# AC 2012-3120: AT-RISK VISUAL PERFORMANCE AND MOTIVATION IN INTRODUCTORY ENGINEERING DESIGN GRAPHICS

**Dr. Jeremy V. Ernst, Virginia Tech**

Jeremy V. Ernst is an Assistant Professor in the Integrative STEM Education program of the Department of Teaching and Learning at Virginia Tech. He currently teaches graduate courses in STEM education foundations and contemporary issues in integrative STEM education. Ernst specializes in research focused on dynamic intervention means for STEM education students categorized as at-risk of dropping out of school. He also has curriculum research and development experiences in technology, engineering, and design education.

**Dr. Aaron C. Clark, North Carolina State University**

Aaron C. Clark, Ph.D. is a professor of technology, design, and engineering education and Director of Graduate Programs and Associate Department Chair at North Carolina State University. Clark has worked in both industry and education, including college administration at various levels. His teaching specialties are in visual theory, 3-D modeling, technical animation, and STEM-based pedagogy. Research areas include graphics education, game art and design, and scientific/technical visualization. He presents and publishes in both technical/technology education and engineering and has won numerous awards for his research. He has been and continues to be a Principle Investigator on a variety of grants related to technology education and has focused his funded research in areas related to STEM curricula integration. Clark is a member of the Engineering Design Graphics Division of the American Society for Engineering Education (ASEE) were he currently serves as Chair; and has served in leadership roles and on committees for the K-12 Outreach Division. He has served in various leadership roles in disciplines related to career and technical education at state, regional, and national levels. He consults to a variety of businesses, educational agencies, and organizations and is currently working with the global education initiative.

# At-Risk Visual Performance and Motivation in Introductory Engineering Design Graphics


## Abstract

This supplemental motivation/learning and spatial acuity study was initiated as a follow-up to a preliminary study conducted in an introductory graphics course in the summer of 2011. The intent of the preliminary study was to assess the abilities of students to visualize rotated three-dimensional objects and determine associations/relationships with intrinsic goal orientation, extrinsic goal orientation, and task value, control of learning beliefs, self-efficacy learning performance, and test anxiety. Specific subgroups were identified within the study concerning high and low achievement in previous university offerings; however, student participant numbers prevented comprehensive subgroup analysis and therefore was restricted to a whole sample analysis concerning motivation and spatial acuity association. The supplemental study was conducted in the fall of 2011. Summer 2011 student enrollment was restricted to 30 students per section, where fall of 2011 sections of the introductory graphics course are restricted to 60 students per section, thus permitting adequate sample size to investigate the at-risk population based on previous university achievement. The preliminary study methodology was replicated for the supplemental investigation, the Purdue Spatial Visualization Test - Visualization of Rotations: Mental Rotation Test and the Motivated Strategies for Learning Questionnaire (MSLQ) Attitude Survey were paired and administered to university undergraduate technology, engineering, and design education and engineering students. Similarly, a determination of student intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy learning performance, and test anxiety was conducted and paired with abilities of students to visualize rotated three-dimensional objects to highlight associations/relationships among student motivation and learning and mental rotation ability. The supplemental study data collection allowed for subgroup investigation of the at-risk population, therefore enabling the researchers to capture a more holistic data-based view of student belief systems and how they can potentially promote student abilities in engineering design graphics courses.


## Introduction

It has long been a mission of professionals in engineering design graphics to better serve students by researching instructional strategies and methodologies that can be employed in engineering graphics courses that promote student successes. For many engineering, technology and design students, introductory engineering graphics courses are foundational for subsequent courses that require technical communication skills throughout their academic career and beyond. Many students enter introductory engineering graphics classes eager to learn, but for some reason there persists to be a subset of students leaving the course unfulfilled concerning content being presented and have an identifiable lacking perception regarding the importance of introductory graphics course offerings to their future anticipated careers[1]. Researchers in engineering design graphics have attempted to study what motivates students to learn, as well as best practices for doing so; but few have examined motivation in tandem with spatial acuity for students in these courses that are identified as "at-risk" of not completing a program due to low grade point average[2].

This supplemental motivational and spatial acuity study is a continuum of a thematic research premise that tries to find best practices for engineering design graphics instruction at the post secondary level and what affects the outcomes of students in these courses. The preliminary study's methodology was replicated for this supplemental investigation using the same two instruments; the Purdue Spatial Visualization Test - Visualization of Rotations: Mental Rotation Test and the Motivated Strategies for Learning Questionnaire (MSLQ) Attitude Survey. These two instruments have been given to undergraduate students taking an introductory engineering design graphics course at the post secondary level. The researchers for this study decided to stratify the population for this study so that students defined as at-risk, those with a GPA of less than 3.0 and unlikely to matriculate into an engineering related discipline, would be analyzed separately for what motivates them to learn in an introductory engineering design graphics courses, as well as compare their visual acuity with those not deems at-risk in the same classes. This is an important step as per the previous studies conducted by the researchers using the same instruments, general population, and research methodology came to the conclusion that no significant difference existed between the mental rotations capabilities of students in these introductory courses and what motivates them to learn the content. The researchers found a weak positive correlation between mental rotation abilities and motivation that does exist between the two instruments assessment scores indicating that further research is needed for subgroup analysis. This led the researchers to start exploring with subgroups an begin with one population that has little to no research about it at the post secondary level, at-risk populations and the potential differentiation this population could have between the two assessment instruments being used for both this study, and previous ones[3].

**Research Questions**

There were two research questions with a total of two subsequent investigational hypotheses proposed and researched in this study:

1) Are there identifiable differences or associations between introductory engineering graphics at-risk and not at-risk students' mental rotation abilities?
    - *Hypothesis 1* - There is no difference in introductory engineering graphics at-risk student mental rotation abilities and not at-risk students' mental rotation abilities.
2) Are there identifiable differences or associations between introductory engineering graphics at-risk and not at-risk students' motivational beliefs/use of learning strategies?
    - *Hypothesis 2* - There is no difference in introductory engineering graphics at-risk student motivational beliefs/use of learning strategies and not at-risk students' motivational beliefs/use of learning strategies.

To fully explore research question one, a Kruskal-Wallis nonparametric procedure was utilized to examine differences in mental rotation abilities and a Pearson product-moment correlation coefficient was computed in efforts to determine if there are identifiable associations between at-risk and not at-risk student mental rotation abilities. Similarly, a Kruskal-Wallis nonparametric procedure was also employed to study differences in motivational beliefs/use of learning strategies and a Pearson product-moment correlation coefficient was computed in efforts to determine if there are identifiable associations between at-risk and not at-risk student motivational beliefs/use of learning strategies.

**Instrumentation**

There were two instruments used in this study: 1) the Purdue Spatial Visualization Test - Visualization of Rotations and 2) the Motivated Strategies for Learning Questionnaire. Spatial visualization involves mentally rotating, twisting, or inverting a perceived object[4]. Research has shown that the Purdue Spatial Visualization Test - Visualization of Rotations measures spatial visualization ability[4]. The Purdue Spatial Visualization Test - Visualization of Rotations is one assessment of the numerous Purdue Spatial Visualization Test measurement instruments. The rotations test assesses the abilities of students to visualize rotated 3-dimensional objects. The test consists of thirty questions that call for students to employ their spatial abilities requiring students to study how a given object is rotated, visualize what a second object would look like when rotated in exactly the same manner as the previous object, and select the rotated object that depicts the second object rotated in the correct position from among five rotated object answer choices[5].

The second instrument examined motivation. This instrument, known as the Motivated Strategies for Learning Questionnaire (MSLQ), was designed to evaluate college students' motivational orientation and use of varied learning strategies in college level courses[6]. The MSLQ is comprised of two sections, one for motivation and one for learning strategies. The motivation segment has 31 items that evaluate students' goals and value beliefs, students' beliefs about skills necessary to succeed, and test anxiety associated with a specific course[7]. Duncan & McKeachie differentiate the learning strategy section as identifying students' use of different cognitive and metacognitive strategies as well as management of resources. The motivation section and the learning strategies section of the MSLQ include 81 items. Each item is rated using a 7-point Likert-type scale. The rating scale ranges from one (not at all true of me) to seven (very true of me). For the purposes of this study, the MSLQ scale was normalized to correspond with the 30 component Purdue and functioned as an overall non-categorical measure of motivation and learning strategy.

**Methodology**

Participation was requested of students in an undergraduate introductory engineering graphics course. The course sections met twice a week for fifteen weeks. Nine weeks of instruction proceeded as scheduled with content and associated application including orthographic projection, isometric drawing, sectioning and auxiliary creation, and a complete focus on three-dimensional static model development in a virtual environment. At the completion of the ninth week of instruction, the course instructor administered the MSLQ instrument. The Purdue Spatial Visualization: Visualization of Rotation instrument was administered to the students the following class meeting in efforts to prevent participant fatigue. The course instructor collected the completed instruments, data were entered, and subsequent analyses were conducted.

## Data and Findings

The introductory engineering graphics students' spatial acuity and motivation and strategies for learning were investigated to find identifiable differences among subgroups of the sample. The first project hypothesis evaluated was: There is no difference in introductory engineering graphics at-risk student mental rotation abilities and not at-risk students' mental rotation abilities. This hypothesis was evaluated in Table 3 using the Kruskal-Wallis Test. The Kruskal-Wallis Test ranks designated elements from lowest to highest in the designated subgroups. This procedure uses the critical value to evaluate the proportional value derived from the Chi-Square table. The sampling distribution for the H statistic was used to test the null hypothesis[8]. The calculated values for the H statistic were evaluated in comparison to the critical values to determine if the null hypothesis is rejected or if there is evidence that fails to reject the claim. The H statistic is less than the critical value so the null hypothesis is not rejected. The analysis suggests that at-risk participant mental rotation abilities do not significantly differ from non at-risk participants' mental rotation abilities.

Table 3. Kruskal-Wallis Purdue At-risk/Not At-Risk

| Group | n | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| At-Risk | 21 | 1 | 23 | 41.05 | 0.97 | 0.33 |
| Not At-Risk | 70 | 1 | 24 | 47.49 | | |

The second project hypothesis evaluated was: There is no difference in introductory engineering graphics at-risk student motivational beliefs/use of learning strategies and not at-risk students' motivational beliefs/use of learning strategies. This hypothesis was evaluated in Table 4, again, using the Kruskal-Wallis Test. The analysis suggests that at-risk participant motivational beliefs/use of learning strategies do not significantly differ from non at-risk participants' motivational beliefs/use of learning strategies.

Table 4. Kruskal-Wallis MSLQ At-risk/Not At-Risk

| Group | n | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| At-Risk | 21 | 1 | 380 | 47.93 | 2.46 | 0.12 |
| Not At-Risk | 70 | 1 | 369.5 | 38.58 | | |

The researchers constucted a Pearson product-moment correlation matrix in efforts to determine if there are identifiable associations between at-risk and not at-risk student mental rotation abilities, as well as motivational beliefs/use of learning strategies. Based on the correlation coefficients in the matrix (Table 4), there are no subgroup or between group associations that indicate a strong relationship. The strongest relationship is noted between at-risk student and not at-risk student mental rotation abilities ($r = 0.38$). Other subgroup pairings, such as at-risk motivational beliefs/use of learning strategies and not at-risk mental rotation abilities (r = 0.13), at-risk motivational beliefs/use of learning strategies and at-risk mental rotation abilities (r = 0.14), and at-risk motivational beliefs/use of learning strategies and not at-risk motivational beliefs/use of learning strategies, show minimal relationships. Although there is no strong positive correlation between subgroups or between groups, there is a moderate negative correlation between not at-risk motivational beliefs/use of learning strategies and at-risk mental rotation abilities (r= -0.54). This negative correlation indicates that as the value of not at-risk student motivational beliefs/use of learning strategies increases, the value of the at-risk student mental rotation abilities decreases and vise versa.

Table 4. Correlation Matrix Purdue and MSLQ At-risk/Not At-Risk

| | Purdue | At-Risk Purdue | MSLQ |
|---|---|---|---|
| At-Risk Purdue | 0.38 | - | - |
| MSLQ | -0.43 | -0.54 | - |
| At-Risk MSLQ | 0.13 | 0.14 | 0.06 |

**Conclusions**

Conclusions for this study are limited due to no statistical findings as per the testing of the two hypotheses established at the onset of the research. Although, the researchers did find a moderate negative correlation between at-risk students and their Purdue test scores and the not at-risk students and their MSLQ scores (indicated in table 4). A simplified explanation for this as a conclusion would be that the higher the motivational beliefs are of not at-risk students, mental rotation ability for at-risk students decreases. The rationale or outcome from this finding is that all students learning strategies in this sample are generally consistent, however, there is an identifiable converse association between mental rotation abilities of at-risk participants and motivation beliefs and learning of strategies of not at-risk participants. Although an unusual finding, this further demonstrates the need for additional research into this area and with different populations. A second conclusion the researchers draw from this study was that at-risk and not at-risk students in engineering graphics have no identifiable MSLQ or mental rotation differences, presenting the possibility that instruction can operate from a consistent baseline for at-risk and not at-risk alike. This provides for the possibility that varied pedagogical methods are not necessarily required for teaching visualization, based upon specific individualized learner needs. Finally, the researchers of this study concluded that at-risk in post-secondary is not as large of an academic attainment discrepancy as in secondary environments. Evidenced by this study, being deemed at-risk in college is an unassociated variable in a fundamentals engineering graphics course. The focus in the introductory engineering graphics courses is primarily on visualization; maybe visualization is an "equalizer" for all student learning as the field progresses to provide better instruction to students as they develop 21$^{st}$ century skills in engineering, technology, and design.

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