Name(s) of Applicant(s): Ben T. Phillips

Title of Proposed Project:

Determining the Cognitive Strategies of High-Performing Test-Takers on a College Readiness Math Assessment

Primary Discipline: Education Secondary Discipline(s): ______________________

Has this proposal been submitted to another agency, publication, or program? Not for funding

Location of proposed research: Union University, Jackson, Tennessee

Desired start date: Fall 2012

Sponsoring Scholars (and discipline, please):

External: Dr. Alan H. Schoenfeld, Elizabeth and Edward Conner Professor of Education
School of Education, University of California at Berkeley

Union: Dr. Tom Rosebrough, Executive Dean, College of Education and Human Studies

Signature of the Dean in your discipline: _____________________________ Date: __________

Overall Checklist:

___ Request for Letters of Recommendation
___ Project description with major goals and brief examination of scholarly literature
___ Essay on Christian faith and academic discipline
___ Brief budget
___ Plan for completion and dissemination
___ Current curriculum vitae
___ Six copies of proposal

N.B. The Center for Faculty Development may offer additional checklists and resources to assist in grant writing; see [http://www.uu.edu/centers/faculty/](http://www.uu.edu/centers/faculty/) Also, successful applications can be reviewed at [http://www.uu.edu/programs/pew/Pew FormerApplications.htm](http://www.uu.edu/programs/pew/Pew FormerApplications.htm) and in a white binder marked “Grant Proposal Examples” in the Emma Waters Summar Library.
Letters of Recommendation
Pew Research Program
Union University

Dear Colleagues:

I write in the hope that the Pew Research Program at Union University will see fit to award Ben Phillips a 2012 Pew Research Grant for the study of successful ACT test-taking strategies.

To my mind, there are at least two potentially interesting outcomes from Dr. Phillips’ proposed study. First, it will be interesting to see (above and beyond the content-related knowledge that is the backdrop for the ACT) what kinds of problem-solving strategies and critical reasoning skills successful students (as opposed to less successful) students bring to bear on the ACT. Some of these strategies and skills may be useful to teach more broadly. Second, it will be interesting to see how much of students’ success is due to test-taking skills - certainly a useful thing to know, but perhaps not as valuable as the reasoning and problem solving strategies that are the primary focus of Dr. Phillips’ proposed work.

Dr. Phillips proposes to videotape students working on the ACT and to take a close look at their actual thinking as they work through the problems. I find this to be exactly the right approach - and to my mind it is not used enough. (Much to my surprise when I served on the committee that put together the advanced mathematics GRE test for ETS, I discovered that the staff had never watched students solve problems; they just assumed that students did the mathematics the same way as the faculty. I find this unlikely.)

I think this is a project worth funding and encourage you to do so.

Sincerely,

Alan H. Schoenfeld
September 13, 2011

Pew Research Committee
Union University
Jackson, TN 38205

Dear Colleagues:

Dr. Ben Phillips, Associate Professor of Educational Leadership and Program Director for the Ed.S. and Ed.D. in Jackson, has initiated an intriguing and ambitious research study designed to measure the cognitive strategies used by high-performing test-takers on ACT math and science exams. As documented in Ben’s proposal, the ACT has increased its role in recent years in American public education, thus increasing the significance of this effort.

Dr. Phillips’s study seeks to observe and measure, through the use of video-taping, by recording subjects saying aloud what they are thinking as they problem solve on the ACT. He wants to use the findings to advance the college-readiness preparation of high school students who take the ACT.

I find this research as extremely timely in the current P-12 culture that emphasizes more rote test-taking skills over problem solving strategies. It is my hope the committee will award this research grant to Dr. Phillips.

Sincerely,

Thomas R. Rosebrough, Executive Dean
College of Education and Human Studies
Project Description
Taking a college admissions test is a rite of passage for the typical college-bound high school student. Between the SAT® and the ACT® (hereafter referred to as simply SAT and ACT), millions of high school juniors and seniors set aside one or more Saturdays to take an exam to gauge their college readiness levels. The ACT, in particular, measures a variety of skills and content-specific objectives with the aim of predicting a student’s probability of success in subsequent college courses (Allen & Sconing, 2005). While the content-specific objectives are well defined by the ACT and readily available on its website (ACT, Inc., 2010), the skills more aligned with general problem solving and reasoning have not been examined or described in detail. This less familiar set of general skills deserves more attention in educational research.

As students answer questions on the ACT, or any test for that matter, they employ a variety of cognitive strategies to arrive at their answers. Sometimes the strategies are used at a subconscious level; other times, students are fully aware of the strategies needed. “A strategy is essentially a method for approaching a task, or more generally attaining a goal” (Kirby, 1984, p. 5). Presley, Forrest-Presley, Elliot-Faust, and Miller (as cited in Pressley & Harris, 2008/2009) offer a more specific definition:

A strategy is composed of cognitive operations over and above the processes that are natural consequences of carrying out a task, ranging from one such operation to a sequence of interdependent operations. Strategies achieve cognitive purposes (e.g., comprehending, memorizing) and are potentially conscious and controllable activities. (p. 77)
Cognitive strategies have been examined and discussed for decades; however, the use of cognitive strategies on the ACT in particular has not been widely researched.

**Significance of the Study**

The ACT is a nationwide college-readiness test developed and administered by ACT, Incorporated. The test was first administered in the fall of 1959, and by 1960 it was given in all 50 states (ACT, Inc., 2011). The ACT consists of four multiple-choice tests in English, math, reading, and science and is one of the more popular college-readiness assessments taken by high school juniors and seniors (along with the SAT, which is administered by the College Board). Each of the four tests is scored on a scale of 1-36, and all four test scores are averaged to calculate the composite score. Over the past few years, the ACT has increased its role in public education in America. According to ACT, Inc. (2011), nearly 1.6 million high school graduates took the test in 2010. More and more states are using the ACT as a measure of school effectiveness, and some states are using the ACT as the official graduation exam (Achieve, Inc., 2007). Universities are continuing to use ACT scores to determine college acceptance, scholarship awards, and student placement (Achieve, Inc., 2007). ACT scores are accepted by every college and university in the United States (ACT, Inc., 2011).

**Purpose of the Study**

The purpose of this study is to determine what strategies high-scoring test-takers use to answer questions on the ACT math test. One would hypothesize that high-performing test-takers—those who earn ACT scores of 30 or higher—would use a wide variety of sophisticated cognitive strategies. This research project is designed to observe and describe the cognitive strategies used by these test-takers and distinguish the strategies of high performers from the strategies of average performers. The ACT math test requires problem-solving strategies and
critical reasoning skills. Many of the problems students encounter on this test require a multi-step and well-thought-out approach. The ACT English and reading tests are not as reliant on such cognitive strategies and are, therefore, not being included in this current research project. The ACT science test is also not included in this current project, but may be studied in future projects. The researcher will use videotaping to record subjects taking the math test while subjects say aloud whatever they are thinking as they solve the problems. This technique has been used extensively by Dr. Alan Schoenfeld (1985), a University of California-Berkley professor who expounded on his findings in *Mathematical Problem Solving*.

The findings of this study can be used to advance the college-readiness preparation of high school students who will be taking the ACT. Ideally, future students who are taught the cognitive strategies of high-performing test-takers will be able to adopt the strategies for themselves. Also, high school teachers would benefit from the research by having measurable and identifiable cognitive strategies that they could use as they prepare students to be more college-ready. Depending on the sophistication of the strategies, some strategies may even be age-appropriate for elementary and middle school students, extending the path to college-readiness all the way to young children. The endgame of finding strategies to teach to others is significant as “there is substantial evidence that teaching problem-solving strategies improves math achievement” (Pressley & Harris, 2008/2009, p. 88).

Furthermore, the findings will help educators understand the cognitive strategies that undergird success both on the ACT and in college performance. The ultimate goal is not to identify tips, techniques, or shortcuts simply to answer multiple-choice questions on a particular exam. Instead, the skills that lead to high performance on the ACT are the same skills that lead
to high performance in the college classroom (Allen & Sconing, 2005). This study will help identify, clarify, and explain those underlying skills by analyzing students’ cognitive strategies.

**Research Questions**

By recording the audio and video of students working ACT math problems, this researcher will analyze the cognitive strategies used by high- and average-scoring students and determine any meaningful commonalities and differences.

The research questions are as follows:

1. What cognitive strategies do high-scoring test-takers use to answer questions on the ACT math test?
2. What cognitive strategies do average-scoring test-takers use to answer questions on the ACT math test?
3. What similarities among strategies can be determined?
4. What differences among strategies can be determined?

**Review of Literature**

In the 1950s, researchers and educators began to examine and discuss the concept of cognitive strategies (Pressley & Harris, 2008/2009). One of the landmark works in terms of mathematical problem solving strategies was authored by twentieth century mathematician George Polya. His work, *How to Solve It*, put forth a new way to understand and teach math strategies, including specifics like drawing figures, restating the problem, and working backwards (Polya, 1957).

From that point to the modern day, educational researchers have investigated the role that cognitive strategies play in teaching and learning. Research has run the gamut from elementary grade children memorizing picture cards to high school students solving math problems (for a review, see Kirby, 1984, and Pressley & Harris, 2008/2009).
The heart of cognitive strategy research is to find what mental processes and tools increase educational performance. While tests, such as the ACT in the present study, are used to observe the strategies in use, the purpose of the research is not about raising test scores. Instead, the purpose is to determine the “underlying cognitive processes” that influence both test performance and educational performance (Kirby, 1984, p. 52). Once those cognitive processes have been determined, educators could develop more targeted curriculum and instruction to improve students’ educational performance.

As a major contributor to the field of cognitive strategy research, Schoenfeld (1985) has written extensively about his pursuits in observing and describing the strategies students use when solving math problems. He maintains that direct observation of a subject actually working problems is the best way to analyze the subject’s performance. Schoenfeld explains that simply seeing the final grade a student earns on a test does not allow an educator or researcher to judge the student’s problem-solving performance. Even reviewing the student’s final solutions lacks critical information. However, transcripts and scratch work produced as a person works problems indicate what “the person does, rather than what the person produces,” thereby giving a researcher (or teacher) key information to understanding the subject’s (or student’s) performance (Schoenfeld, 1985, p. 4).

Schoenfeld (1985) utilized an experimental protocol whereby subjects talked out loud as they solved problems. The subjects were taped during the experimental sessions; the tapes and subsequent transcripts were coded and analyzed. This protocol calls for a noninterventionist methodology where the researcher does not direct the student or ask any questions during the observation sessions. This protocol allows the student to solve problems as he or she normally would, including making mistakes. By observing test-takers this way, the findings are less likely
to be biased by the researcher who was in the room at the time of the session. The protocol for the present study is based on Schoenfeld’s work.

While research on cognitive strategy has been present in educational literature for over 50 years, there are still gaps related to specific groups of students and specific tests. Given the widespread use of college-readiness tests such as the ACT, more research should be conducted on the strategies needed to perform well on these tests, which ultimately are the strategies needed to perform well in the college classroom.

**Methods**

This is a qualitative exploratory study using direct observation techniques. The study is divided into two phases. Phase 1 includes the data collection. In this phase, which is already complete, subjects were recruited and observed taking an ACT math test. Subjects were recruited from the Fall 2011 and Fall 2012 freshman population of Union University students. In addition, some area high school seniors were recruited at the end of Spring 2012. The high-performing students met the criteria of having scored a 30 or higher on the ACT math and science tests while in high school. For the average-performing students, the criteria included scores of 18-22. For college participants, only freshmen were recruited—and only during the fall semester—because these students have not progressed far into their collegiate training, making their cognitive processing more like a high school student than a college student. Ultimately, the researcher will generalize the findings to high school students (the audience who stands to benefit the most from the findings), and using college upperclassmen simply would not allow for such generalization.

Phase 2 of the project, which will begin in the fall of 2012, will include the data analysis component. Recordings will be reviewed by both the primary researcher and a research
assistant. Cognitive strategies and other observable indicators will be coded, entered into a spreadsheet, and analyzed. The outcome of Phase 2 will be a reliability measure that gauges the inter-rater scores from the researcher and the assistant. Other outcomes include the specific strategies used by high- and average-scoring test-takers along with the similarities and differences between the two types of students.

**Subjects**

The subjects were incoming freshmen at Union University and outgoing seniors from an area high school. The invitation to participate was emailed to students who had been identified as having met the score criteria. The researcher used both male and female subjects, who typically ranged in age from 18-19. Neither students’ ethnicity nor high school academic preparation (public, private, or homeschool) was a consideration for selection. All students who met the criteria and responded to the invitation were included. Since the researcher works only with graduate students on campus, none of the subjects were related to or known by the researcher.

**Procedure**

Subjects were asked to report to a room in the Blasingame Academic Complex and spend approximately 2 hours taking portions of a sample ACT math and science test while being recorded. Prior to the recording, students completed the consent form and the Cognitive Strategies Research Participant Information Sheet (included in this proposal). A camera was used to capture the video portion of the observation while a lapel microphone was used to capture the audio. Both signals were routed into a DVD recorder, which recorded the hand of the subject solving problems and the voice of the subject talking through the solutions. Neither students’ faces nor any other identifying information were recorded on the DVD. At the end of
the 2-hour session, students were given a gift card for their participation in the study.

Since the recordings provide the evidence of specific cognitive strategies in use, segments of the recordings may be used for future training of students and teachers. Segments also may be viewed if the research is presented at a conference. However, the subjects’ real names will never be revealed to anyone other than the researcher. In any future screenings, the subjects will be referred to by code (“Subject 1”) or an alias. All materials—the DVDs, the Information Sheets, and any transcripts—will be locked in a safe or filing cabinet that only the researcher will have access to.

**Instruments**

Students answered questions from ACT test version 0556A, a retired test that the company has released for purchase. This particular test was administered in 2005 and is among multiple tests that have been retired, so the likelihood that any of the participants would have seen this exact test is extremely low. Figure 1 shows the instrument to be used by the researcher to code the student responses. The data from this instrument will be entered into an Excel spreadsheet so that the frequency of certain strategies and other elements of the student’s work can be calculated and analyzed.
57. In the figure below, $\overline{BCF}$ is a straight line and all distances are given in centimeters. What is the ratio of the area of quadrilateral $ABCD$ to the area of quadrilateral $DCFE$?

![Figure 1](image)

**Figure 1.** Instrument for coding student responses on the ACT math test.

**Conclusion**

Pressley and Harris (2008/2009) have identified a research gap related to cognitive strategies. As prolific researchers in this area, they state, “We expect work on cognitive strategies instruction in math to continue, but probably more as part of multi-component instructional packages attempting to develop the strategies, knowledge, and understanding that excellent problem solvers use” (p. 88). This study seeks to use the ACT test and the videotaping
protocol as tools to learn more about the thought processes of these “excellent problem solvers” referred to by Pressley and Harris.
References


Cognitive Strategies Research Participant Information Sheet
Cognitive Strategies Research Participant
Information Sheet

CONTACT INFORMATION

Name: __________________________________________________________

Address: ____________________________ City: __________ State: _______ Zip: __________

Best phone contact number: ________________  UU email address: _____________________

ACADEMIC INFORMATION

Name of high school attended: ____________________________________________

Type of high school attended:

- ☐ Public
- ☐ Private (religiously affiliated)
- ☐ Private (not religiously affiliated)
- ☐ Homeschool
- ☐ Other: __________________________

Highest level math course taken in high school: __________________________

Highest level science course taken in high school: __________________________

ACT INFORMATION

Highest ACT composite score: ____________

When did you take this test (highest composite score)? _______________________

- Highest ACT English score: ____________
- Highest ACT math score: ____________
- Highest ACT reading score: ____________
- Highest ACT science score: ____________

Number of times you took the ACT in high school: _______________________

What kind of ACT training or test preparation did you participate in prior to taking the ACT?
Essay on Christian Faith and Academic Discipline
Learning about the Creator and Following His Model

In the first chapter of Genesis, we gain precious insight into our very origins. God declares (presumably to the Godhead), “Let us make man in our image, in our likeness” (Genesis 1:26, New International Version). In the following verse, we read, “God created man in his own image, in the image of God he created them; male and female he created them.”

The creation story is one of the fundamental narratives of the Christian life. It shapes Christian perspectives, informs the Christian intellectual tradition, and provides the backdrop to our entire existence. And in the very beginning, we learn that, as “the created,” we are in some way like the Creator. We have been made in His image according to His likeness. The exact nature of our shared likeness has been debated since this truth was revealed. Does God have ten fingers and ten toes? Does His face look like our human face? Is His physical structure similar to our bodies? While these specific questions may not have concrete answers on this side of eternity, we still accept the truth that we are patterned after God at some level and in some dimension.

I contend that one area where humans reflect the nature of God is in rational thought, including cognition and problem solving. This is certainly not the contention that humans think at God’s level. The Scriptures are clear on that matter: “‘For my thoughts are not your thoughts, neither are your ways my ways,’ declares the Lord. ‘As the heavens are higher than the earth, so are my ways higher than your ways and my thoughts than your thoughts’” (Isaiah 55:8-9, New International Version). Instead, the contention is that God created the human thought process, including cognition, problem solving, critical thinking, and reasoning. To examine such processes is to examine God’s very handiwork at a deep and meaningful level. At the same time, such an investigation reveals more about God Himself since we are created in imago Dei.
The purpose of this study is to determine what strategies high-scoring test-takers use to answer questions on the ACT math test. At a micro-level, the study utilizes a specialized test targeted to a narrow group of students. However, at a macro-level, this study seeks to learn more about the way we think in general. The proposed protocol and instrumentation are merely tools to begin developing a much bigger picture—that is, how we cognitively reason through a problem we encounter. By observing participants narrating their thoughts as they answer questions, I intend to capture how a person approaches thinking through solutions and ultimately analyze the entire process.

This level of problem solving is uniquely human, and the observation of such is a window into the human mind. As humans are the highest of the created order, the observation is also a window into the mind of God. Through a Christian lens, it has spiritual implications to accompany the academic implications. The underpinnings of the faith-learning integration of this project can be summed up in a simple truth: To study the creation is to study the Creator.

My personal passion for this project is fueled by another desire in addition to studying the Creator. In my education career, I have encountered countless students who struggle in the classroom, particularly the mathematics classroom. Some students who find math difficult do not have even rudimentary strategies for problem solving or mathematical reasoning. At the same time, I have had the privilege of knowing and teaching extremely bright students who speak math as fluently as a native language. These talented students often develop their own problem solving strategies and may not even need a teacher to explain the techniques to navigate a challenging problem. These personal experiences beg the question: Could we in a sense “export” the cognitive strategies of gifted students to those who desperately need them? Could we identify exactly what is happening in the minds of the bright students and then teach that to
students who struggle? If that transfer to strategy is possible, the Christian-informed educator in me says I have a moral obligation to facilitate it. This pattern of passing down cognitive strategies could become a type of intellectual discipleship, based on the model of discipleship used by Christ himself.

In the Gospel accounts of Jesus’ public ministry, one of his first tasks was to assemble a group of men to be his closest disciples. For the next three years, Jesus poured His life and teaching into them so they could turn around and pour their lives and teaching into others. His inner circle included the men who had the experiences and empowerment to spread the news of the Messiah to those who needed to know it. Jesus established a discipleship model that has been utilized for centuries in all kinds of contexts.

One of the outcomes of this research project could be curriculum that is made available to math teachers. Through a collection of instructional videos, practice worksheets, and sample tests, high school students could learn from the best and brightest minds. The only way cognitive strategies could be developed into curriculum, though, is to first identify exactly what the best and brightest minds are doing when actually solving problems. After the key strategies are identified, then materials could be developed that help students learn and sharpen the same strategies, which would in turn increase their chances for success not only on college-readiness math assessments but for math in general.

The students who need such targeted instruction and specialized curriculum are often students who would never be exposed to this type of teaching. Our country continues to battle an achievement gap that plagues schools and society in general. The achievement gap—which once implied a gap along racial lines—now affects myriad subgroups of students. There are documented achievement gaps between privileged students and their poorer counterparts,
between English-speaking students and their non-native counterparts, and between regular education students and their learning disabled counterparts. One consistent theme emerges: Some students have the skills and knowledge base to outperform others. In my estimation, those who are being outperformed are the students who desperately need every legitimate advantage. These underperforming students often lack access to quality teachers and resources. They often lack parental involvement and the means to advance their own learning. To use a Biblical allusion, these underperforming students really are “the least of these.” The right curriculum, based on a model of intellectual discipleship, could potentially open doors of opportunity for generations of students who need help the most.

While this cognitive strategies research project is not an overtly Christian project, it is built on two fundamental Christian principles. Since we are created in God’s image, we can gain insight into God Himself by examining the rational mind He designed. In addition, we can follow Christ’s very model of discipleship to pass wisdom and knowledge from those who possess it to those who need it.
Brief Budget and Plan for Completion and Dissemination
**Budget**

Travel costs for future presentations/conferences..............................................................$1000.00

Researcher stipend .............................................................................................................$3500.00

TOTAL .................................................................................................................................. $4500.00

**Plan for Completion and Dissemination**

August 2011 ...................... Receive approval from Union University’s Institutional Review Board (approval was received August 3, 2011)

Aug-Oct 2011, May-Jun 2012, and Aug-Oct 2012............ Conduct observations with participants (observations have already been conducted with 18 participants)

Fall 2012-Spring 2013 .......................................................... Submit proposal for conferences

November 2012-July 2013.............................Review recordings of observations, code the data, write up results, implications, and conclusions

Fall 2013-Spring 2014 ..........................................................Present findings at conferences
Curriculum vitae
BEN T. PHILLIPS, Ed.D.
Director of Ed.S. and Ed.D. Programs, Union University (Jackson campus)
Associate Professor of Educational Leadership

EDUCATION

1999-2002 University of Memphis Memphis, TN
  • Ed.D., Leadership and Policy Studies; Concentration in Educational Leadership

1997-1999 University of Memphis Memphis, TN
  • M.S., Leadership and Policy Studies; Concentration in School Administration and Supervision

1993-1997 Freed-Hardeman University Henderson, TN
  • B.S., Mathematics; Graduated summa cum laude

CERTIFICATION

• Tennessee Professional Certificate; Grades 7-12; Mathematics endorsement
• Tennessee Beginning Administrator’s License
• Association of Christian Schools International Secondary Principal Certificate

EXPERIENCE

June 2010-Present Union University, Jackson, TN
  Director of Ed.S. and Ed.D. Programs
  Associate Professor of Educational Leadership

July 2007-June 2010 Trinity Christian Academy, Jackson, TN
  High School Principal; Interim Head of School (2008-2009)

August 2007-May 2010 Union University, Jackson, TN
  Adjunct Instructor

July 2004-June 2007 Memphis City Schools; Cordova High School, Cordova, TN
  Principal (2006-2007); Vice-Principal (2004-2006)

March 2004-May 2005 Christian Brothers University, Memphis, TN
  Adjunct Instructor

July 2002-June 2004 Memphis City Schools; Ridgeway High School, Memphis, TN
  Assistant Principal
Jan. 2001-July 2001  Dyersburg State Community College, Dyersburg, TN  
*Adjunct Mathematics Instructor*

August 1997-May 2002  Tipton County Schools; Munford High School, Munford, TN  
*Mathematics Teacher*

**RESEARCH INTERESTS**

- Student performance on college-readiness assessments, particularly the ACT
- Education-related statistical analysis
- Education funding
- Education law
PUBLICATIONS/PRESENTATIONS

- Dissertation: The Use of Value-Added Gain Scores to Assess the Impact of School Funding on Student Learning and Educational Adequacy. (Doctoral dissertation, The University of Memphis, 2002).

- Peer-reviewed article: The Use of Value-Added Gain Scores to Assess the Impact of School Funding, Education Leadership Review, 3, 17-21, 2002.

- Workshop: “The Important Thing is That Students Are Changed,” Full-day Faculty Workshop, Columbia International University, August 2012.

- Presentation: “Bridging the Gap: Making MoodleRooms Work for You,” Union University’s Fall Faculty Workshop, August 2012.


- Presentation: “Using Graphics and Animation in PowerPoint to Create Significant Learning Experiences,” Union University’s Fall Faculty Workshop, August 2011.

- Presentation: “The Ease of Quality Instruction,” Haywood County Schools Teachers’ In-Service, August 2011.

- Presentation: “Understanding the ACT, PLAN, and EXPLORE,” teacher workshop presented in multiple schools and school districts throughout West Tennessee and Western Kentucky, 2007-present.

- Presentation: “Preparing for the ACT,” student workshop presented in multiple schools and school districts throughout West Tennessee, Western Kentucky, North Mississippi, and Eastern Arkansas, 2002-present.


- Presentation: “Discipline is Psychological Warfare,” Memphis City Schools New Teachers’ Induction, July 2006 and September 2006; Haywood County Schools Teachers’ In-Service, August 2010.
