Critical Factors for Success in an Introductory Astronomy Class

Stuart D. Kellogg¹, Dan Durben² and Shauna Ayars-Junek³

Abstract - A number of researchers suggest that a student’s learning preference curve can be an effective predictor of student success in a particular course. Others suggest that cognitive development, as measured by a student’s development of learning and study strategies, may be more relevant. Still others suggest that preconceived notions of science and astronomy may be more useful yet. In this paper we explore the critical factors in each of these areas as they relate to student success in an introductory astronomy class. In this study, 65 students were given the Visual, Aural, Read/Write, and Kinesthetic learning style inventory (VARK), the Learning and Studies Strategies Inventory (LASSI), and the Astronomy Diagnostic Test (ADT). Results of these inventories along with gender, age, and previous academic performance were correlated with overall classroom performance. A step-wise regression analysis was then performed to determine the most critical factors that affect student performance in this area.

Index Terms - learning style, multi-media, technology

INTRODUCTION

A growing body of research suggests that students may enhance their performance academically with an understanding of the learning process [21]. A number of researchers suggest that a student’s learning preference curve can be an effective predictor of student success [3, 6-7]. Many educators are finding that a variety of presentation methods can aid in the student learning process [9, 18, 20]. Middle Tennessee State University offers online versions of learning style inventories as a study skills aid to assist students in adapting to college academics [14]. Black Hills State University uses learning styles inventories as a testing instrument for first year students to help establish positive study habits before they have finished their first semester of classes.

Other researchers suggest that diagnostic tests measuring preconceived notions of math and science may be more useful [1, 8, 9, 15]. Concepts inventories provide significant insight into student beliefs about the way the world in which they operate functions. Addressing and, in many cases, correcting these preconceived notions may lead to the greatest gains in student learning.

Still other researchers suggest that the most critical factors may be related to study habits and strategies that can affect student cognitive development [13, 19, 21]. Armed with a knowledge of student learning and study habits, an educator can most effectively address those attitudes and habits in the classroom that are most likely to limit student learning and growth.

In the Spring of 2003, we initiated a pilot study to help answer the question about which of these measures might provide the most useful predictor of success in an introductory Astronomy class.

AVAILABLE INVENTORIES

Modern self-assessment of learning styles can be traced back to early personality tests developed during World War II. Personality types can be tested with the Meyers-Briggs Type Indicator (MBTI), which categorizes people into sixteen personality types [16, 17]. Not only has the Myers-Briggs Type Indicator been utilized for work placement, it has also been used in the college classroom [4]. There are, however, two significant drawbacks to the use of the Myers-Briggs inventory. It requires a certified professional to administer the inventory. Even then, researchers argue that it is more useful when used to indicate personality type than as a useful predictor of student learning preference style.

In 1971, David A Kolb developed a Learning Style Inventory to assess individual learning styles [11]. This model classifies preference for how a person will learn. The Kolb Learning Style Inventory categorizes people into four learning styles that relate to how they deal with ideas and daily situations [2, 5, 11]. The Kolb Learning Style Inventory is widely available and may be administered by anyone. For a modest fee, the Kolb Learning Style Inventory can be completed entirely online. Since it is specifically designed for assessing learning preferences, the Kolb Learning Style Inventory can be packaged with material that includes instructional and learning strategies for specific learning preferences. The Kolb Learning Style Inventory is perhaps the most widely used inventory currently in use in educational research.

Neil Fleming and Charles C. Bonwell, with the hope of improving teaching and learning, created the VARK test in 1998 [6, 7]. The Visual, Aural, Read/Write and Kinesthetic Learning Style Inventory (VARK) classifies students based on how they process information presented to them. One
advantage of the VARK Learning Style Inventory is that it can be taken online with an immediate assessment [23]. Those administrators interested in the VARK Learning Style Inventory without Internet access can request a teacher’s guide and evaluation kit directly from the VARK Company.

The Learning And Study Strategies Inventory (LASSI) was developed as part of a research project at the University of Texas in the late 1990’s. Creators Claire E. Weinstein, PhD, Davis R. Palmer, PhD and Anne C. Shulte, PhD developed a testing instrument designed to assist those students that were having difficulty adjusting to college curriculum. Students are classified based on ten areas of assessment listed below in Table 1. All scales used in the LASSI inventory are set so that a low score indicates difficulty in a particular strategy. For example a low score on the Anxiety Scale (ANX) would indicate a high level of anxiety. A low score on the Attitude and Interest Scale (ATT) on the other hand would indicate a need to work on higher-level goal setting. More information, or copies of the LASSI Learning Style Inventory can be obtained by contacting the publishing company, or assessing their website [12].

| TABLE 1 |
| ASSESSMENT SCALES USED IN THE LASSI |
| ANX – Anxiety Scale |
| ATT – Attitude and Interest Scale |
| CON – Concentration Scale |
| INP – Information Processing Scale |
| MOT – Motivation Scale |
| SFT – Self Testing Scale |
| SMI – Selecting Main Ideas Scale |
| STA – Study Aid Scale |
| TMT – Time Management Scale |
| TST – Test Strategies Scale |

The Astronomy Diagnostic Test (ADT) was developed by a group of Astronomy educators in 1998 at a meeting of the Astronomical Society of the Pacific [8]. The ADT was developed because Astronomy educators needed a standard instrument to evaluate student understanding in undergraduate astronomy classes. Identifying misconceptions that students may have could then be used to improve learning in these undergraduate classes. The ADT is limited in its content because of the level of the students not exceeding high school level Astronomy. Version 2.0 of the ADT was released, for public use in June 1999 [1, 9].

The ADT was beneficial to this study because it was a non-graded, non-lecture test. Students did not have added performance pressure because results did not affect overall class grade. As a measure of preconceived notions, the test provided valuable insight as to areas where the curricular content may need additional attention. Student performance on the ADT may also be compared to national norms provided through recent research provided by Hufnagel, et. al. [9].

**PROCEDURE**

For this study, the VARK was selected to evaluate student learning preferences. VARK testing is available online with immediate results and is user friendly for the students. In addition, the VARK has been adopted by Black Hills State University for the first year students and will be readily available for a more expanded study. The LASSI was selected to inventory studying strategies. While it does not measure cognitive development directly, it has often been used for indirect measurement and has also been adopted for standard use at Black Hills State University.

The study was conducted in the Spring Semester 2003 in PHYS 185 Introduction to Astronomy at Black Hills State University. Students were given information about the project as well as supplementary material related to the inventories used in the project. Students participating in the project were required to submit a signed consent form that provided details of the research project along with the benefits and risks associated with the project. All researchers were required to complete the online Human Subjects tutorial through NSF sponsored projects.

The VARK and LASSI tests were administered to 65 eligible participants in the study. The Astronomy Diagnostic Test was administered to evaluate student preconceived notions about concepts pertaining to Astronomy. Information was gathered about student performance on regularly scheduled testing for the course. Additional information concerning the student’s age, gender and major were recorded as part of the study. Because of inherent scheduling conflicts and logistical problems, a total of 57 students were used in the final data analysis.

**STUDENT DEMOGRAPHICS**

Class profile is comprised of data based on class level, gender, declared major, VARK and LASSI categories. Student demographics by age (freshman-senior) is shown below in Figure 1.

While the distribution of students by age category is not unexpected, women disproportionately favor the course (41
women vs 16 men). Similarly, only 11 of the students taking the course were majoring in a science area. The remainder of the students completed the course primarily as a means of fulfilling a mandatory science requirement.

Figures 2 and 3 below, compare scores on the ADT and LASSI inventories by students in the PHYS 185 class against national norms.

**FIGURE 2**
ADT RESULTS OF ASTRONOMY CLASS VS NATIONAL NORMS

**FIGURE 3**
LASSI RESULTS OF ASTRONOMY CLASS VS NATIONAL NORMS

**TABLE 2**
CORRELATION MATRIX FOR ASTRONOMY DATA

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**Session T1F**

Class success is defined by performance on the in class examinations – the higher the average test grade, the higher the level of success. While this definition is inherently limiting and may, in fact, have little to do with actual gains in student learning, it was nevertheless selected because it is a measure that is understood by educators and is the most commonly used measure in the classroom environment.

Scatter plots and correlations of student performance against each indicator variable were made. Table 2 below lists the correlation between the performance measure (test average) and each factor considered in this study. In addition, the co linearity between the independent variables is considered in determining which variables may be significant contributors to the desired outcome, higher test average.

In Table 2, primary correlations of test average versus the indicator variables are shown at the bottom with correlations between indicator variables shown along the lower diagonal matrix. Column 1 shows the correction between age and each of the indicator variables and test average. Column 2 shows the correlation between gender and each of the remaining indicator variables as well as the course test average. Column 6 shows the correlation between gender and each of the remaining indicator variables as well as the course test average. Column 7 indicates major (science or non-science). Column 8 shows correlations between class level (freshman-senior) with overall test average and remaining indicator variables. Column 9 shows the correlation between the ADT score and remaining variables and test average. Columns 10-

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Initial diagnostic results indicate that students in the introductory astronomy class have fewer initial misconceptions in the area of astronomy but in general are fairly representative of the population as a whole.

**Performance; Results and Analysis**

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between each category of the LASSI instrument and remaining variables and test average.

Correlations of 0.3 or higher are generally considered significant in educational studies. However, because of the size of this study not all correlations are significant. In Table 1, correlations with a p value of 0.2 or less are considered for the subsequent regression analysis. Correlations between factors with a value of 0.300 or higher are also highlighted and were considered for multi-collinearity problems. As an example, we note that the correlation between MOT (Motivation Scale) and TST (Test Strategies Scale) is 0.383. Since both variables are considered significant predictors of test performance, it is entirely possible that only one variable need be included in the final regression equation.

A step-wise regression was performed on all indicator variables with a p value of 0.2 or lower. Consequently, the following variables were included in the initial analysis for regression: cumulative GPA at the time of the course offering (GPA), gender (M/F), class, pre-score on the astronomy diagnostic test (ADT), visual, reading, and kinesthetic scores on the Vark inventory (V, R, K), LASSI Anxiety Scale (ANX), LASSI Attitude Scale (ATT), LASSI Motivation Scale (MOT), and the LASSI Study Aids Scale (STA), and the LASSI Time Management Scale (TMT). Results from the regression analysis for a variety of p values are summarized below in Table 3. The regression output for p<0.1 is shown below in Figure 4.

### Table 3

<table>
<thead>
<tr>
<th></th>
<th>GPA</th>
<th>ADT</th>
<th>ANX</th>
<th>MOT</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>P&lt;0.15</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>0.663</td>
</tr>
<tr>
<td>P&lt;0.10</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>0.647</td>
</tr>
<tr>
<td>P&lt;0.05</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>0.621</td>
</tr>
</tbody>
</table>

### Summary Output

**Regression Statistics**

- Multiple R: 0.673
- R Square: 0.453
- Adjusted R: 0.437
- Standard Error: 0.437
- Observation: 57

**ANOVA**

<table>
<thead>
<tr>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>8.39</td>
<td>4.20</td>
<td>4.671E-07</td>
</tr>
<tr>
<td>Residual</td>
<td>54</td>
<td>10.14</td>
<td>0.19</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>56</td>
<td>18.54</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Coefficients**

- Intercept: 0.93 (p-value: 0.03)
- ANX: 0.03 (p-value: 0.01)
- INP: 0.06 (p-value: 0.01)
- MOT: 0.06 (p-value: 0.01)

Results from this analysis suggest that students who perform well tend to be more highly motivated and tend to exhibit lower course and test anxiety. To some extent they also more effectively use imagery and organizational skills to more effectively process information. There is also some evidence to indicate that women may be more likely to possess some of these skills than are men.
In this preliminary study, we attempted to explore critical factors that might affect overall student performance. Not surprisingly, the single best predictor of student success tends to be previous academic success. That is, the inherent complexity of student learning is such that students seem to have a tendency to adapt to variety of teaching and learning styles.

There is some evidence to indicate that preconceived notions about astronomy (as measured by the ADT), test anxiety level (as measured by the LASSI ANX area), and student motivation (as measured by the LASSI MOT area) may have a stronger impact on student learning. Accordingly, some class time devoted to motivational strategies or strategies aimed at reducing course and/or test anxiety may yield some gains in student learning.

While knowledge of important factors for predicting student-learning gains may ultimately be of use for classroom instruction, such suggestions are at this point premature. Student learning is a much more complicated process involving the interaction of a number of variables. Even if a more straightforward model such as the one presented were valid, a much larger study across a broader spectrum of courses would need to be accomplished before any level of confidence could be claimed. Still the research presented here begins to provide some insight as to which factors may be more critical and warrant further study.

REFERENCES


SESSION T1F

Stuart Kellogg, Ph.D., Dr. Kellogg is Professor of Industrial Engineering at the South Dakota School of Mines & Technology where he currently serves as coordinator of the Industrial Engineering and Technology Management programs. In addition to pedagogical issues related to engineering education, his research interests include applied and numerical probability models in the industrial environment. He has published works Mathematics and Computers in Simulation, Proceedings of IIE Research Conference, Quality Engineering, and Proceedings of the Joint Statistical Meetings. Dr. Kellogg is a member of the Institute of Industrial Engineers and the American Society for Engineering Education.
Dan Durben, Ph.D., Dr. Durben is an Associate Professor in the College of Arts and Science at Black Hills State University. In addition to research interests in physics education, Dr. Durben has an active research program in environmental physics with recent publications in the *North American Journal of Aquaculture*. An 1988 Olympian, Dr. Durben was named head coach of the 2000 U.S. Olympic rifle team and has recently been named head coach of the rifle team for the Paralympic Games.

Shauna Ayars-Junek, M.S., Ms. Junek is a graduate of the Technology Management program at the South Dakota School of Mines and Technology. Ms. Junek research interests include assessment tools and methodologies for Physical Science and Mathematics.