students?

To answer question one, we calculated the numeric equivalent of students' course grades (e.g., A = 4.0, B = 3.0, etc.). Students could earn a grade of "C" by passing all quizzes but not taking exams. At the weekly total quiz score level, there was no significant grade difference across the three learning strategy conditions: ($F [2, 85] = 0.763$, $p = 0.470$; Tables 3, 4, and 5). Post hoc t-tests also showed no significant differences between the groups, and therefore we can conclude that none of the learning strategies resulted in more learning than did any of the other learning strategies based on weekly quiz scores.

Table 5. ANOVA of student total quiz scores compared to learning strategy group based on sequencing of reverse learning.

| | Sum of Squares | Mean Square | Significance |
|---|---|---|---|
| Between Learning Strategy Groups | 19.240 | 9.620 | NS |
| Within Groups | 1072.100 | 12.613 | |
| Total | 1091.340 | | |

NS refers to no significant difference.

Students who took all three exams in addition to the quizzes had those exam scores factored into their course grades. An analysis of variance showed that there were no significant differences between student's grades among the three learning strategies ($F [2, 85] = 1.808$, $p = 0.170$; Table 6).

Our analysis of learning performance across preferred learning

Table 6. ANOVA of differences between learning strategy group based on learning strategy and final total score of exams and quizzes

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Learning Strategy Groups | 2.519 | 2 | 1.260 | 1.808 | NS |
| Within Groups | 59.220 | 85 | .697 | | |
| Total | 61.740 | 87 | | | |

NS refers to no significant difference.

Table 7. ANOVA of weekly quiz and final scores grade compared to learning strategy group and Kolb learning style.

| | | Sum of Squares | Mean Square | Significance |
|---|---|---|---|---|
| Weekly Quiz: Total Score | Between Groups | 83.195 | 20.799 | NS |
| | Within Groups | 3376.866 | 43.855 | |
| | Total | 3460.061 | | |
| Final Grade: Number | Between Groups | 0.452 | 0.113 | NS |
| | Within Groups | 58.001 | 0.753 | |
| | Total | 58.453 | | |

NS refers to no significant difference.

styles showed that grade performance was not influenced by learning style regardless of learning strategies ($F [4, 77] = 0.150$, $p = 0.962$), nor was their learning performance using the recalculated grades ($F [4, 77] = 0.469$, $p = 0.759$; Table 7). Student with different learning styles within a learning strategy did not significantly differ in their grade performance ($F [14, 67] = 1.105$, $p = 0.370$).

## Summary

The supremacy of reverse learning compared to more traditional ways of learning was not supported statistically in this study based on our method of course grading. However, the results do show that students using the computer-aided reverse learning strategy do learn, on average, as well as students using more traditional strategies. That finding is in keeping with other research showing the students in a hypermedia (computer-aided) learning environment learn as well as in traditional environments (Howard et al., 2004; Yildirim et al., 2001).

The large amount of unexplained variance within the learning strategy groups in our study suggests factors exist that may help explain when or for whom reverse learning may be most beneficial. Previous research with the CIMPLE program shows that high levels of motivation to use the self-assessment, video tutorial, and applied environmental / ethical issues portions of the program is significantly, positively correlated to high grades in the course (McAndrews et al., 2005). Yet motivation may be driven by a more basic underlying factor. Song (2002) argues that students need complex learning skills to manage learning environments, including computer-aided environments, especially environments in which students are in control of the learning. Possibly the newness of the CIMPLE program, whether used in part or in whole, was sufficient to mask the differential gains in learning that could result if students were adept at using the system throughout. Specifically training students in CIMPLE before allowing them to use it would help us test that proposition.

Finally, the calculation of final grades in this course is rather complex and allows students to "settle" for a grade of "C" without necessarily distinguishing if that student knows more than the "C" grade represents. We believe that if we used a more traditional, nonflexible grading method that assigned A through F grades strictly on exam and quiz performance, we would have a better measure of learning and we may find that reverse learning is a significantly better strategy than more traditional learning strategies for some students. The option of using reverse learning may be more important for the self-learning process for some students than a final grade demonstrates.

## Literature Cited

Bangert-Drowns, R.L., J.A. Kulik, and C.C. Kulik. 1985. Effectiveness of computer-based education in secondary schools. Jour. of Computer-Based Instruction, 12(3), 59-68.

Khalili, A., and L. Sashaani. 1994. The effectiveness of computer applications: A meta-analysis. Jour. of Research in Computing in Education, 27(1), 48-61.

Kolb, D.A. 1981. Learning styles and disciplinary differences. In A. W. Chickering (Ed.), The Modern College. San Francisco, CA: Jossey-Bass.

Kolb, D.A. 1984. Experiential learning: Experience as a source of learning and development. Englewood Cliffs, NJ: Prentice-Hall.

Kulik, C.C., and J.A. Kulik. 1991. Effectiveness of computer-based instruction: An updated analysis. Computers in Human Behavior, 7, 75-94.

Liao, Y.C., and G.W. Bright. 1991. Effects of computer programming on cognitive outcomes: A meta-analysis. Jour. of Educational Computing Research, 7(3), 251-268.

Mayer, R.E. 2000. Instructional Technology. In F. T. Durso, Handbook of applied cognition (pp. 551-569). New York: John Wiley and Sons.

McAndrews, G.M., R.E. Mullen, and S.A Chadwick. 2005. Relationships among learning styles and motivation with computer-aided instruction use and grades in an introductory agronomy course. Jour. of Natural Resources and Life Science Education, 43, 13-16.

Howard, W.G., H.H. Ellis, and K. Rasmussen. 2004. From the arcade to the classroom: Capitalizing on students' sensory rich media preferences in disciplined-based learning. College Student Jour., 38(3), 431-440.

Ryan, A.W. 1991. Meta-analysis of achievement effects of microcomputer applications in elementary schools. Educational Administration Quarterly, 27(2), 161-184.

Seiler, J.R., O. Popescu, and J.A. Peterson. 2002. A woody plant identification tutorial improves field identification skills. Jour. of Natural Resources and Life Science Education, 31:12-15.

Song, C.R. 2002. Literature review for hypermedia study from an individual learning differences perspective. British Jour. of Educational Technology, 33(4), 435-447.

Yildirim, Z., M.Y. Ozden,, and M. Aksu. 2001. Comparison of hypermedia learning and traditional instruction on knowledge acquisition and retention. Jour. of Educational Research, 94(4), 207-214.