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ABSTRACT

This study examined differences in personality type for college freshmen and the effects of participation in undergraduate research on critical thinking and reflective judgment scores. Participants were 266 undergraduate students. While correlations between personality and the thinking measures were low and of little practical significance, a repeated measures analysis revealed a two-way interaction between research participation and major for change in critical thinking score. A second repeated measures analysis with simple contrasts revealed a two-way interaction between research participation and gender for change in reflective judgment score. Findings thus indicate that participation in undergraduate research affects critical thinking and reflective judgment for some students. The paper also discuses implications and limitations of the study. (Contains 5 figures, 4 tables, and 39 references.) (SLD)

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Abstract

The study examined differences in freshman year personality type and the effects of participation in undergraduate research on critical thinking and reflective judgment scores. While correlations between personality and the thinking measures were low and of little practical significance, a repeated measures analysis revealed a two-way interaction between research participation and major for change in critical thinking score. A second repeated measures analysis with simple contrasts revealed a two-way interaction between research participation and gender for change in reflective judgment score. Findings thus indicate that participation in undergraduate research effects critical thinking and reflective judgment for some students. Implications and limitations are discussed.

In recent years, there have been numerous calls for focused attention and reform in the research university to bolster student achievement, and in particular, critical thinking skills (National Commission on Excellence in Education, 1983; American Association of Colleges, 1985). The authors of *Reinventing Undergraduate Education* (Boyer Commission, 1998), urged research universities to "restructure the pedagogical and integrative aspects of the research university experience" (p. 1), in part, by making research-based learning the standard. These notions of inquiry-based learning enable faculty to guide students by mentoring and acknowledge that learning is a reciprocal process whereby both students and faculty learn from each other.

Reinventing Undergraduate Education, was designed to be not another document deploring the state of undergraduate education but rather a guide, a "blueprint," for the way forward into integrating research in education; the way toward "reinvention," the report says, is to "make research-based learning the standard" for undergraduate

education at research universities (Boyer, 1998, pp. 15-16). Historically, research and education have been closely integrated for undergraduates who collaborate with faculty to conduct research, and this practice underlies the "model" that the Boyer Commission proposes, with "scholar-teachers" who "would treat the sites of their research as seminar rooms in which not only graduate students but undergraduates observe and participate in the process of both discovery and communication of knowledge" (Boyer, 1998, p. 18).

Among college outcomes, achievement has been one of the most frequently researched topics in higher education (Astin, 1977, 1993). Similarly, critical thinking skills are regarded as one of the major outcomes of college education (Pascarella, 1989; Pascarella & Terenzini, 1991). Pascarella, et al. (1989) found that college experiences were modestly associated with higher critical thinking skills, while the composite college experience scale (e.g., type of course work, non-classroom interaction with faculty, study time, and extra-curricular activities) showed significant partial correlation with overall critical thinking skills. Facione, Sanchez, Facione, and Gainen (1995) also argue that critical thinking dispositions are an important outcome of higher education and The American Association of Colleges and Universities commission report discusses the importance of reasoning about real-world issues as a central goal of higher education in the publication, *The Challenge of Connecting Learning*:

> "In the final analysis, the real challenge of college students and faculty members alike is empowering individuals to know that the world is far more complex than it first appears and that they must make interpretive arguments and decision-judgments that entail real consequences for which they must take responsibility and from which they may not flee by disclaiming expertise." (AAC, 1990)

Cognitive Development

Based on Perry's (1970) theory of ethical and intellectual development, King and Kitchener (1994) Wood (1997a), Knefelkamp (1974) and Widick (1975), Baxter-Magolda (1985), have applied cognitive development theory to college students. In a cross sectional data analysis of The KneWi, a measure of intellectual development, Heidke and Omahan (1981) found seniors to score higher than freshmen. With a semi-structured interview, the Measure of Epistemological Reflection (MER), Baxter-Magolda (1987) examined six domains of thinking related to learning. Each domain is measured by a series of questions that follow a general question intended to focus the respondents' thinking on the domain. While Baxter-Magolda (1988) found that both men and women "demonstrate similar cognitive structures regardless of learning style" (p. 533), she also reported (1987; Baxter-Magolda and Porterfield (1985) significant increases in MER score from freshmen to senior years.

In a series of studies, Kitchener and King (1981) and colleagues King and Parker (1978, in Welfel, 1982), Lawson (1980), Strange and King (1982) and King, Kitchener, and Wood (1994) have examined the seven-stage theory of reflective judgment. The semi-structured interview, the *Reflective Judgment Interview (RJI)*, and the paper-pencil instrument, *Reasoning About Current Issues* (RCI; Wood, 1997a) have established a positive correlation between education level and reflective judgment score. Consistent with findings of King, Kitchener, Davison, Parker, and Wood (1983), Welfel and Davison (1986) found a significant increase in reflective judgment stage for a sample of 25 students from the freshman to senior years (about one-half of one stage). Further, Welfel and Davison reported no significant difference in RJI score by gender, or time by

major interaction. Related to the developmental nature reflective judgment, Welfel (1982) notes two important points: 1). higher stages of reflective judgment cannot be explained by maturation alone; and 2). measures of critical thinking and verbal ability are associated but do not account for differences between groups in reflective judgment. Although research has revealed a significant relationship between education level and reflective judgment score, it is not known which factors within the educational institution influence this relationship. For example, Kitchener and King (1981) suggested that academic major may be related to reflective judgment. Similarly, co-curricular activities such as major-related internships and undergraduate research may be positively affecting one's reflective judgment score. Thus, the value in further investigation of reflective judgment is warranted.

Use Of Personality Type to Help Assess Undergraduate Success

While personality type has been used to predict occupational performance (Mount & Barrick, 1989; Hough, 1992), the use of personality type to assist in college student success has recently received more attention as an additional factor to help assess collegiate success. Entwistle's (1972) review of studies involving Cattell's 16 Personality Factors and Eysenck's Personality Inventory concluded that college success is associated with introversion, and Entwistle & Entwistle (1970) partly attribute introverts' higher academic achievement to their good study habits. Additionally, Digman & Takemoto-Chock (1981) found that conscientious students are well-organized, purposeful, and persistent, and that these characteristics are highly related to academic achievement (e.g., GPA). In a 45-year longitudinal study of 63 men, Soldz and Vaillant (1999) found that openness to experiences was strongly related to creativity and that

conscientiousness in college was the best predictor of what happened to men in the future. Tross, Harper, Osher, and Kneidinger (2000) found that conscientiousness was related to retention and contributed significantly to the prediction of college GPA.

Participation in Undergraduate Research

Student involvement in research is an effective way to heighten inquiry-based learning. This involvement in research typically manifests itself in the colleagial and synergystic relationships that develop between undergraduate student, graduate students, and faculty members. Recognizing this benefit, the National Science Foundation Report (1989) stated "it is clear that the academic community regards the involvement of undergraduate student majors in meaningful research ... with faculty members as one of the most powerful instruction tools" (p. 6). According to Hakim (1998), there are four features inherent in undergraduate research (UR) experiences: mentorship, originality, acceptability, and dissemination. These features assume that students will be involved in meaningful contributions and will be using methods consistent with current practices within the discipline. UR experiences also include interactions between the faculty and student researcher focus on student learning, and experiences that will culminate in a tangible product that is critiqued by others in the discipline. Thus, undergraduate research students get the opportunity to develop both practical and complex thinking and problem-solving, technical competence, and leadership skills. These are important tasks that strongly contribute to the undergraduate experience and successful attainment of the baccalaureate degree.

Research Questions for Current Study

In an attempt to better understand factors that contribute to high quality undergraduate education, this researcher sought to understand the effect of participation in UR on critical thinking and reflective judgment for undergraduates at one Mid-Atlantic doctoral-extensive university. The research questions are:

1) What role does participation in undergraduate research play in the change in critical thinking scores (as measured through the *Watson Glaser Critical Thinking Appraisal* and the *Reasoning About Current Issues* test)?

2). Are there differences in these outcomes by major or gender? and

3). Does personality (as measured by NEO-FFI in the freshman year) differ for research versus non-research students?

Participants

Participants were 266 undergraduate students at a Research-Extensive state university who were part of a four-year longitudinal study funded by the National Science Foundation to the benefits of participation in undergraduate research. Students were enrolled in 47 majors, which were grouped into three categories: sciences/math/nursing; chemistry and engineering; and psychology and other majors. Among them were 155 females (58%) and 111 males (42%), 202 White (76%) and 64 non-Whites (24%).

Instruments

Information about these students were collected from the university's student records database and by responses obtained from the following three published measures: the *Watson-Glaser Critical Thinking Appraisal* (WGCTA; Watson & Glaser, 1994), the

Reasoning About Current Issues Test (Wood, 1987), and the *NEO-Five Factor Inventory* (NEO-FFI; Costa, Jr.& McCrae, 1991).

Watson Glaser Critical Thinking Appraisal (WGCTA). The WGCTA is a composite measure that examines attitudes of inquiry, knowledge of the nature of valid inferences, abstractions, and generalizations, and skills using attitudes and knowledge (Watson & Glaser, 1994). The *WGCTA* Form S consists of 40 items measuring five subtests of critical thinking: 1) inference--discriminating the truth or falsity of inferences drawn from given data; 2) recognition of assumption--recognizing unstated assumptions or presuppositions in given statements or assertions; 3) deduction--determining whether certain conclusions necessarily follow from information in given statements or premises; 4) interpretation--weighing evidence and deciding if generalizations or conclusions based on the given data are warranted; and 5) evaluation of arguments--distinguishing between arguments that are strong and relevant and those that are weak or irrelevant to a particular question at are strong and relevant and those that are weak or irrelevant to a particular question at issue (Watson & Glaser, 1994, pp. 9-10). The *WGCTA* was completed in the freshman and senior year, and has a reliability of 0.77 for this sample.

Reasoning About Current Issues (RCI). The *RCI* is a paper-pencil measure designed to measure the epistemologic construct, reflective judgment. Reflective judgment research seeks to document progressive sophistication in the way that individuals reason about a particular type of problem termed an "ill-structured problem." The *RCI* is composed of two parts, each scored separately. These two parts are:

1). Student Essay Discrimination Measure. The first half of the *RCI* asks

students to play the role of an instructor who has assigned students "minute essays" about a real world topic. Students are presented with pairs of such essays and are asked to judge which student is reasoning about the issue in a more complex or sophisticated fashion. This part of the instrument is designed to assess whether students can identify which of a pair of statements is a more sophisticated justification for a position.

2). RCI Dilemmas: Student Endorsement of Justifications. The second half of the RCI presents students with five real-world issues as well as statements written to reflect arguments at varying levels of sophistication according to the Reflective Judgment Model. Students are asked to indicate how similar each of these statements are to their own thinking about the issue, and are then asked to rank the three statements which are most similar to their own reasoning about the issue.

NEO-Five Factor Inventory (NEO-FFI). This instrument measures the most basic dimensions underlying human traits (Costa & McCrae, 1991). There are five subtests in this inventory, each composed of twelve items. The five subtests are: 1) *NEO-Neuroticism* which measures an individual's level of adjustment and emotional stability (coefficient alpha= 0.86); 2) *NEO-Extroversion* measures level of sociability and consequent behaviors that occur as a result of interactions with others (coefficient alpha= 0.81); 3) *NEO-Openness to Experiences* measures imagination, aesthetic sensitivity, attentiveness to inner feelings, preference for variety, intellectual curiosity, and independence of judgment (coefficient alpha= 0.73); 4) *NEO-Agreeableness* measures level of sympathy and altruism toward others, eagerness to help (coefficient alpha= 0.77); and 5) *NEO-Conscientiousness* measures ability to manage impulses and desires and the process of planning, organizing, and carrying out tasks (coefficient alpha= 0.83).

Procedure

After receiving approval from the University's Human Subjects Committee, researchers sent a letter in March, 1997 to second semester freshmen students majoring in science, math, and psychology requesting their participation in this four-year longitudinal study of their academic experiences. Two hundred sixty-six students agreed to participate and met with the researchers to complete several questionnaires including the *WGCTA and NEO-FFI.* Students were also asked to complete the *Reasoning About Current Issues (RCI)* beginning in Spring 1998. Each survey took approximately 15 to 30 minutes to complete. A signed consent form also enabled the researchers to obtain demographic data from the university's student record system (i.e., high school GPA, sex, ethnic classification, SAT, and cumulative GPA). During each survey completion, students were offered a small monetary incentive ($5 in Spring 1997, $10 in 1998; $15 in 1999; and $20 in Spring 2000).

Characteristics of the Undergraduate Research Program and Definition of Participation in Undergraduate Research

Undergraduate Research Program opportunities, which are open to all interested undergraduates, include research collaborations that occur during the academic year as well as summer research, senior thesis, and oral presentations of research-in-progress to other students and faculty. Over 66 percent of the University's approximately 900-member faculty regularly participate inUR, including over 90 percent of the faculty in the sciences and engineering. From 600 to 700 students are estimated to be engaging in UR at any one time. Students can begin research at any point in their undergraduate careers; however, normal starting time is mid-sophomore year. Student involvement generally

lasts for one and one-half to two or more years and usually includes one or more summer or winter terms in addition to the academic semesters.

Each spring, students reported the number of hours per week they had been involved in a variety of campus activities, including undergraduate research. Student self-reports were verified with faculty and then summed to reveal the total number of hours over the four baccalaureate years each student had participated in UR. The total number of hours for participation in research ranged from 0 to 3,342; the mean number of hours for those who participated in research was 626 hours, SD = 596.5. Based on a scatterplot of research hours, students were then grouped into three categories: 1). no research; 2). total research less than 700 hours; and 3). total research 700 or more hours.

Results

Table 1 shows descriptive statistics and Table 2 highlights the correlation matrix for the primary measures in this study. Shown in Table 2 and as expected, SAT is strongly correlated with first year cumulative grade point average. Also, WGCTA score is significantly correlated with SAT, but RCI score is not highly correlated with SAT. Although the correlation coefficients are significant, the values between .21 and .29 do not reveal strong relationships. An independent samples T-test revealed significant differences between research and non-research students for NEO-N ($t=2.81$, $p=.005$) and NEO-E ($t=1.98$, $p=.048$). These findings indicate that students who later participated in UR scored higher on the neuroticism and lower on the extroversion scales as freshmen than peers who did not participate in UR.

Table 1
Descriptive Statistics for WGCTA, RCI, and NEO FFI

	M Year 1	*M* Year 2	*M* Year 3	*M* Year 4
WGCTA	29.47 (5.33)			30.12 (5.22)
RCI		5.26 (.62)	5.31 (.66)	5.28 (.67)
NEO – N	21.90 (8.22)			
NEO – E	30.51 (6.54)			
NEO – O	30.37 (6.13)			
NEO – A	32.33 (6.12)			
NEO – C	32.72 (6.72)			

Changes in Critical Thinking

Repeated measures analyses were performed to examine the effect of research participation on changes in critical thinking and reflective judgment. Table 3 illustrates the effects of research, major and gender on the outcome variable, WGCTA. Because of the high correlation between SAT and WGCTA, SAT was included as a covariate in the analysis for WGCTA. As shown in Table 3, major ($F=4.129$, $p<.01$) and the interaction and major and research ($F=3.094$, $p<.02$) had an effect on the WGCTA change score. Changes in WGCTA were not effected by gender or interactions of gender with major or gender with research. Figures 1 to 3 illustrate the interaction of research and major on WGCTA. As shown, WGCTA change is greatest for students who participated in 800 or more hours of research, but this change differs by major. As shown in the figures, freshman to senior year WGCTA scores increase for science/math/nursing and chemistry/engineering majors, but decreases for psychology/other majors.

Table 3
Repeated Measures ANOVA for Watson-Glaser Critical Thinking Appraisal

Measure	Sum Sq	df	MS	F
WGCTA	5.960	1	5.960	.362
WG x Research	5.270	2	2.635	.160
WG x SAT	2.970	1	2.970	.180
WG x Gender	28.806	1	28.806	1.748
WG x Research x Gender	75.130	2	37.565	2.280
WG x Major	136.081	2	68.041	4.129 *
WG x Research x Major	203.929	4	50.982	3.094 *
Error	3163.578	192	16.477	

* $p < .02$

Figures 1-3
Estimated Marginal Means for WGCTA by Research Participation and Major

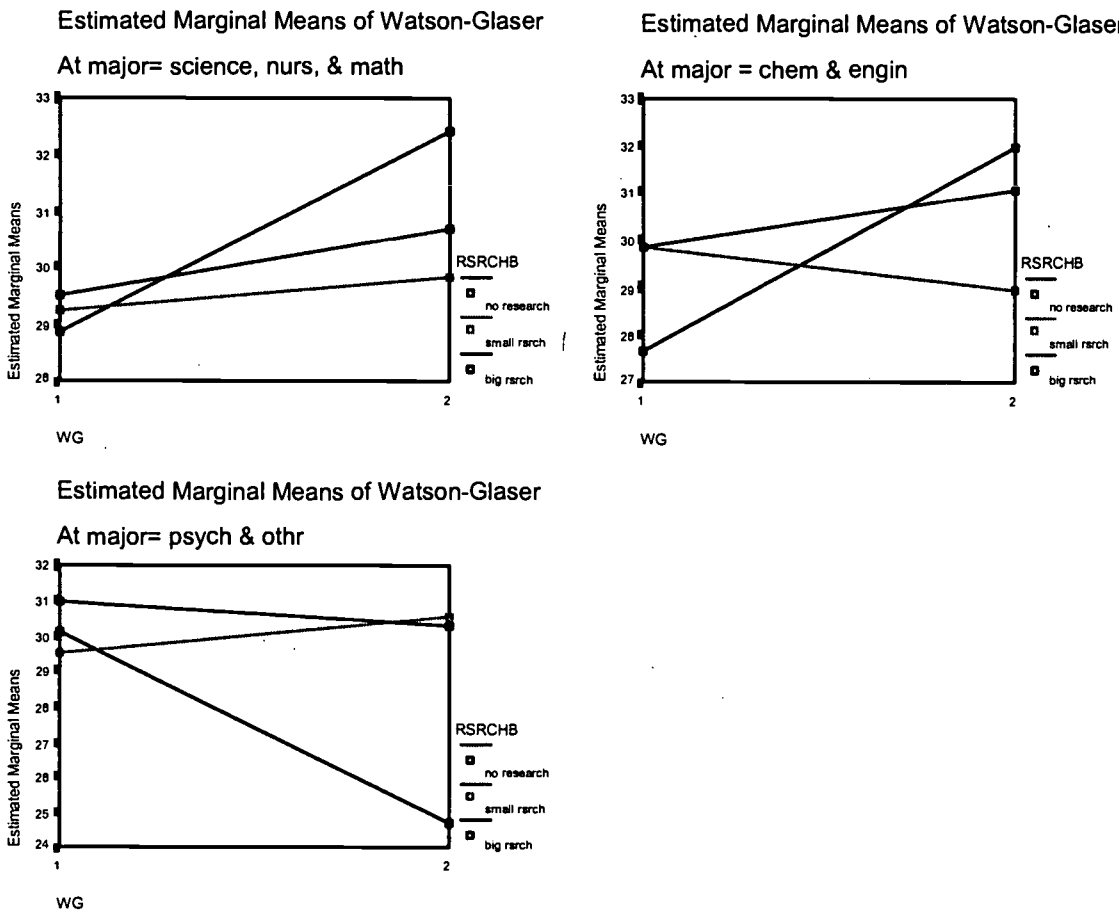


Table 2 Correlation Matrix

		Yr1 gpa	total SAT	Yr1 WG	Yr 2 WG	Yr2 RCI	Yr3 RCI	Yr4 RCI	NEO-N	NEO-E	NEO-O	NEO-A	NEO-C
Total SAT	Pearson Corr.	0.42											
	Sig. (2-tailed)	0.00											
	N	260											
Yr1 WGCTA	Pearson Corr.	0.25	0.62										
	Sig. (2-tailed)	0.00	0.00										
	N	264	258										
Yr2 WGCTA	Pearson Corr.	0.22	0.66	0.67									
	Sig. (2-tailed)	0.00	0.00	0.00									
	N	212	207	210									
Yr2 RCI	Pearson Corr.	0.09	0.23	0.22	0.25								
	Sig. (2-tailed)	0.18	0.00	0.00	0.00								
	N	230	225	228	196								
Yr3 RCI	Pearson Corr.	0.09	0.29	0.34	0.35	0.52							
	Sig. (2-tailed)	0.18	0.00	0.00	0.00	0.00							
	N	203	198	201	181	203							
Yr4 RCI	Pearson Corr.	0.06	0.21	0.23	0.27	0.46	0.70						
	Sig. (2-tailed)	0.39	0.00	0.00	0.00	0.00	0.00						
	N	208	205	206	202	195	180						
NEO-N	Pearson Corr.	0.00	-0.11	-0.08	-0.01	-0.08	-0.07	-0.13					
	Sig. (2-tailed)	0.94	0.08	0.17	0.86	0.21	0.35	0.07					
	N	263	257	263	209	227	200	205					
NEO-E	Pearson Corr.	-0.17	-0.18	-0.17	-0.16	0.06	0.06	0.01	-0.39				
	Sig. (2-tailed)	0.00	0.00	0.01	0.02	0.38	0.38	0.86	0.00				
	N	263	257	263	209	227	200	205	263				
NEO-O	Pearson Corr.	-0.02	0.03	0.15	0.07	0.29	0.15	0.17	-0.05	0.01			
	Sig. (2-tailed)	0.80	0.68	0.02	0.33	0.00	0.04	0.02	0.40	0.84			
	N	263	257	263	209	227	200	205	263	263			
NEO-A	Pearson Corr.	0.06	-0.07	0.09	0.11	0.22	0.25	0.19	-0.17	0.32	0.09		
	Sig. (2-tailed)	0.34	0.27	0.16	0.12	0.00	0.00	0.01	0.01	0.00	0.16		
	N	263	257	263	209	227	200	205	263	263	263		
NEO-C	Pearson Corr.	0.22	-0.14	-0.23	-0.30	-0.01	-0.09	-0.04	-0.25	0.23	-0.01	0.14	
	Sig. (2-tailed)	0.00	0.02	0.00	0.00	0.89	0.18	0.53	0.00	0.00	0.92	0.02	
	N	263	257	263	209	227	200	205	263	263	263	263	

Change in Reflective Judgment Score

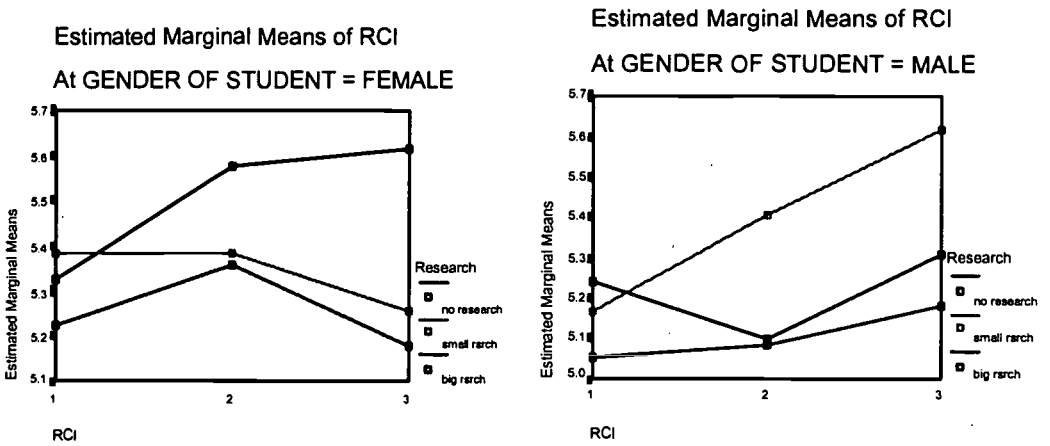
Table 4 shows the effects of research, major and gender on the outcome variable for reflective judgment, *Reasoning About Current Issues.* A separate model including NEO-N and NEO-E as covariates was run; no substantial differences were shown, thus the analysis presented herein does not include NEO scores as covariates. As shown in Table 4 using a simple comparisons contrast, participation in research had a main effect on RCI change when comparing change from the sophomore to senior year (F=3.818, p=.05). Similarly, the interaction of gender and research had an effect on RCI change from the sophomore to senior year (F=3.063, p=.04). Figures 4 and 5 illustrate the interaction between RCI, research participation and gender.

Table 4
Repeated Measures ANOVA for Reasoning About Current Issues Test

Measure		SS	df	MS	F
RCI	level 2 vs 1	.743	1	.743	1.945
	level 3 vs 1	1.626	1	1.626	3.818 *
RCI x Rsrc	2 vs 1	.085	2	.042	.111
	3 vs 1	.604	2	.302	.709
RCI x Gendr	2 vs 1	.196	1	.196	.513
	3 vs 1	.850	1	.850	1.997
RCI x Rsrc x Gndr	2 vs 1	1.673	2	.837	2.190
	3 vs 1	2.608	2	1.304	3.063 *
RCI x Major	2 vs 1	.434	2	.217	.568
	3 vs 1	2.272	2	1.136	2.668 (p=.07)
RCI x Rsrc x Maj	2 vs 1	.553	4	.138	.362
	3 vs 1	1.220	4	.305	.716
Error	2 vs 1	64.178	168	.382	
	3 vs 1	71.530	168	.426	

* $p < .05$

Figures 4 and 5
Estimated Marginal Means of RCI by Gender and Research



Discussion

This study examined the effects of participation in undergraduate research on two college outcomes, critical thinking and reflective judgment. Based on findings from this sample of 266 students, results indicate that involvement in research does affect critical thinking score and, to a lesser degree, reflective judgment. Students who participated in research scored higher on NEO-Neuroticism and lower on NEO-Extroversion as freshmen than peers who did not participate in research. However, correlations between NEO scales and the outcomes measures were less than .30 and determined to be of little practical significance. Results from repeated measures analyses indicated that the change in WGCTA score from freshman to senior year was greatest for science/math/nursing and chemistry/engineering majors who participated in 800 or more hours of undergraduate research. The interaction of research participation and gender had an effect on RCI change, thus indicating that females who participated in 800 or more hours of research and males who participated in 1-799 hours of research showed the greatest increases in RCI score over the three year period.

Participation in undergraduate research can benefit undergraduate students by contributing to the development of complex thinking, evaluation, and communication abilities, time management skills, and enhancing interpersonal independence. Increases in these skills will likely increase the students' chances for success as well as increase level of satisfaction with the undergraduate experience.

Limitations of this study included the relatively small size of the sample and selective inclusion of only certain majors. If the sample were larger, it is possible that additional relationships may emerge. Like King, et al, (1983) we found some of our students to regress in RCI score. Additional study of the pattern of epistemological development is warranted. Due to the selective sample, findings from the study are limited in generalizability to science and engineering majors. Findings from this study are also unique to the set of academic and social experiences, including undergraduate research, that are available at this institution. Additional studies with a larger, random sample may be helpful in examining the effects of academic experiences on critical thinking and reasoning outcomes.

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