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ABSTRACT

The undergraduate liberal arts program is assumed to promote sophistication in thinking. At the same time, certain levels of cognitive ability are assumed to be present in students accepted into selective undergraduate colleges. Beginning in the fall of 1991, a long-term research study was undertaken at a small residential liberal arts college that was designed to test both of these assumptions. Some data were collected from each of the 1,7777 students who matriculated in fall 1991, 1992, and 1993. Students were assessed for formal operational ability and intellectual flexibility at the beginning of their freshman year, as sophomore, and finally as seniors. Although it is not possible to differentiate them from changes that might have occurred just because of the passage of time, the findings do suggest that the young adults in this sample did become less concrete and more formal thinkers over their college careers (percent concrete thinkers decreased from 21.8% to 7%). Participants also became less absolute and more evaluative in their approach to problems. (Contains 28 tables and 7 references.) (Author/SLD)

Longitudinal Study of the Development and Consequences of Formal Operations and Intellectual Flexibility

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1

Abstract

The undergraduate liberal arts program is assumed to promote sophistication in thinking. At the same time, certain levels of cognitive ability are assumed to be present in students accepted into selective undergraduate colleges. Beginning in the fall of 1991, a long-term research study was undertaken at a small residential liberal arts college that was designed to test both of these assumptions. Specifically, students were assessed for *formal operational ability* and *intellectual flexibility* at the beginning of their freshman year, as sophomores, and finally, as seniors. Although it is not possible to differentiate them from those changes that might have occurred just because of the passage of time, these findings do suggest that the young adults in this sample did become less concrete and more formal thinkers over their college careers (percent concrete thinkers decreased from 21.8% to 7%). Participants also became less absolute and more evaluative in their approach to problems.

The undergraduate liberal arts program is assumed to promote sophistication in thinking. At the same time, certain levels of cognitive ability are assumed to be present in students accepted into undergraduate colleges such as Allegheny. Beginning in the fall of 1991, a long-term research study was undertaken that was designed to test both of these assumptions. Specifically, students were assessed for *formal operational ability* and *intellectual flexibility* at the beginning of their freshman year, as sophomores, and finally, as seniors. Eventually, three cohorts of students (those matriculating in 1991, 1992, and 1993) were included in the study.

This effort was designed to provide information about the efficacy of our curriculum as well as to meet the evaluation requirements of several grants and outside agencies such as Middle States.

It is important to remember that *formal operational ability* and *intellectual flexibility* are but two of the many skills and abilities which our curriculum is designed to foster. For example, the proposed testing did not directly examine either writing or creative abilities, among others. This effort should be seen as an attempt to begin the process of evaluating our curriculum by looking at some global achievements and not as an attempt to examine every goal of our teaching.

There is some disagreement in the literature on the appropriateness of the model proposed by Jean Piaget to adult intelligence. Some researchers and theorists, Perry in particular, suggest that college students should be seen as being in a "postformal" period rather than in the formal operations stage. Consequently, a paper-and-pencil measure of *adult intellectual development* that focused on absolutism, relativism, and evaluativism was added to the test battery in the fall of 1992.

Defining Formal Operations and Intellectual Flexibility

Formal Operational Abilities

Formal operations is the highest stage of cognitive development in Piaget's (1950) model, entailing the ability to use abstractions in the construction of hypothetical perspectives. The stage immediately prior to formal operations,

concrete operations, entails a dependency on concrete experience. Undergraduate studies typically depend heavily upon cognitive abstractions. However, current research suggests that as many as 40% of college freshman either lack formal operational ability or that they are in a state of transition unable to make effective use of their newly acquired abilities. Measurement over time was designed to determine if formal operational ability is acquired and/or more fully developed during the course of our undergraduate program.

Intellectual Flexibility

Under many different names, disciplined flexibility in analytical thinking is usually thought of as a hallmark of the liberally educated person. Sometimes it is called relativism of judgement or commitment to one position while understanding diverse views (Perry, 1970). Sometimes it is simply called reasoning ability. In any case, it involves the ability to see the elements of truth in all sides of a controversy, to analyze arguments, and to construct coherent ways of evaluating those arguments.

Adult Intellectual Development

A number of investigators, including Perry, have studied the development of postformal operational thought. Perry showed that students began college with a dualistic belief in absolute right and wrong and then enter a period in which they accepted multiple possibilities while contradictorily maintaining a belief in ultimate truth. Next, these students advance through a phase of relativism in which they believe there was no absolute right or wrong, and that all knowledge was contextually based. Subsequent to their period of relativism, the students end their collegiate tenure with a commitment to knowledge based on the best personal judgement possible.

Kitchener and King (1981) developed their Reflective Judgement Interview (RJI) from the Perry tradition specifically to provide a more standardized, a more reliable, and a more exclusively cognitive measure of these levels and transitions. Seven intellectual positions in the RJ model can be described in terms of three broad levels of Absolutism, Relativism, and Evaluativism.

Individuals within the *Absolutism* level believe in the existence of absolute knowledge and in the direct availability of that knowledge through appropriate sources. Absolutists consider appropriate sources to be authorities and their own sensory and mental experiences.

For the *Relativist*, knowledge has become contextual, and tends to loose its truth-value. Only in concrete, scientific areas of knowledge are the idea of truth even slightly meaningful and often even that is doubted.

At the *Evaluativism* level, individuals began to critically evaluate ideas, evidence, authorities, and arguments. For the Evaluativist, knowledge is explicitly justified by the method through which it was obtained.

Measuring Formal Operations and Intellectual Flexibility

Measuring Formal Operations

Formal operations was be assessed by the Arlin Test of Formal Reasoning (ATFR, Arlin, 1984). This 32 item, multiple choice test takes about 45 minutes but is not timed and students are permitted finish all the items. The items in the test were designed to closely parallel the description of tasks employed by Inhelder and Piaget (1958) to clinically assess an individual's ability to use the eight specific concepts associated with the stage of formal operations. Although the names used for these eight formal concepts are reminiscent of the science and mathematics experiments which were first used to illustrate Piaget's formal logic system, it is important to realize that they also represent thinking processes used in all intellectual endeavors. Each concept represents a form of thinking and not necessarily the content of that thinking. They are known by the fact of their varied applications rather than being concepts in the narrow sense of the term (Inhelder & Piaget, 1958, p. 309). This instrument was chosen over several others because of its ease of administration and because of the wealth of published research that

can be used to provide comparative data for this effort.

The eight formal schemes are described below using details provided in the ATFR manual.

1) Multiplicative Compensations is the concept which supports the understanding that when there are two or more dimensions to be considered in a problem, gains or losses in one dimension are made up for by gains or losses in the other dimensions. A common question that requires this kind of thinking for its answer is: "If I make this change what effect does this have on ...?"

2) Correlations is a concept that implies the ability of a student to conclude that there is or is not a causal relationship, whether negative or positive, and to explain the minority of cases by inference of chance variables. Correlational reasoning provides answers to questions that begin: "What is the relationship ...?"

3) Probability is a concept that supports the ability to develop a relationship between the confirming and the possible cases. Students are using this concept whenever they ask themselves the question "What is the possibility that...?" or "What's the likelihood that ...?"

4) Combination reasoning involves the concept of generating all possible combinations of a given number of variables, choices, events, and scenarios when a problem solution requires that all possibilities are accounted for. Students use this concept when they ask the question: "What are all possible combinations of...?"

5) Proportional reasoning is the fifth formal scheme. It is defined as a mathematical concept that involves the ability to discover the equality of two ratios that form a proportion. Aristotle in his poetics defined an analogy as a statement where the second element is compared to the first, as the fourth is the third. Is this not a restatement of the definition of proportionality? Interpreting analogies and complex poetic examples require multiple classifications and their coordination. Studies (Billow, 1975; Arlin, 1977, 1978) show that the proportional reasoning concept appears to be a necessary but not sufficient condition for interpreting analogies and expanded metaphors beyond their more literal level.

6) Forms of Conservation Beyond Direct Verification and the seventh scheme, Mechanical Equilibrium would appear to be narrowly defined in terms of scientific concepts but they too have implications for other areas of inquiry. For example, consider the saying: "By their deeds you will know them." This dictum suggests a type of inference is required to get *at the essence of personal definition that one cannot directly see*. In a sense it requires the use of the scheme of forms of conservation beyond direct verification in its broadest sense.

7) Mechanical Equilibrium requires the ability to simultaneously make the distinction and the coordination of two complementary forms of reversibility-reciprocity and inversion. Most economic theories presuppose these types of trade-offs to maintain equilibrium in the system. The writing of novels and the interpretation of complex plots in plays, all represent this delicate balance.

8) The Coordination of Two or More Systems or Frames of Reference is one of the most complex schemes, and yet is applications are wide-ranging. It may well be the scheme which acts are a bridging concept between formal and any type of post-formal thinking.

Scoring the ATFR. Based on the test score, students are assigned to one of five cognitive levels as defined below.

1) Concrete represents performance on the formal tasks which is best described as providing no evidence of abstract reasoning and some difficulty with reasoning skills that are problem specific.

2) High Concrete represents performance that provides some evidence of a systematic approach to problems but not evidence of forming a general rule or abstraction from the problems.

3) Transitional students provide some evidence of a systematic approach to the problems and some use of

abstractions and inferences but the performance is quite inconsistent.

4) Low Formal students give clear evidence of three-to-five of the formal schemes being present in their thinking.

5) High Formal students give clear evidence of most of the formal schemes being in evidence in their thinking.

Measuring Intellectual Flexibility

Intellectual flexibility will be measured by using a variation of a procedure proposed by Winter, McClelland, and Stewart in their book *A New Case for the Liberal Arts* (1981). Their measure, called the Analysis of Argument Test, duplicates as much as possible the familiar situation in which a complex, potentially emotional issues is being discussed.

Students are first given a brief quotation that expresses a strong, extreme position on a controversial and emotional issue. The issue chosen is one that was expected to produce a strong negative reaction in most college students. After reading the quotation (300 to 400 words), they are given five minutes to write a response: "Assume that you argue against it. Your response can be of whatever form and nature that you think is most satisfactory and appropriate." After writing their responses, without any prior mention, subjects are then told to turn the page, where the next instruction reads as follows: "Write a defense of the quotation--including if you wish, argument against your criticism that you have just written. Again, your defending response can be of whatever form and nature that you think is most satisfactory and appropriate."

The same article was used as a stimulus to this writing throughout all the years of the study. The topic of the article was drinking among college students and in quite strong and emotional language, it made the point that college aged students were much too immature to drink alcohol and that colleges must take an active and intrusive role to limit the consumption of alcohol. Hence, the Attack essay would try to refute this point while the Defense essay would support it.

Winter, et al. (1981) have developed a scoring system that they claim can reach 90%+ agreement among trained scorers.

Measuring Adult Cognitive Development

Factor analysis of items derived from Kitchener and King's (1981) descriptions of interviews of college age and older adults revealed three factors, interpreted as representing three developmentally related epistemic strategies, *Absolutism, Relativism, and Evaluatism*. Newman and Martin (1989) have made available a sixty-item paper-and-pencil scale (*Scale of Adult Intellectual Development--SAID).* The measure has proven quite reliable and has been shown to have convergent validity by predicted correlations between *SAID* and Dogmatism, Locus of Control, Desire for Control, Need for Cognition, and Erwin's Scale of Intellectual Development.

Students at the *Absolutist* level exhibit a simple acceptance of a viewpoint with reasoning. Beliefs that are consistent with, or similar to, previously held beliefs, are accepted. In the parlance of current epistemological discussion, *Absolutists* are foundationalist in the extreme.

Among other things, the *Relativist* level shows a process of individual choice in a context where everyone is thought to be entitled to their own opinion. Instead of consistency with a single perspective, an appreciation of, or an accommodation to, a more complete array of inconsistent perspectives is valued at this level.

At the *Evaluativist* level, decisions are based on critical evaluations of evidence, authority, and argument. *Evaluativists* move toward making judgements in the context of the tension constituted by the joint appreciation of the clashing epistemological values of consistency on the one hand, and completeness on the other. *Evaluativism*

represents a move beyond foundationalism and relativism.

The *SAID* consists of 60 items, each consisting of two or three sentences. Students are asked to read each item and then indicate on a scale of 1 to 7 whether the item was Strongly Like Me (7) or Strongly Unlike Me (1) or some where in between.

Nineteen items are included in the *Absolutist* subscale, 20 in the *Relativist* subscale, and 21 in the *Evaluativist* subscale. An example of an item from each of the scale is given below.

Item from the *Absolutist* subscale: I have been surprised many times to find out how differently people can feel about straight-forward issues. I think that when it gets right down to it, there is really only one right view. That's why most people naturally feel the same way.

Item from the *Relativist* subscale: I'm willing to stand behind the decisions I have made because I look at problems from all sides before I make a judgement. Sometimes, standing up for my ideas results in conflicts with other people. I'm able to take that responsibility for sharing my views, but I don't feel like I must change their opinions even if my ideas are better.

Item from the *Evaluativist* subscale: It's not possible to say that someone is totally right or wrong in what they think. Issues are so complex it would be easy for me to be wrong; so, how could I say someone else is? I might believe something more because of the reasons for it, but I would say it might be better, not right.

Available Data

At least some data was collected from each of 1,777 students who matriculated at Allegheny College in the fall of 1991, 1992, and 1993. Freshmen testing was done during orientation (before the first week of class) while sophomores were tested on the last day of their LSW course in the fall or spring of their second year. Seniors were tested as part of a senior exit interview procedure. For most seniors this testing was done in the spring semester but for fall graduates it was done just before they finished their final semester.

At each testing session (freshmen, sophomore, and senior) measures of formal reasoning, intellectual flexibility, and intellectual development were taken. The *Arlin Test of Formal Reasoning* provides a raw score that allows the student to be assigned to one of five cognitive levels (concrete, high concrete, transitional, low formal, and high formal).

The test of intellectual flexibility required that students write two essays, one defending and one attacking the position taken in a short, newspaper style article. The essays were read and scored by trained raters employed by McBer and Company in Boston. The scoring procedure, developed by Winter and McClelland, provides for scores ranging from –4 to +6.

A +1 would be given, for example, when an essay focused on the logical and logical errors of the statement (attack) or when the writer reworked or delimited the original statement so as to defend it (defense). On the other hand, a score of –1 would be given if the writer simply provided a series of criticisms that were not organized around a central principle, insight, or focus (attack) or when, in the course of defending the article, the writer introduced new arguments not given in the original statement.

The *SAID* provides scores on three subscales, one for each of the epistemic strategies, *Absolutism, Relativism, and Evaluatism.*

In addition to these measures described above, demographic information was obtained on students who completed the surveys from the Allegheny College database. The following data where therefore available for analysis on

most, but not all, students:

- SAT scores (recentered, ACT scores were converted to equivalent SAT scores where possible)
- Gender
- Ethnic group
- High school rank
- Size of high school
- LSW200 grade
- Cumulative GPA
- Initial interest (field of study the student might like to pursue)
- Major at graduation
- Change in interest (did initial interest differ from major?)

Data Analysis

Given the rich data set provided by this project, there are virtually hundreds, if not thousands, of possible hypotheses and questions that might be examined. However, this project was initially conceived to examine the relationship, if any, between intellectual flexibility, initial interest, college major, and retention. However, before those more meaty hypotheses are examined, let's try to get a picture of how Allegheny students look on the measures taken and how those scores changed over time.

Since there were no significant differences or trends from one cohort to the next, data from all three of the three classes were combined for the analyses provided below.

Formal Operations

Recall that results of the ATFR place students in one of five categories ranging from Concrete to High Formal that indicates their level of abstract thinking. Figures 1 and 2 present the proportion of freshmen, sophomores, and seniors in the various cognitive stages. Several things are worth noting.

First, almost 25% of the freshmen in this sample were in the Concrete or High Concrete stage. Although this certainly presents problems to those faculty attempting to cover abstract material in their classes, this proportion is just about equal to that reported across the country for college freshmen.

Second, and on a more positive note, the proportion of students in these lower stages declines significantly by the senior year where the proportion of High Formal operators has doubled from 14% in the freshmen year to 28%.

Third, although there are still some students who score in the High Concrete stage as seniors, no students in our survey scored as Concrete thinkers as seniors.

In summary, this data indicate that although we don't turn all of our students into accomplished abstract thinkers by the time they leave Allegheny, our students do become more sophisticated thinkers during their four years with us.

Intellectual Flexibility

Intellectual flexibility was measured by asking the students to write two essays, one supporting and one opposing material provided in a short newspaper article. Scores on each essay can range from –4 to +6. In this particular measure we can not only observe changes over time as we did with the ATFR but we have some national normative data for comparison.

Table 1 presents the results of the Analysis of Argument data. There are several interesting as well as several curious

findings indicated in this table. First note the Attack scores.

The Attack scores not only improved from the freshmen to the sophomore year (-.87 to -.76) but these scores are below (that is better than) all categories of the norm group. (The "Ivy Colleges" norm group included students from several schools but most were from Harvard University. The mean SAT score for this group (recentered) was 1,420. Mean SAT (recentered) for the "State Teachers Colleges" sample was 1,040 while that for the "Community Colleges" was 1,020.)

On the other hand, the scores for the Defense essay are consistently poorer than those in the norm group and got worse as students move from their freshmen to senior years!

However, if we keep in mind the nature of the essays being written we may understand this outcome. The Attack essays were written to attack the point being made in the article that students were too immature to drink and that colleges must intervene to reduce the negative outcomes that follow from drinking by college age students. The Defense essay would need to support that argument.

In may be that this particular topic was simply too emotional and too close to the hearts of many of our students and they therefore simply could not formulate reasonable and cogent arguments to support a position that was so far from their own views.

Adult Cognitive Development

Table 2 presents a summary of the data for the various subscales on the SAID. Several interesting findings are evident in this table. First, not only are Allegheny students less absolute in their thinking when they arrive when compared to the norm group but they become less absolute in their thinking the longer they stay at Allegheny. (Statistical tests on this data are difficult since the number of students who presented scores at all three measurements is relatively small. However, there is a significant decrease on the SAID A scale from freshmen to senior years, $t(84) = -2.32$, $p < .02$).

The relativism subscale presents another interesting finding. Here we see that our students' scores are virtually identical to the norm group and they don't change over time.

The most positive finding can be seen on the evaluativism subscale. Here our students begin well below the norm group but their scores show significant increases over time (freshmen to senior change, $t(84) = 5.62$, $p < .01$).

Initial Interest

As part of the admission process, students are asked to indicate the field of study they hope to pursue at Allegheny. These initial interests were classified into one of the three divisions of the College plus an Undecided category. As can be seen in the following tables, there are some measures where students differ according to their initial interest and as well as other measures where there were no differences.

Differences among groups based on initial interest were done using one-way analysis of variance for independent groups with a Tukey HSD follow-up test were appropriate. Results are presented in terms of homogenous subsets.

ATFR. Significant differences were found between initial interest groups on their ATFR scores ($F(3,1276) = 6.78$, $p < .01$). As can be seen in Table 3, students who express an initial interest in the Natural Sciences have significantly higher ATFR scores than those with interests in the Social Sciences (Undecided and Humanities students fall between the two extremes). This suggests that those students who express an initial interest in the natural sciences come to Allegheny with more mature thinking skills than those who initially express an interest in the social sciences do.

Analysis of Argument: Attack. This data indicates that students who express an initial interest in the

humanities write significantly better essays than those interested in the natural sciences (F (3,1174) = 3.89, $p < .01$). See Table 4 for the details.

Analysis of Argument: Defense. No significant differences were found in the Defense scores based on the initial interest of students (F (3,1204) = 0.47, $p > .70$).

Adult Cognitive Development. No significant differences were found on any of the subscales on the SAID based on initial interest (SAID A, $F(2,643) = 0.22, p > .80$; SAID E, $F(2,643) = 1.94, p > .14$; SAID R, $F(2,643) = 2.69, p > .68$).

SAT scores. An interesting, but not unexpected, pattern can be seen in the distribution of SAT scores for groups with different initial interests. Specifically, those interested in the natural sciences have higher SAT math scores (Table 5, $F(3,1388) = 13.84, p < .01$) while those interested in the humanities had the higher SAT verbal scores (Table 6, $F(3,1388) = 12.59, p < .01$). When the scores are combined, we see essentially two groups: natural science and humanities students with high scores and social science and undecided students with lower scores (Table 7, $F(3,1573) = 12.88, p < .01$).

Grades. Although there are no significant differences among the cumulative GPAs for those expressing different interests as freshmen ($F(3,1584) = 1.65, p > .18$), those who listed their initial interest as Undecided achieved a lower grade in LSW200 than those who expressed interest in a specific discipline ($F(3,1282) = 3.45, p < .02$).

High school Rank and Size. Size of high school was unrelated to the initial interest of students ($F(3,1428) = .78, p > .50$) but high school rank did ($F(3,1428) = 4.17, p < .01$). Those who have initial interest in the natural sciences rank, on average, 42 in their class while those with other interests rank on average at about 50.

Academic Major

Now that we have some idea of the differences among students based on their initial interest, we are presented with an obvious question: Is this pattern of differences present when student chose their academic major? To answer this question, differences among the same set of freshmen scores were examined for the division of major at. In addition, since some of the measures were repeated, differences among division of major were also examined for those tests given to seniors as well.

ATFR. As can be seen in Table 8, the same pattern observed when the freshmen ATFR was examined as a function of initial interest can be seen when academic major is examined. That is, natural science students had the highest scores while those who eventually majored in the humanities or social sciences had significantly lower scores ($F(2,1046) = 16.05, p < .01$).

A slightly different pattern is seen when ATFR scores taken from seniors are examined. Here three groups emerge (Table 9). Those who majored in the natural sciences still score the highest but now the humanities and social science students diverge with those who major in the humanities scoring below those who majored in the social sciences ($F(2,399) = 12.20, p < .01$).

Analysis of Argument: Attack. The distribution of freshmen analysis of argument, attack scores by major is the same as that seen for initial interest: Humanities majors scored the best, natural science students the worst, and social science students fell in the middle (Table 10, $F(2,957) = 3.70, p < .05$). However, when analysis of argument scores, attack, for seniors are examined we see no difference among the major divisions ($F(2,382) = 1.85, p > .10$).

Analysis of Argument: Defense. No significant differences were found among academic majors for either the analysis of argument, defense scores for freshmen ($F(2,999) = 0.80, p > .45$) or for seniors ($F(2,309) = 1.36, p > .26$).

Adult Cognitive Development. No significant differences were found on any of the subscales on the SAID based on major for any of the SAID scores taken as freshmen (SAID A, $F(2,643) = .22$, $p > .80$; SAID E, $F(2,643) = 2.69$, $p > .07$; SAID R, $F(2,643) = 1.94$, $p > .14$) or as seniors (SAID A, $F(2,96) = 1.21$, $p > .30$; SAID E, $F(2,96) = .16$, $p >$,85; SAID R, $F(2,96) = 1.99$, $p > .14$).

SAT scores. The pattern observed for initial interest and SAT Math was again seen when major and SAT math sores were examined but the differences became even more pronounced. That is, those majoring in the natural had significantly higher SAT Math scores than those who majored in either the humanities or the social sciences. (Table 11, $F(2,1145) = 34.57$, $p < .01$). Although the size of the differences is not as pronounced, differences among majors on SAT Verbal scores parallel those for initial interest ($F(2,1145) = 4.68$, $p < .01$) with those in the humanities scoring the highest. (See Table 12). Finally, the same pattern seen in initial interest for SAT Total are also seen with major ($F(2,1271) = 12.60$, $p < .01$). As seen in Table 13, those majoring in the natural sciences had SAT Total scores significantly higher than those in the other divisions.

Grades. There are significant differences in cumulative GPA among the majors, with those in the humanities having the lowest grades (Table 14, $F(2,1276) = 8.32$, $p < .01$). A related finding is that those majoring in the natural sciences also had the highest grades in LSW200 (Table 15, $F(2,1215) = 6.18$, $p < .01$).

High school Rank and Size. As with initial interest, high school size was unrelated to major ($F(2,1167) = .69$, $p > .50$) but high school rank was: Natural science majors ranked significantly higher in their high school classes than did those majoring in the social sciences or humanities (Table 16, $F(2,1167) = 17.68) = p < .01$). An interesting figure to note is that the average high school class rank for freshmen interested in science is about 42 while the class rank of those who complete a degree in science is the much better 32.

Graduation Rates

Now that we know that students differ on some, but not all, of the measures taken in this study as a function of initial interest and academic major, we can begin to explore other relationships. For example, do students who graduate differ from those who do not complete their degree on any of these indicators taken during the first week of the freshmen year?

Table 17 provides information to help us answer this question. As can be seen, the only consistently reliable measures that differentiates between those who graduate and those who did not is the ATFR. (There are statistically reliable differences reported on the SAID E, the *Evaluativist* scale. However, since this test provided no other significant relationships among any of the variables studied, it is likely that this result is a statistical anomaly.)

Table 18 includes similar statistics for graduates and non-graduates based on their SAT scores. Those who completed their education at Allegheny outscored those who did not in all categories.

Table 19 presents differences between those who graduated and those who did not on several additional variables, including high school rank and cumulative *GPA*. Significant differences are evident for all of the variables except size of high school. One note of caution, cumulative *GPA* for those who graduated and those who did not graduate are based on different numbers of courses, with those who graduated including many more advanced courses in a major where *GPAs* are often higher than those in the first two years general education courses.

One interesting finding concerning graduation is that the graduation rate for women is significantly higher than that for men ($X^2(1) = 21.89$, $p < .01$). About 75% of the women in this sample completed their degree while only 69% of the men did.

It is also interesting to note that graduation rates did not differ among students based on their initial interest ($X^2(3) = .721$, $p > .89$). That is, about 1/3 of the matriculating students did not graduate, no matter what field of inquiry the student expressed interest in upon admission to Allegheny. There is a small, but marginally significant, trend in graduation rates based on major, however: The highest graduation rate is found among social science students (88%)

and the lowest among humanities majors (83%) ($X^2(2) = 4.86, p < .09$). (Note that these graduation rates only apply to those who have declared a major so they are higher than the rates based on all incoming students.)

And finally, although the sample size is small so we should be cautious about the finding, the graduation rate for white students was significantly higher than that for non-white students ($X^2(5) = 31.30, p < .01$). While the graduation rate for whites was about 70%, that for minorities was close for 50%.

Change in Interests

But what about those students who change their mind about a major? That is, are students who come to Allegheny with an interest in the natural sciences but end up majoring in the humanities different from those who stick with their original choice? The answer to that question is somewhat complex, in that in some ways students with changing interests are the same as those who do not change while on some other measures there are interesting differences.

There are two ways we can consider change in interest. One way is to simply classify students into one of two groups, those who changed divisions from initial interest to major and those who did not change. Second, we could examine those changes in more detail. For example, are there differences on any of our measures between those who come with an interest in the natural sciences but end up majoring in the humanities and those who come with an interest in the humanities and continue that interest through a major?

Changed division of interest or not. Let's begin by comparing those who continued to a major in the division of their initial interest ("did not change") with those who majored in a division different from their expressed initial interest ("changed"). Table 20 presents a summary of the variables where there were statistically reliable different between the two. Perhaps not surprisingly, in every case, those who ended up in a major different from their initial interest scored lower on the variable in question (SAT math, SAT verbal, SAT total, high school rank, grade in LSW200, cumulative GPA, and score on the Arlin Test of Formal Reasoning).

On the other hand, reliable differences were not obtained for the analysis of argument measures (Attack or Defense) or any of the subscales on the SAID.

Many more students who remained with their initial interest as a major graduated when compared to those who changed their initial interest ($X^2(1) = 262.3, p < .01$). The percentages are interesting here. More than 85% of those who majored in the same division as their initial interest graduated while only about 50% of those who changed divisions finished with a degree.

Males are no more likely than females to change their division of interest ($X^2(1) = 1.23, p > .27$) and there is no difference in division change among the ethnic groups included in this sample ($X^2(5) = 5.09, p > .40$).

Initial interest/division of major. Now let's examine the in more detail the changes that students made as their interests shifted from initial interest to major. Initial interests were classified into one of four categories (natural science, social science, humanities, and undecided). Since there are three possible divisions for majors, there are 12 possible combinations ranging from humanities/humanities to natural science/humanities to undecided/humanities.

Note: In the discussion below H/NS means that a student began with an interest in the humanities but majored in the natural sciences, UD/SS is a student who was undecided upon admission but majored in the social sciences, etc. Major, by the way, does not necessarily mean that the student graduated; either the student graduated with the stated major or he or she had declared that major before he or she left the College.

ATFR. There is a significant but complex relationship between freshmen ATFR scores and change of division of major ($F(11,1019) = 4.34, p < .01$). In general it appears that those who begin with an interest in the social sciences or who end up majoring in the social sciences had the lowest freshmen Arlin scores (mean ATFR

scores for SS/H = 16.19, SS/SS = 17.88, and UD/SS = 18.07) while those who end up the natural sciences have the highest scores (mean ATFR scores for H/NS = 20.14, NS/NS = 20.20, and SS/NS = 21.65). The similar pattern held for the ATFR given to seniors ($F(11,381) = 4.22, p < .01$) but here those with majors in the humanities and the social sciences scored below those majoring the natural sciences (mean ATFR SS/H = 14.17, H/H = 17.73, and H/SS = 19.13; UD/NS = 21.65, NS/NS = 22.39, and SS/NS = 23.40).

Analysis of argument: Attack. Although there significant differences among the initial interest/major groups on the Attack portion of the analysis of argument test ($F(11,932) = 2.54, p < .01$), but there is no discernable pattern in the results. The lowest scores were obtained by SS/NS (mean = -1.14), NS/SS (mean -1.12), and SS/H (mean = -1.12) while the highest scores were obtained by NS/H (mean = -.64), H/H (mean -.56), and H/SS (mean = -.26). No differences were found for the analysis of argument: Attack essays written by seniors ($F(11,367) = 1.18, p > .30$).

Analysis of argument: Defense. There were no significant differences for Defense essays written by freshmen ($F(11,973) = .19, p > .99$) or by seniors ($F(11,294) = .78, p > .66$).

Adult Cognitive Development. No differences were evidenced on any of the SAID subscales for either freshmen or seniors (SAID A, freshmen, $F(11,621) = 1.67, p > .07$; SAID A, seniors, $F(10,86) = 1.51, p > .15$; SAID E, freshmen, $F(11,621) = .92, p > .52$; SAID E, seniors, $F(10,86) = .39, p > ..94$; SAID R, freshmen, $F(11,621) = .79, p > ..65$; SAID R, seniors, $F(10,86) = 1.37, p > ..21$).

SAT: Math. Perhaps not surprisingly, those who majored in the natural sciences, no matter what their initial interests, had significantly higher SAT Math scores than those who majored in the humanities (Table 21, $F(11,1116) = 7.58, p < .01$).

SAT: Verbal. Although the picture is not quite as clear as with the Math scores, those with initial interests in or who majored in the humanities had higher SAT Verbal scores than those with other interests or majors ($F(11,1116) = 4.15, p < .01$). The lowest scores were obtained by UD/H (mean = 631), NS/SS (mean = 635), and UD/SS (mean = 638) while the highest SAT Verbal scores were obtained by NS/H (mean = 669), H/SS (mean = 672), and H/H (mean = 675).

SAT: Total. The addition of Math and Verbal scores results in significant but not easily understood differences ($F(11,1241) = 4.97, p < .01$; see Table 22). The differences is scores is striking (1150 to 1266) but no one division or no one pattern of changing interests would appear to be evident although it is interesting to note that some of the highest scores in the table are for students with initial interests in the humanities who ended up majoring in the social or natural sciences.

Grades. Since we know that those who major in the natural sciences have higher GPAs than those in the humanities, is it not surprising to see that finding replicated here (Table 23, $F(11,1246) = 3.49, p < .01$). However, note the finding that those with the highest mean GPA are those with an initial interest in the humanities who graduated with a major in the social sciences.

LSW200. A clearer pattern emerges when we look at the grades students obtained in LSW200. Those who majored in the natural sciences had significantly higher grades than those with majors in the other divisions ($F(11,1186) = 2.67, p < .01$, Table 24).

High school Rank and Size. No reliable differences were found among the initial interest/major as a function of high school rank ($F(179,969) = 1.14, p > .11$) nor size of high school ($F(395,753) = .95, p > .71$).

Gender. There is a significant relationship between gender and initial interest/major ($X^2(11) = 19.74, p < .05$). For most of the groupings (SS/SS, NS/H, etc.) approximately 53% of those in the group are female and 47% male (the over all sample is divided 52.4% female and 47.6% male). However, there is one group that had significantly more females (H/H, 68% female) and another with significantly more males (UD/SS, 55% male).

Ethnic Group. Although there is a significant relationship between initial interest/major and ethnic group ($X^2(55) = 76.64, p$,.05), there are only two cells that differed much from the overall trend (92% white and 8% no white). In both cases (H/SS and SS/H) significantly more non-white students are found in these groupings (82% white and 22% non-white).

Graduation Rate. There is no significant relationship between initial interest/major and graduation rate ($X^2(11) = 8.73, p < .64$). That is, no group (H/SS, UD/SS, etc.) was more or less likely to graduate than any other group.

Initial interest/major. An interesting and statistically significant relationship exists between initial interest and major ($X^2(6) = 432.5, p < .01$). As can be seen in Table 25, those who express an initial interest in the natural sciences are most likely to change, although those with an initial interest in the humanities are close behind. On the other hand, those who express an initial interest in the social sciences are least likely to major in another division. Finally, almost half of those who indicate that they are undecided upon admission to Allegheny ended up majoring in the social sciences.

Gender

Although gender has been considered in several earlier analyses, in this section we will examine differences, if any, between men and women in our sample.

Table 26 provides information on gender differences on some basic demographic variables. Men out perform women on SAT Math while women outscore men on SAT Verbal and high school class rank. No gender differences were evidenced in SAT Total or high school size.

Differences on measures specific to this study are shown in Table 27 and Table 28. In Table 27 we see significant differences at all three measurement times on the ATFR. In all cases, males outscore females. Freshmen males also do significantly better than freshmen females on the Analysis of Argument: Attack essay and as sophomores on the Defense essay.

Table 28 presents some interesting results for the various subscales of the SAID. At all three measurement times, women were significantly less absolute in their thinking than men and they were more relativistic (differences for seniors, SAID R, was not statistically significant, however). However, as freshmen and sophomores, the men had higher scores on evaluativism.

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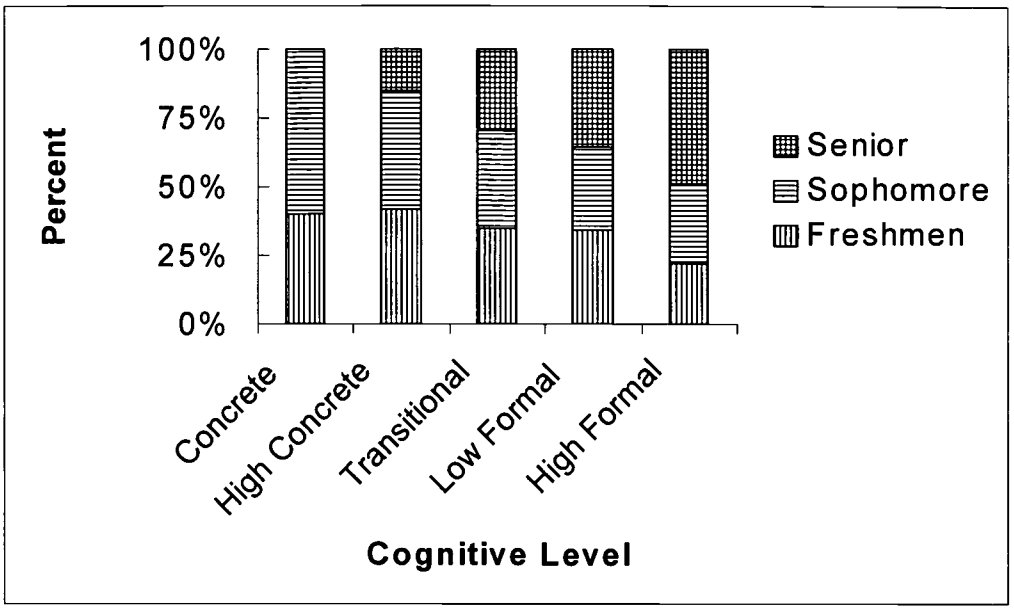

Figure 1. Mean number of students in each stage of Formal Operations for freshmen, sophomores, and seniors.

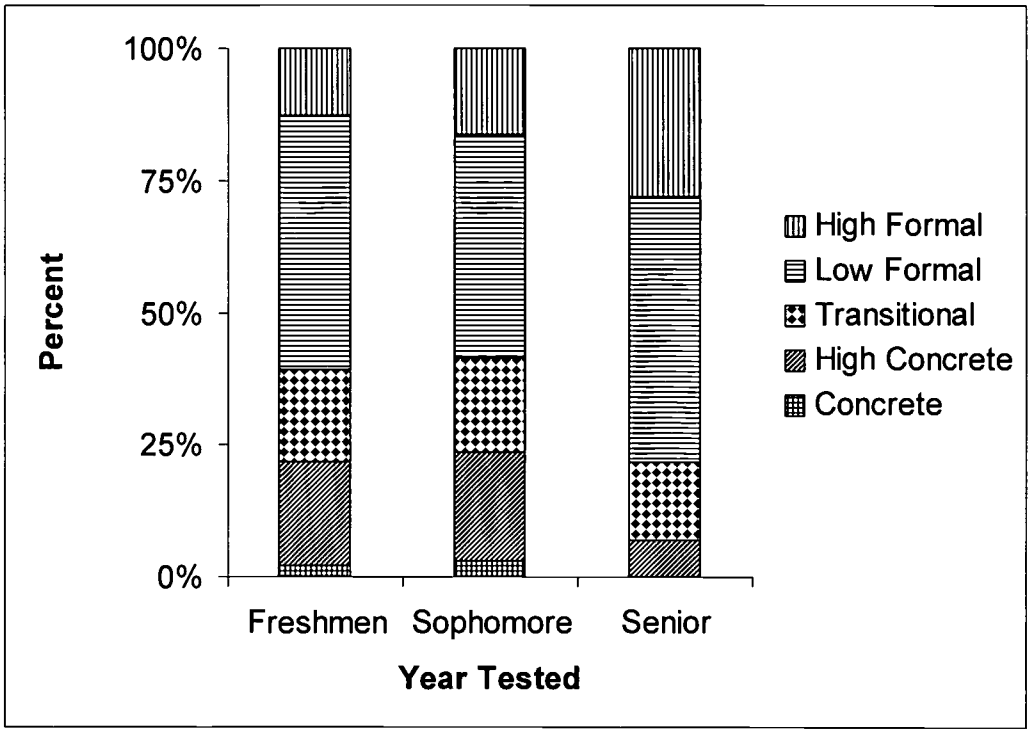

Figure 2. Mean number of freshmen, sophomores, and seniors at each level of cognitive functioning.

Table 1. Mean Analysis of Argument scores for freshmen, sophomores, and seniors for attack and defense essays.

Reference Group	Attack	Defense	Total
Freshmen	-.87	-1.68	-2.55
Sophomores	-.76	-1.77	-2.54
Seniors	-.76	-1.86	-2.62
Norm Group			
Ivy Colleges	-.95	-1.30	-2.25
State Teachers Colleges	-1.50	-1.10	-2.60
Community Colleges	-2.25	-1.15	-3.40

Note: Normative data from Winter, McClelland, and Stewart (1981), page 65.

Table 2. Mean scores for the Scale of Adult Intellectual Development (SAID)

Reference Group	Absolutism		Relativism		Evaluativism	
	Mean	SD	Mean	SD	Mean	SD
Freshmen	59.9	16.7	94.4	17.6	93.4	17.4
Sophomores	57.9	16.6	92.8	15.4	94.8	13.4
Seniors	55.6	15.4	93.7	11.7	98.6	10.7
Norm Group	62.4	16.7	93.6	15.3	99.5	13.2

Norm group of 446 university students.

Table 3. Homogeneous subsets for initial interest by division on the Arlin Test of Formal Reasoning.

		Subset for alpha = .05	
Initial Interest by Division	N	1	2
Social Science	262	17.87	
Humanities	162	18.32	18.32
Undecided	214	18.38	18.38
Natural Science	642		19.47

Table 4. Homogeneous subsets for initial interest by division on Analysis of Argument: Attack.

		Subset for alpha = .05	
Initial Interest by Division	N	1	2
Natural Sciences	564	-.97	
Social Sciences	236	-.89	-.89
Undecided	199	-.80	-.80
Humanities	159		-.60

Table 5. Homogeneous subsets for initial interest by division on SAT Math.

		Subset for alpha = .05	
Initial Interest by Division	N	1	2
Social Sciences	273	570	
Undecided	231	578	
Humanities	187	578	
Natural Science	701		594

Table 6. Homogeneous subsets for initial interest by division on SAT Verbal.

		Subset for alpha = .05	
Initial Interest by Division	N	1	2
Undecided	231	635	
Social Sciences	273	639	
Natural Science	701	649	
Humanities	187		671

Table 7. Homogeneous subsets for initial interest by division on SAT Total.

		Subset for alpha = .05	
Initial Interest by Division	N	1	2
Social Science	327	1174	
Undecided	260	1194	
Natural Science	783		1221
Humanities	207		1224

Table 8. Homogeneous subsets for major by division on the freshmen ATFR.

		Subset for alpha = .05	
Major by Division	N	1	2
Humanities	244	18.15	
Social Science	425	18.39	
Natural Science	380		20.15

Table 9. Homogeneous subsets for major by division on the senior ATFR.

		Subset for alpha = .05		
Major by Division	N	1	2	3
Humanities	71	18.61		
Social Science	178		20.47	
Natural Science	153			22.27

Table 10. Homogeneous subsets for major by division on the freshmen analysis of argument: attack

		Subset for alpha = .05	
Major by Division	N	1	2
Natural Science	340	-.99	
Social Science	384	-.85	-.85
Humanities	236		-.70

Table 11. Homogeneous subsets for major by division for SAT Math

		Subset for alpha = .05	
Major by Division	N	1	2
Humanities	266	572	
Social Science	460	578	
Natural Science	422		603

Table 12. Homogeneous subsets for major by division for SAT Verbal.

		Subset for alpha = .05	
Major by Division	N	1	2
Social Science	460	644	
Natural Science	422	651	651
Humanities	266		659

Table 13. Homogeneous subsets for major by division for SAT Total.

		Subset for alpha = .05	
Major by Division	N	1	2
Humanities	307	1199	
Social Science	508	1202	
Natural Science	459		1237

Table 14. Homogeneous subsets for major by division cumulative grade point average.

		Subset for alpha = .05	
Major by Division	N	1	2
Humanities	307	2.89	
Social Science	510		3.00
Natural Sciences	462		3.05

Table 15. Homogeneous subsets for major by division grade in LSW 200.

		Subset for alpha = .05	
Major by Division	N	1	2
Social Science	491	3.14	
Humanities	283	3.16	
Natural Sciences	444		3.27

Table 16. Homogeneous subsets for major by division for high school class rank..

		Subset for alpha = .05	
Major by Division	N	1	2
Natural Science	423	31.78	
Social Science	472		47.10
Humanities	275		55.93

Table 17. Mean scores on basic measures of intellectual functioning for students who graduated and those who did not graduate.

Measure	Mean		*t*	Significance Level (2-tailed)
	Graduated	Did Not Graduate		
Arlin	19.06	18.32	2.49	.013*
Attack	-.83	-.95	1.63	.103
Defense	-1.64	-1.77	.82	.415
SAID A	59.36	60.89	-1.25	.212
SAID E	94.54	91.17	2.64	.008*
SAID R	94.88	93.41	1.13	.257

* differences significant, $p < .05$.

Table 18. Mean SAT scores for students who graduated and those who did not graduate.

Measure	Mean		*t*	Significance Level (2-tailed)
	Graduated	Did Not Graduate		
SAT Math	587	578	2.76	.006*
SAT Verbal	653	635	5.26	.000*
SAT Total	1219	1183	4.75	.000*

* differences significant, $p < .05$

Table 19. Mean scores on demographic variables for students who graduated and those who did not graduate.

Measure	Mean		*t*	Significance Level (2-tailed)
	Graduated	Did Not Graduate		
HS rank	40.45	61.27	-6.44	.000*
HS class size	227.96	234.29	-.80	.422
LSW200 grade	3.26	2.60	14.21	.000*
Cum GPA	3.08	2.33	25.48	.000*

* differences significant, $p < .05$

Table 20. Mean scores on several variables for students who majored in a division different from that expressed as an initial interest and those who did not major in the division of their initial interest.

Measure	Mean		*t*	Significance Level (2-tailed)
	Did not change	Changed		
SAT math	591	579	4.09	.000*
SAT verbal	652	645	2.04	.041*
SAT total	1222	1198	3.66	.000*
HS rank	39.6	51.5	-3.94	.000*
LSW200 grade	3.24	3.04	5.19	.000*
Cum GPA	3.04	2.72	9.94	.000*
ATFR (freshmen)	19.23	18.54	2.41	.016*

* differences significant, $p < .05$

Table 21. Homogeneous subsets for initial interest /major on SAT: Math.

		Subset for alpha = .05	
Initial Interest/Major	N	1	2
SS/H	43	551	
UD/H	52	566	566
H/H	90	573	573
SS/SS	166	575	575
UD/SS	88	577	577
NS/SS	147	580	580
H/SS	47	586	586
NS/H	76	588	588
UD/NS	43		600
SS/NS	16		601
H/NS	14		601
NS/NS	346		604

Table 22. Homogeneous subsets for initial interest /major on SAT: Total.

		Subset for alpha = .05	
Initial Interest/Major	N	1	2
SS/H	52	1149	
SS/NS	20	1190	1190
UD/H	57	1191	1191
SS/SS	186	1193	1193
UD/SS	97	1196	1196
NS/SS	164	1197	1197
H/H	103	1211	1211
NS/H	90	1220	1220
UD/NS	46		1230
NS/NS	375		1239
H/SS	48		1260
H/NS	15		1266

Table 23. Homogeneous subsets for initial interest /major for GPA.

		Subset for alpha = .05	
Initial Interest/Major	N	1	2
SS/H	52	2.75	
UD/H	57	2.80	
NS/H	90	2.88	2.88
NS/SS	164	2.92	2.92
UD/SS	98	2.94	2.94
H/NS	15	2.95	2.95
H/H	103	3.01	2.01
SS/SS	187	3.03	3.03
UD/NS	47	3.05	3.05
NS/NS	377	3.05	3.05
SS/NS	20	3.07	3.07
H/SS	48		3.14

Table 24. Homogeneous subsets for initial interest /major for grades in LSW200..

		Subset for alpha = .05	
Initial Interest/Major	N	1	2
UD/H	56	2.97	
UD/SS	96	3.06	3.06
NS/SS	156	3.06	3.06
SS/H	49	3.14	3.14
SS/SS	178	3.18	3.18
UD/NS	45	3.18	3.18
NS/H	83	3.19	3.19
H/H	90	3.24	3.24
N/SS	46	3.28	3.28
NS/NS	362	3.28	3.28
H/NS	14	3.31	3.31
SS/NS	20		3.40

Table 25. Initial interest by division as a function of major division.

Division of Initial Interest	Division of Major		
	Humanities	Natural Sciences	Social Sciences
Humanities	103 (62%)	15 (9%)	48 (29%)
Natural Science	90 (14%)	377 (60%)	164 (26%)
Social Science	52 (20%)	20 (8%)	187 (72%)
Undecided	57 (28%)	47 (23%)	98 (49%)

Table 26. Mean scores for men and women on SATs, highschool rank and highschool size.

Measure	Mean		*t*	Significance Level (2-tailed)
	Women	Men		
SAT Math	575	594	-6.33	.000*
SAT Verbal	656	640	4.66	.000*
SAT Total	1210	1205	.78	.435
Highschool Rank	38	55	-5.65	.000*
Highschool Size	227	233	-.80	.423

* differences significant, $p < .05$

Table 27. Mean scores for men and women on ATFR and analysis of argument scores.

Measure	Mean		*t*	Significance Level (2-tailed)
	Women	Men		
ATFR, freshmen	18.2	19.6	-4.82	.000*
ATFR, sophomores	18.9	19.7	-2.22	.026*
ATFR, seniors	20.20	21.84	-2.98	.003*
Attack, freshmen	-.95	-.78	-2.41	.016*
Attack, sophomores	-.78	-.74	-.46	.648
Attack, seniors	-.75	-.74	-.10	.920
Defense, freshmen	-1.66	-1.69	.16	.870
Defense, sophomores	-1.84	-1.70	-2.40	.017*
Defense, seniors	-1.88	-1.83	-.80	.421

* differences significant, $p < .05$

Table 28. Mean scores for men and women on analysis of argument scores.

Measure	Mean		*t*	Significance Level (2-tailed)
	Women	Men		
SAID A, freshmen	59.29	64.60	-7.30	.000*
SAID A, sophomores	52.85	65.05	-8.40	.000*
SAID A, seniors	51.48	63.18	-3.99	.000*
SAID E, freshmen	95.03	92.54	2.08	.038*
SAID E, spohomores	96.20	93.60	2.19	.035*
SAID E, seniors	98.31	98.84	-.23	.815
SAID R, freshmen	96.91	91.88	4.15	.000*
SAID R, spohomores	95.42	90.78	3.44	.001*
SAID R, seniors	93.79	92.64	. 53	.596

* differences significant, $p < .05$

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