Theoretical Implications of a Quasi-Experimental Investigation Comparing Academic Outcomes of Honors and Non-Honors Students in a Globaloria Biology Course

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Abstract

The constructionist (Papert and Caperton, 1991) dimensions of the Globaloria technology initiative make it unique among technology projects. They may, in fact, lend themselves to exerting a positive influence on students' learning in other classes by allowing them to develop transferable cognitive skills that can be applied in other academic contexts. Should such skills transfer occur, the constructionist approach to teaching and learning can be confirmed as a theoretically sound technological strategy for helping students develop the kinds of skills most often mentioned as "21st century skills": critical thinking and problem-solving. The findings from this preliminary study showed that students enrolled in the honors section of a Globaloria-based biology course had only moderately higher outcomes on specific evaluation measures than did their non-honors Globaloria peers (who actually had a better outcome on one measure), suggesting that the constructionist approach is an appropriate epistemological tool for students regardless of skill level.

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> The general message is that the unit of analysis for cognitive studies of new technologies cannot be restricted to the technology itself, nor to isolated tasks removed from the context of their performance …. Rather, research needs to begin with a broader view – an analysis of the societal conditions, institutional settings, and activity structures into which new tools and symbolic systems are being introduced ... (Martin & Scribner, 1991, p. 585)

While discourse and policy regarding the appropriate use(s) and role(s) of computer technologies in education have shifted somewhat over the past two decades, the language of "accountability" policies continues to undermine this "broader view." So too do state technology policies that are inclined to an instrumental view of the use of computers in schools. In their examination of 15 states' technology plans, Zhou and Conway (2001) drew these conclusions:

> [In] terms of technology, we found that state technology plans seem to favor 'new' technologies over 'old' technologies .... [In] terms of students, we found that the plans more often than not focused on technology's capacity to improve student test scores, while paying little attention to important epistemological assumptions about student learning ….

West Virginia's educational technology plan, detailed in "A Chronicle of West Virginia's Global21 Initiative" (WVDE, 2009a), appears to conform to those findings featuring reasonably "new" technologies (e.g., laptops and white boards), support via 600 days of professional development and dedicated technical support help-desk services, and upgrades infrastructure for all elementary and secondary schools. Assessment, however, while described as "balanced" and including “a combination of summative, benchmark, and formative classroom assessments” (WVDE, 2009a, p. 57), continues to rely primarily on standardized performance measures: WESTEST2, the official state test for meeting No Child Left Behind accountability requirements; the ACT predictive and readiness tests (EXPLORE for 8th graders and PLAN in grade 10); the WV Writing Assessment, an online criterion-referenced test; and benchmark assessments that “allow ‘in course’ correction before students are held accountable for those objectives on a summative assessment” (WVDE, 2009a, p. 58).

We make this observation not to single out West Virginia for criticism, since the past two decades have seen a steadily increasing reliance on standardized measures of student achievement as keystones for education policymaking across the country at virtually all levels. During the same period, states have made substantial investments in educational technology and infrastructure, so it is logical that policymakers and the public would hope for a positive relationship between expenditures and what they consider appropriate measures of achievement. We provide the information only to situate the current analysis and to explain our preference for examining Globaloria in a subject-specific context, a choice supported by recent research (Angrist & Lacy, 2002; Dynarski, Agodini, Heaviside et al., 2007; O’Dwyer, Russell, Babell & Seely, 2008). O’Dwyer et al. address specifically the “psychometric challenges” of linking technology use to improved test scores, arguing that standardized tests “assess a domain too broadly to isolate the types of critical learning skills that have been found to be impacted by technology use” (2008, p. 7).

Caution is required when attempting to measure the potential effect(s) of a treatment or intervention by using an assessment designed to measure something else. The National Assessment of Educational Progress (NAEP), for example, is designed to yield information about each state's academic performance relative to that of the nation. State standardized tests, benchmarking tests, and similar measures have largely the same goal – evaluating students' propositional knowledge in specified content areas. Given that purpose, most are unlikely to capture the gains in procedural knowledge that can accrue from the constructionist model – the skill of learning how to learn. Standardized examinations are simply not sensitive enough to discern deeper epistemological processes or practices.

In the most recent study to take up the issue of the impact of technology on learning – specifically 1:1 laptop initiatives – Weston and Bain (2010) concede that claims that technology will improve test scores or somehow revolutionize schools are for the most part unsubstantiated. Evidence compiled over the last decade, they say, shows a "diminutive effect" at best (p. 6). They also, however, believe that "techno-critics" have failed to place technological education reforms in their proper context, a subject to which we will return in our discussion of findings.

This analysis of the potential academic impact of the technologies involved in Globaloria, thus, will concern itself with the varieties of ways these technologies are drawn into students' work within the context of a specific class. Using Vygotsky's activity theory (1978) as an analytical framework, the question of whether Globaloria skills or activities can be utilized or leveraged in participating students' other academic pursuits will be addressed by examining the following preliminary questions:

- To what extent, if any, do the performance measures (i.e., assignments, classroom evaluations/tests) of biology students differ based on their enrollment in either the honors or non-honors Globaloria biology course?
- To what extent, if any, does the academic engagement of CHS students differ based on their enrollment in either the honors or non-honors Globaloria biology course? and

- To what extent, if any, do selected demographic variables (e.g., sex, race, SES) affect the academic outcomes of CHS students based on their enrollment in either the honors or non-honors Globaloria biology course?

Design and Methods

The theoretical framework for this investigation is situated in the work of Lev Vygotsky (1978), who introduced the concept of "mediated activity" or activity theory into the study of thought and language. Activity theory suggests that the introduction of new systems and tools into work or learning activities may change the intellectual aspects of these activities. The nature of these new intellectual demands, however, "cannot simply be projected from a study of the tools themselves."[1] Rather, they grow from how the tools are used; hence, we focus on the varieties of ways Globaloria technologies are drawn into students' ongoing academic activities within the context of their biology course.

A mixed-methods study was designed involving both quantitative and qualitative measures. Quantitative data were gathered through school-level collection (i.e., participating students' biology assignment grades, test scores, and attendance) and were coded for confidentiality prior to researchers' receiving them. Qualitative data included document analyses, followed by an examination of participating students' and the instructor's blogs and wikis and supplemented by an interview with the instructor. Students enrolled in the honors section of Global Biology were matched with non-honors students enrolled in the same course offered by the same instructor and their academic performances compared through a series of statistical analyses.

[1] Martin, L., & Scribner, S. (1991). Laboratory for cognitive studies of work: A case study of the intellectual Implications of a new technology. *Teachers College Record, 92*(4).

Background

City High School (CHS) had 1,192 students enrolled in grades 9-12 for the 2008-09 academic year, 47% of whom were low-income and 33% minority. At that time, CHS had a 75% graduation rate and a 7.1% drop-out rate. The school's No Child Left Behind data showed that CHS made AYP in the 2006-07 school year, but did not do so in either 2007-08 or 2008-09.

Seventy-three percent of the students scored at the proficient level in reading on the state's standardized test (WESTEST) in 2007-08, while 64% reached the proficiency mark in math. In 2008-09, however, only 48% of the CHS students scored at the proficient level in reading, while 54% tested proficient in math[2](WV Achieves, 2009a).

City High School, one of the original six Globaloria sites in West Virginia, provided the Globaloria program to 27 students in its first year of implementation. Nine of those students, in grades 10 and 11, participated in an after-school course for the Health Sciences and Technology Academy (HSTA). The remaining 18 students in grades 10 through 12 participated for academic credit through their business curriculum courses, and this year 24 students enrolled in Honors Global Biology. Their course outcomes were compared with those of 25 students enrolled in a non-honors biology course taught by the same instructor.

Findings

Researchers conducted a series of statistical analyses to examine whether Globaloria skills and/or activities can be utilized or leveraged in participating students' other academic pursuits by comparing the outcomes of students in an honors Globaloria-based biology course (i.e., Honors Global Biology, n = 24) with those of students in a non-honors Globaloria class with the same instructor (n = 25). As biology is a core class required for all students, students did

[2] The WV Department of Education modified its standardized tests between the 2007-08 and 2008-09 academic years. The 2007-08 WESTEST was replaced by the 2008-09 WESTEST2, designed to align more closely to changes in the state's Content Standards Objectives. The WESTEST2 remains in use at this time.

not choose the sections in which they were enrolled. According to the instructor, students were divided only by the class period to which they were assigned at the beginning of the school year (Instructor, personal communication, August 13, 2010).

Demographic information was collected for all enrolled students in both sections of the course. Participants included 31 females (15 honors and 16 non-honors) and 18 males (9 honors, 9 non-honors). Most were sophomores (41 total with 18 honors, 23 non-honors), along with three honors and two non-honors freshmen, and three honors seniors with no seniors in the non-honors section. Information regarding race and socioeconomic status was requested but not provided. Table 1 displays these data.

Table 1: Demographic Information

Demographics	**Globaloria**	**Non-Globaloria**
n	24	25
Female	15	16
Male	9	9
Freshmen	3	2
Sophomores	18	23
Juniors	0	0
Seniors	3	3

Researchers conducted a series of statistical analyses (i.e., independent samples t-tests, analyses of variance) on all academic variables to examine the potential effects of Globaloria participation on students' mastery of biology concepts. None returned any statistically significant findings. On five measures, however, students in the honors course did score modestly higher than their peers in the non-honors section. Those findings are summarized in Table 2.

Table 2: Outcome Measures

Measure	Honors Mean	Non-Honors Mean
Unit Test 1	3.19	2.52
Unit Test 2	1.76	1.24
Unit Test 3	1.47	1.36
First Semester Final	1.95	2.04
Semester Average	2.28	1.76
Semester Grade	2.28	1.76

There are a few potential explanations for the absence of significant findings within the quantitative analyses, chief among them that the period of the study covers only one semester of coursework. Moreover, the instructor was implementing the Globaloria model for the first time in his biology course, many of the students were new to the approach, and we had no covariate (e.g., prior grades in science – the instructor reported in an interview that there were some sophomores who had failed ninth grade science) to use as a control. The vexing problem of how to account for the potential of cognitive maturation as an explanation for changes in student academic performance is a concern as well. Remedies are addressed in the conclusions and recommendations section of this paper.

One interesting finding is that the non-honors Globaloria students outscored their honors peers on the semester exam. While this outcome, like the others, lacks statistical significance and represents only one assessment, it suggests that Globaloria concepts can be appropriate for implementation across skill levels – neither rendering academic concepts simplistic for advanced students nor making them unnecessarily complicated for average or less able students. This is a particularly interesting development given the challenges the instructor faced with the non-honors class:

> The biggest challenge for me has been in the motivation of the less educationally inclined students. My [non-honors] class has a lot of students that are used to and choose to not

> put forth much effort in general …. My [non-honors] biology has the additional challenge of a fluctuating class roster. Students are suspended or out continuously. Without being able to be on the computers for each and every day, this presents an obstacle to helping students get into the routine …[W]ith the difficulties faced in regard to attendance and students less focused on effort and education, I sometimes wish for the elective course where students have chosen to be part of Globaloria. (World Wide Workshop, 2010)

The difficulties were compounded in the third quarter by the holiday season and more school cancelations due to inclement weather:

> Third period has faltered more than I have expected. As a non-honors class, they have fallen further behind in their work habits and are really experiencing the third nine-weeks blahs … They have been especially hard hit in combination with the extended winter breaks in the schedule. Add to this the continuingly fluctuating students in the class and the social dynamic has changed quite a bit in the past few weeks. (World Wide Workshop, 2010)

When asked about outcomes, however, the instructor reported he was "very pleased" with the outcomes in general, but that he's planning some changes for next year's Globaloria class:

> For the next year, my approach is going to change a bit. Instead of tying each topic done in Globaloria/Flash to the topic being covered in class, I am planning on having the students do a bit of self-learning on a topic covered only briefly through the year as time allows …. My hope is that this will provide a better continuity to the self-learning and really allow students to work at their own pace depending on skill level and improvement … It will also allow for the inclusion of a project-based portion of the final grade …. I also think that the Globaloria approach will be better suited if I focus on one class this

> year …. I think that by focusing on one class, I can avoid feeling overwhelmed as I adjust my approach to better meet the shortcomings of this year. (Personal communication, instructor, August 13, 2010)

His "biggest challenge," however, "the motivation of the less-educationally inclined students," is one that faces all teachers at one time or another. Those issues – excessive absences, time-consuming recovery of previously mastered skills attributable to those absences, and student motivation – are not problems that inhere in the Globaloria approach. Rather, they are problems faced by teachers at virtually every level of schooling regardless of teaching format. That the performance of the non-honors class on the six evaluation measures was so close to that of the students in the honors section – and exceeded their scores in one case (i.e., the semester exam) – suggests that the constructionist model incorporated in Globaloria is an appropriate epistemological tool for students regardless of skill level. It also raises the possibility that the Globaloria model was perhaps more valuable to the less gifted students.

Conclusions and Recommendations

The finding that honors students performed only slightly better than their non-honors peers on the measures reported herein (i.e., three unit tests, semester average and semester grade in a Global Biology class) suggests that Globaloria may have particularly affected performance for the latter group. Further research will be necessary, however, to determine whether the knowledge and skills that accrue as students employ Globaloria processes do, in fact, have a positive effect on achievement across performance levels in subject-specific domains. Should future studies be planned, weaknesses in the current research should be addressed: the study should be longitudinal in scope, covering multiple semesters/school years; at least one covariate should be established to control for past performance; and attempts should be made to acquire additional demographic data (e.g., race, ethnicity, socioeconomic status). It could be helpful as well to investigate the use of Globaloria in other subject-specific areas to determine the influence, if any, of its constructionist approach on high-performing vs. low-performing student outcomes in different domains.

We reiterate the need to view these findings with some caution. The study spanned only one semester, involved only 49 students who were using Globaloria concepts and processes, and was limited to biology classes. Additionally, even modest gains in Globaloria students' academic performance may be simply a result of intellectual maturation of the student. As a consequence, these findings are not generalizable to the larger population of students and teachers involved in the Globaloria initiative.

Still, the positive attitude of the CHS teacher and his commitment to continuing to offer biology via the Globaloria model ("science is often learning by doing and it seems a good fit") shows a level of enthusiasm not often seen for curricular reforms. Should the small performance gap between honors and non-honors students in biology be borne out, the modest space between the two could well be attributable to Vygotsky's (1978) theory that all students gain skills through collaborative problem-solving activities that involve the use of available cultural tools which are not gained by students working independently. Such a finding could establish Vygotsky's theoretical model as a primary framework for analyzing initiatives grounded in constructionist thinking (Papert & Caperton, 1991).

We noted earlier in the paper the position of Weston and Bain (2010) that claims that technology will improve test scores or somehow revolutionize schools are for the most part unsubstantiated. They also, however, believe that "techno-critics" have failed to place technological education reforms in their proper context; that they are not simply replacements for existing tools. Taking much the same perspective as Vygotsky (1978) and Papert and Caperton (1991), they argue that the future of educational technologies lies in viewing them as "*cognitive tools* that shape and extend human capabilities. Cognitive tools blur the unproductive distinctions that techno-critics make between computers and teaching and learning" (Weston & Bain, 2010, p. 10, emphasis in original; see also Bransford, Brown, & Cocking, 2000; Jonassen, 2008; and Jonassen, Peck, & Wilson, 1999). Viewed as cognitive tools, as opposed to replacements for books or chalkboards or card catalogs, emerging technologies and technology practices can benefit learning and teaching in ways that simply can't be done if the expectation is that improved learning "will emerge spontaneously from the deployment" of hardware in classrooms (p. 10). In their ideal school,

> waiting passively for the results of the big, once-a-year standardized test is not an option. That is why, if asked about the value of using a laptop computer in school, each would struggle to see the relevance of such a question because computers have become integrated into what they *do*. (Weston & Bain, 2010, p. 11)

That, in essence, is what the implementation of Globaloria has done in this instance; it has integrated the use of emerging technologies and software into students' daily work in such a way that their relationships to teaching and learning are inconspicuous. Their use in biology class is as unnoticeable and unproblematic for students as is our use of word processing. We concentrate not on the work being done by the hardware and software, but on our ideas and how we wish to express them. Weston and Bain define such use as a "core transaction" (2010, p. 10), the result of technologies' enabling, empowering and accelerating a practice in such a way that their presence evaporates.

As Globaloria continues its integration in schools with the goal of expanding first statewide and then nationwide, however, continued evaluation is imperative. The number of technology initiatives aimed at public school students, who constitute the largest captive audience in the country, is likely only to proliferate. It is critical that schools accept only those that can provide evidence of epistemological value.

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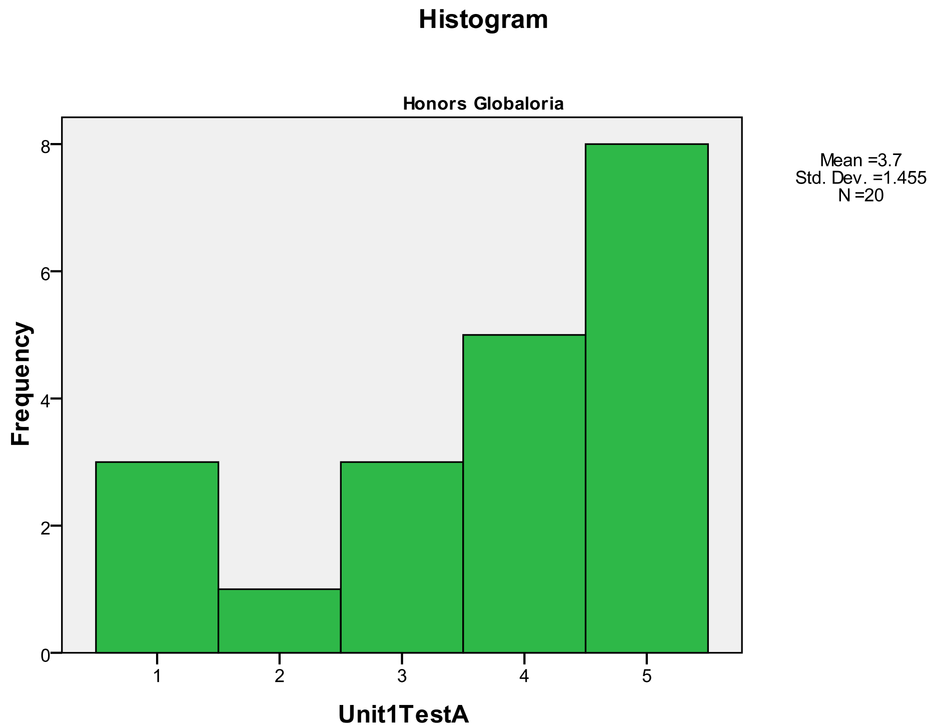
Appendix

Descriptives: Means

	H or NH	N	Mean	Std. Deviation
Unit 1Test	1	21	3.70	1.535
	2	25	2.76	1.451
Unit 2 Test	1	22	2.05	1.397
	2	25	1.32	.945
Unit 3 Test	1	23	1.75	.982
	2	25	1.48	1.122
1st Sem. Final	1	23	1.95	1.014
	2	25	2.04	1.172
Average	1	24	2.80	1.160
	2	25	2.08	1.222
Grade	1	24	2.35	1.032
	2	25	1.76	.926

H (1) = Honors student; NH = Non-Honors student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Std. Dev. =1.455
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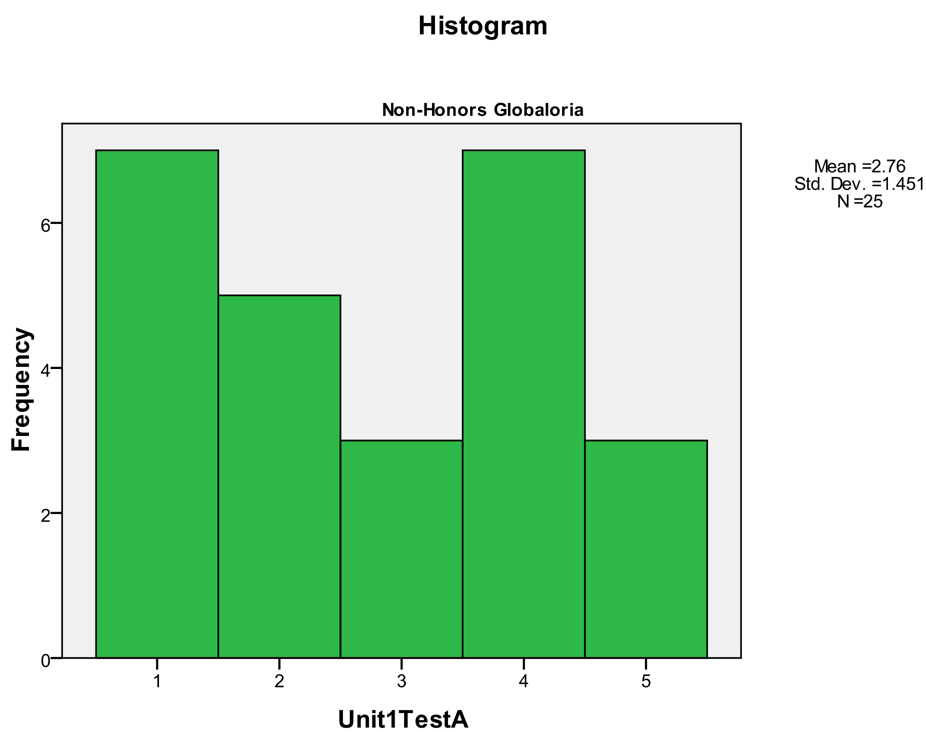
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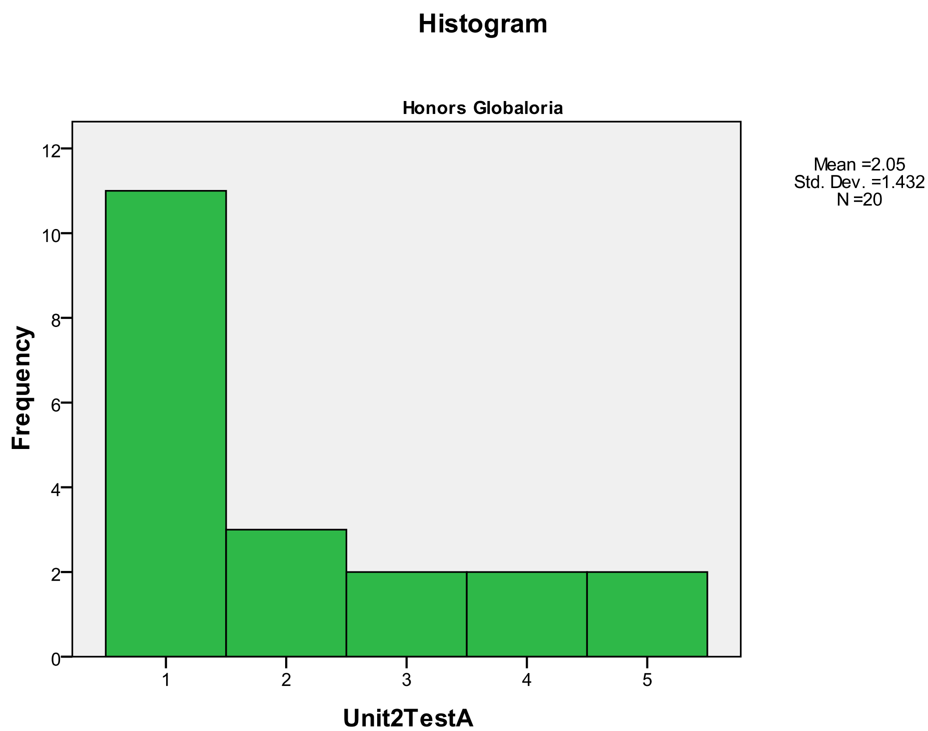
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4
5
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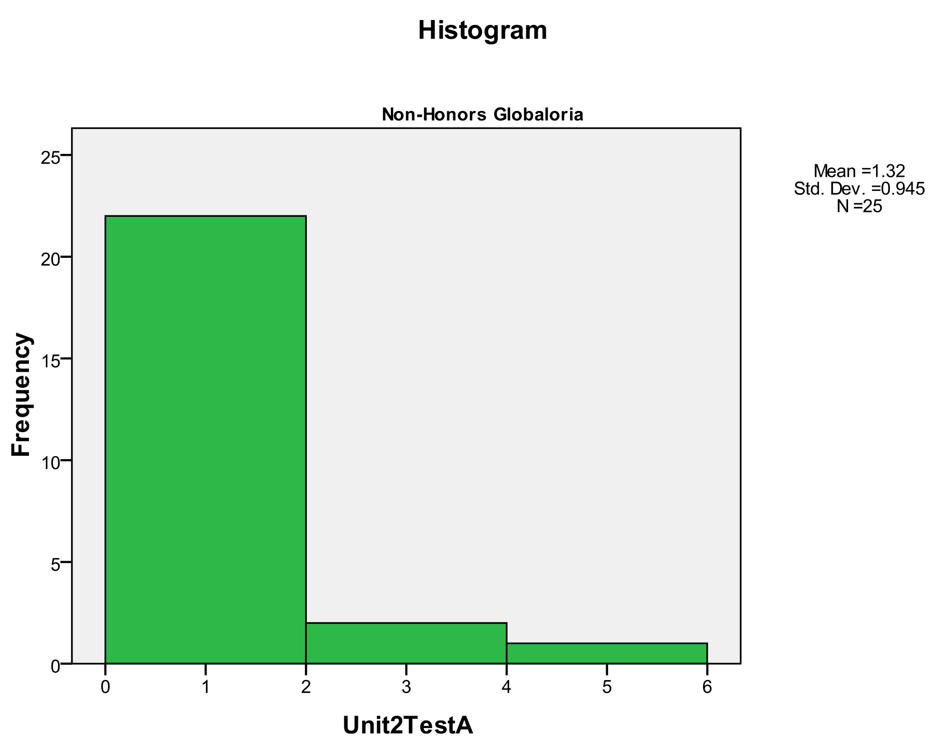
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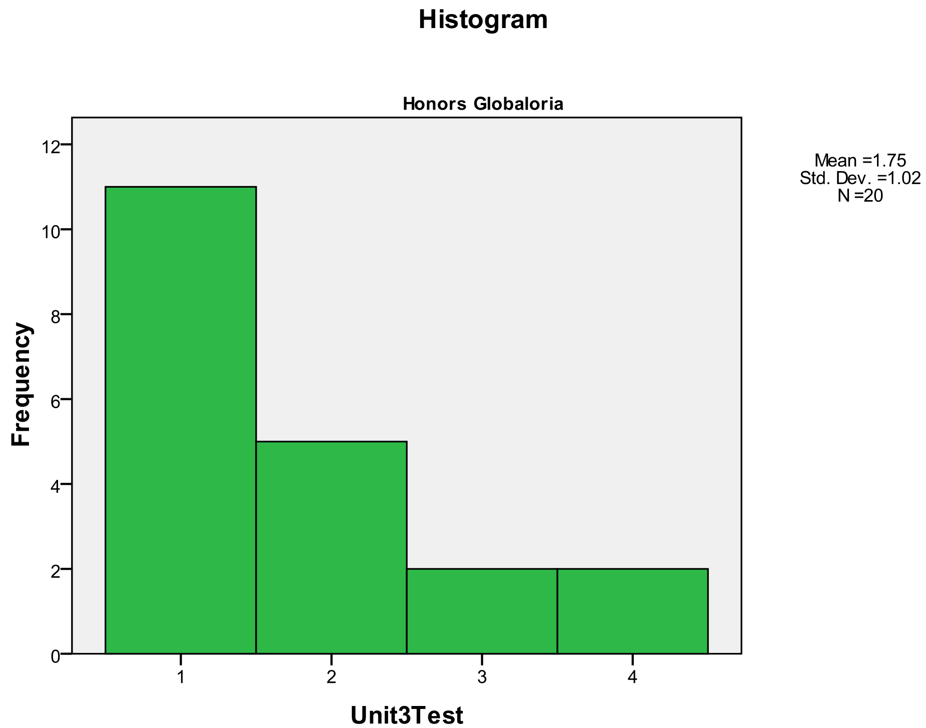
4
5
6
Unit2TestA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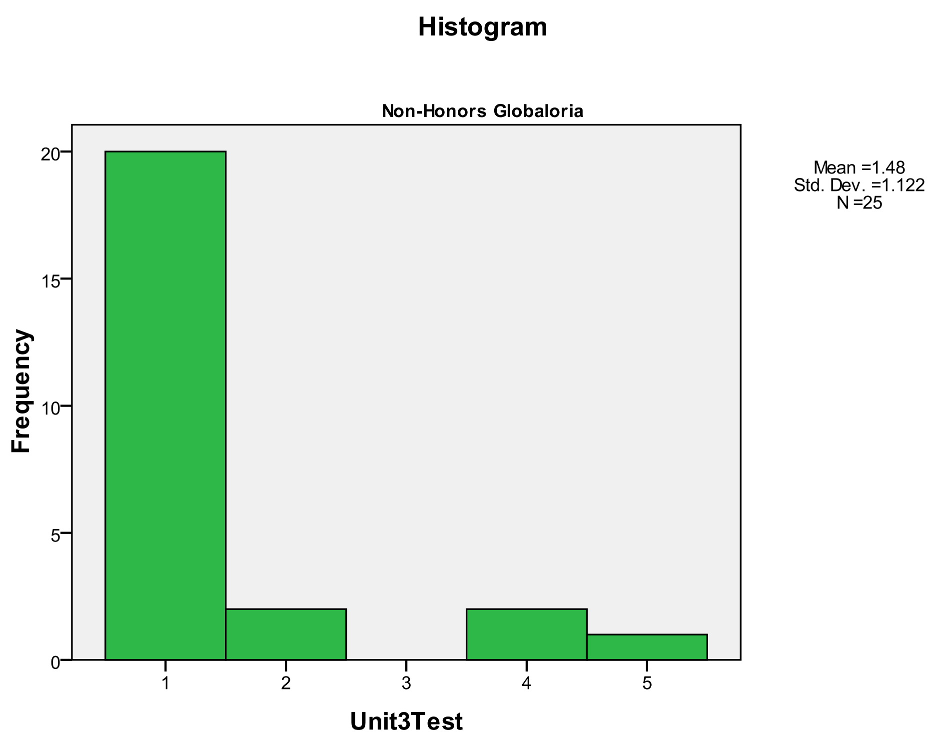
2
3
4
Unit3Test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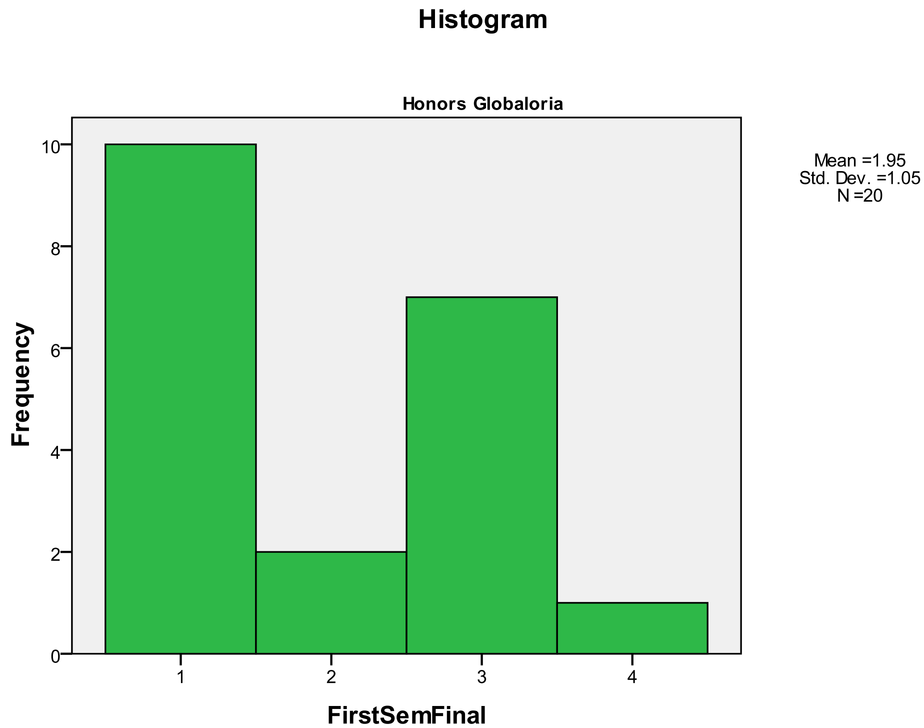
Unit3Test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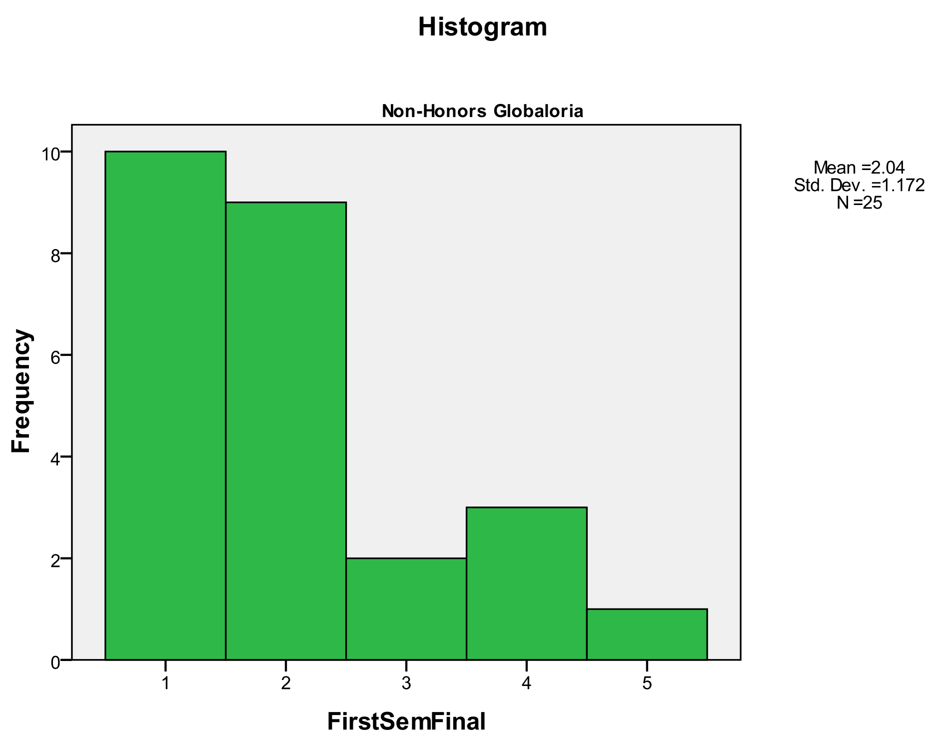
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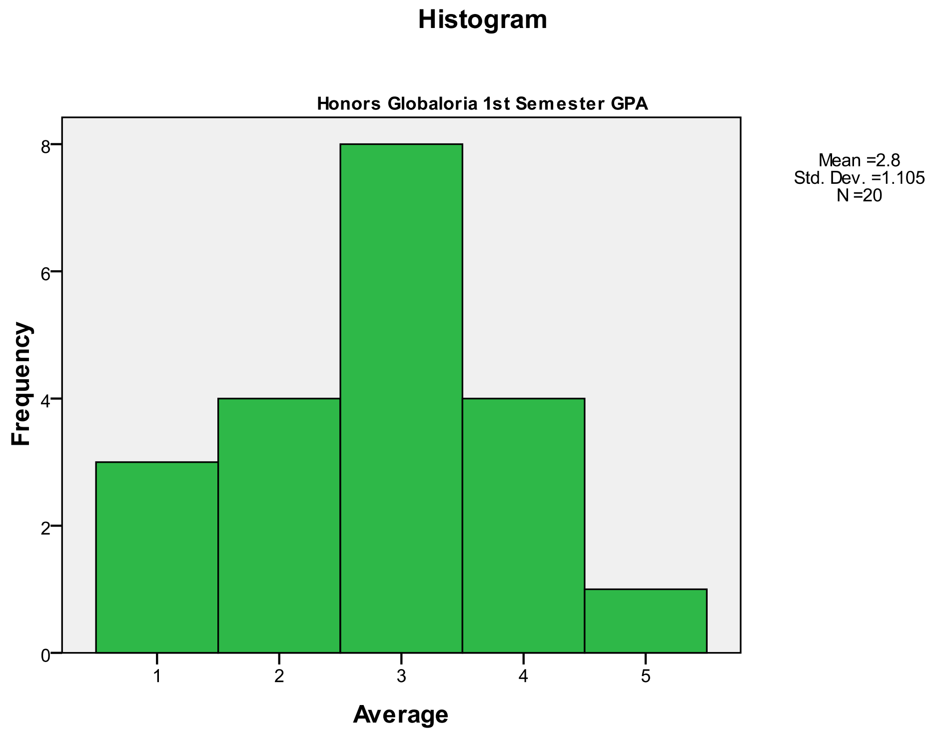
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Frequency
Average
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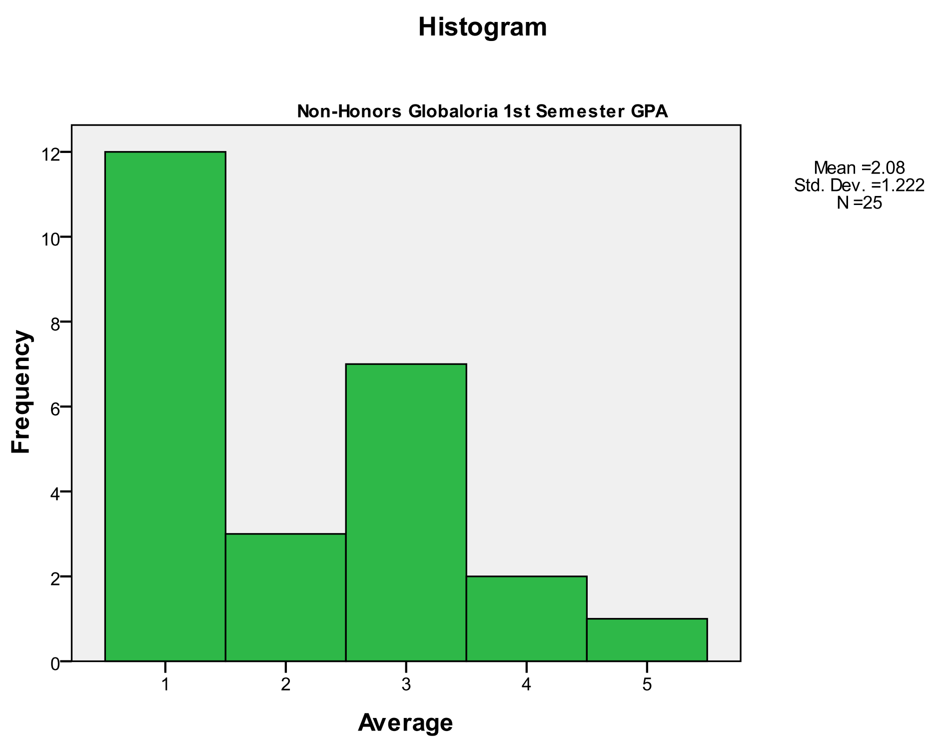
2
3
4
5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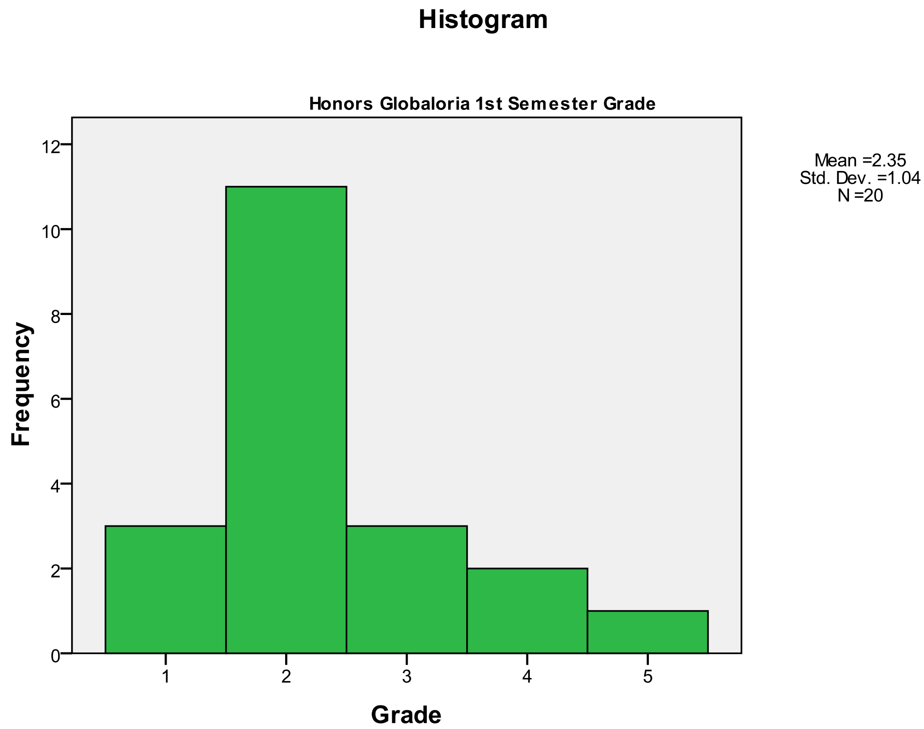
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Honors Globaloria 1st Semester Grade
Frequency
Grade
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1
2
3
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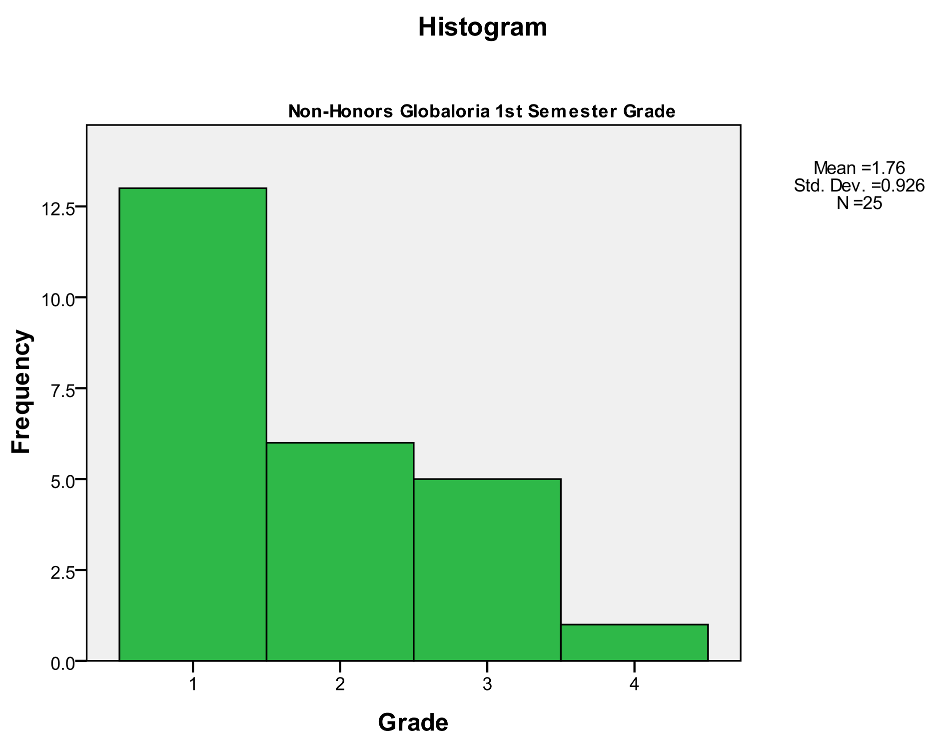
5
Mean =2.35
Std. Dev. =1.04
N =20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Grade
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5.0
7.5
10.0
12.5
1
2
3
4
Mean =1.76
Std. Dev. =0.926
N =25