6. AN EVALUATION OF THE EFFECTS OF USING DIGITAL IMAGERY AND SCIENTIFIC VISUALIZATION EDUCATIONAL TECHNOLOGY TO ENHANCE MIDDLE SCHOOL INQUIRY-BASED INSTRUCTION AND SCIENCE AND TECHNOLOGY EDUCATION STUDENTS' ACHIEVEMENT

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Abstract

Students and teachers are expected to integrate technology across the curriculum. Yet, doing so should be done ultimately to benefit and improve students' achievement. If technology is integrated without careful study and forethought, it can have more negative consequences than positive impacts. In order to integrate digital imagery and scientific visualization into the middle school science and technology education curriculum, research was conducted first on teachers' attitudes toward these technologies and integration in general.

Seven teachers, who teach in grades six through eight, participated in this research process using a qualitative approach with surveys, observations, and interviews. Then, after thorough planning and analysis, the scientific visualization and digital imagery technologies were integrated into the middle school science and technology curricula. Students were given pre-tests, post-tests, and student attitude surveys to determine if the instructional technologies used and the teacher's attitude toward the integration of these technologies affected the students' perceptions and achievement. Administering and analyzing pre-test data and post-test data of an experimental and control group of students accomplished the quantitative data collection. This article explores how teachers attitudes and using instructional technologies like digital imagery and scientific visualization can affect student achievement.

Introduction

The purpose of this study was to investigate the factors that influenced seven middle school teachers as they implemented and integrated two instructional technologies, digital imagery and scientific visualization, into the science and technology education curriculum. This study then further considered what influences, or effects, these factors and the instructional technologies' integration had on student achievement. The quasi-experimental study included both qualitative and quantitative research methods of collecting data, which were composed through surveys, observations, and interviews with the teachers and pre-testing, post-testing, and surveying two technology education-science classes. One class contained a group of students, the control group, whose teachers did not integrate digital imagery or scientific visualization. The other class student group had teachers who integrated digital imagery and scientific visualization in their courses. Triangulation of the data lowered the possibility of researcher partiality. In addition, the increased amount of data collected also potentially increases the dependability of the study.

Background Information on Digital Imagery and Scientific Visualization Use

According to Albert Nous (1998), "Imaging is defined as the acquisition, enhancement, re-representation, and redistribution of a graphic for analysis and reporting" (p. 46). In addition to this definition Nous (1998) explains that: "Visualization is defined as the representation of data using software tools" (p. 46). Specific examples of images that are used and presented in a digital format and incorporated in computer-based scientific visualization of various subjects include: image processing items, magnetic resonance images, geographic imaging systems, satellite imagery, and micro-imagery.

Nous's article contains excellent definitions of both imaging and visualization as they are utilized in science and technology education. He has done significant research into using satellite imagery specifically in science education classes to increase students' awareness and understanding of the Earth and Solar System through visual imagery analyses. His discussions clarify why imaging and scientific visualization is crucial to better understanding of scientific principles. Nous also gives key research articles and information from NASA and other resources that can be of use in the science and technology education classrooms.

Because of the unique characteristics of natural and manmade phenomena, such as fluid mechanics, microscopic organisms, and aerodynamics, digital imagery and scientific visualization allows users in the science classroom to observe processes in ways never before used. The creation and use of scientific visualization and digital images in the science and technology classrooms at all grade levels shows students a different side of science and technology. Bell, Park, and Toti say, "Contrary to what many students believe, the scientific endeavor involves a great deal of intuition and creativity especially at the point of synthesizing data and drawing conclusions from it" (2004, p. 28).

In the increasingly visual world of television, computers, video games, and digital photography, students want more lessons and schoolwork with visually integrated images (Dunn, 1994). Dunn offers numerous strategies to incorporate and engage visual learners in a wide variety of subjects. "Kids who watch television process information uniquely. Specifically, they are visual learners, assimilating concepts better when there are pictures coupled with sound or print" (1994, p. 51). In order to help students process information and skills visually, a teacher should be writing directions on the board while saying them aloud, using the overhead projector, integrating art or other visual means into lessons, and using visual mediums like video, scientific visualization, and digital images to teach. Because the world around most students has inundated them with visual interpretations of ideas, many children find it easier to comprehend information in visual formats (Olshansky, 2003). Since understanding content is easier for students when they have a multitude of ways to interpret the information and apply the requisite skills, teachers should remember to integrate educational technology, such as digital images and scientific visualizations, when appropriate and thus appeal to a wider variety of students' learning styles.

Appealing to multiple learning styles and intelligences has long been studied to prove the effectiveness of incorporating these techniques (Gardner, 1983). Integrating technology is an important initiative that has kindergarten through twelfth grade teachers searching for innovative ways to direct their students through the mastery of various technologies. Digital imagery and scientific visualizations are two technological innovations that allow students to view, manipulate and apply scientific concepts in visual in a way that just reading about them does not allow.

Gordin and Pea in 1995 discovered how scientific visualization (SciVis) makes science accessible for more students rather than the dry and usually boring scenarios of rote memorization of formulas and facts. SciVis also provides the methods for creating realistic scientific inquiry by allowing students to create and use visualizations of their own to better understand scientific principles like scientists do. Because students are using the same or similar tools as scientists this empowers them with new skills and techniques they can use in a variety of classes.

Yet, Gordin and Pea (1995) do not go without recounting the challenges encountered when SciVis was actually used in the IPT and ChemViz projects among others. These challenges include: finding appropriate data to use, creating SciVis files as an inexperienced designer, training teachers to use SciVis files effectively, training students to work independently at their own paces, students with visual impairments may find using SciVis impractical or impossible, time or scheduling limitations may make in-depth inquiry difficult, Materials and resources needed are not cheap, and the computer infrastructure needed may not be available in some schools. I found that the challenges clarified here made me think more carefully about how, when, where, and with whom I should begin integrating scientific visualizations. Then, the authors gave detailed solutions to the potential problems including: training teachers and students better and more actively to use SciVis, creating customized software and data to personalize use, building a community of practice between teachers, students, and the scientists using scientific visualization daily, and connecting schools to high speed networks.

While integrating technologies like scientific visualizations and digital imagery are not without their own unique challenges, they can have a positive affect on student learning if planned for and implemented properly. In 2000, Edelson, Gordin, and Pea designed, implemented and evaluated scientific visualization work for students. The challenges include having a stable technological infrastructure, having consistent technology support for teachers and students, having related data and scientific visualizations, and avoiding the problems associated with time constraints and computer scheduling conflicts (Edelson, Gordin, and Pea, 2000). All in all, their research proves the effectiveness of using scientific visualization, but realizes that much planning and preparation must be done well ahead of implementation with students in any grade level. More than most technologies, scientific visualizations demand large bandwidths to download efficiently and server space because of the files' large sizes. Whenever using scientific visualizations, file space must be adequate to avoid slow load times and other technical problems that can detract from the learning process.

Research about Teachers' Attitudes Toward Instructional Technologies

In a 2001 study, Ediger discussed how attitudinal studies have shown the significance of teacher attitude toward student achievement. Stated was that "Students of more competent teachers achieved significantly higher than those students who had less competent science teachers" (p.25). Teachers' attitudes toward integrating technology can also have significant influence on students' achievement. Training in sound science experimentation and incorporation of technology needs to occur. Partnering science teachers, technology teachers, and scientists can reap many rewards for science students. Sessions called bursts by Koszalka (2004) "consist of short—less than one hour—demonstrations and presentations on current science explorations" (p. 1960). According to Koszalka (2004):

> Coupled with training in technology integration strategies and tools, access to supportive knowledge management systems, and guidance and mentorship from experts and practitioners, these sessions can help educators make connections between scientific practice and pedagogical strategies, leading to the development of effective educational experiences that model scientific practice to students (p. 1960).

Wetzel (2001) states "The availability of instructional technology for teachers is increasing in middle school science to meet societal demands and goals" (p. 2). To successfully meet these perceived and actual demands, teachers and students need to change the way they view, understand and use instructional technology especially in science and technology classes. Teacher dispositions and perceptions about integrating instructional technology in the classroom can greatly affect how students gather, retain, and transfer information and skills (Chang, 2002). When teachers have the support and training to seamlessly integrate instructional technologies like digital imagery and scientific visualizations (SciVis) into their curricula, students have another avenue through which they can experience their lessons' content.

Also, teachers' dispositions and perceptions about instructional technology have a greater influence on student achievement than using any instructional technology alone (Williams, Boone, & Kingsley, 2004). A teacher's attitude toward the use of SciVis and digital imagery can either have a significantly positive or negative effect on how students view, understand, and apply the information and skills obtained from the technology. According to Eisenberg (2001), "Helping students learn to apply technology in these ways requires a change in the computer skills are traditionally taught in school. It means moving from teaching isolated "computer skills" to teaching integrated "information and technology skills" (p. 1075).

However, in order to actuate this shift, educators must first realize and make alterations in their understanding and planning of technology integration. Unfortunately, the reasons that teachers remain pessimistic about the potential in instructional technologies like SciVis and digital imagery is that they have not seen how utilizing this technology can positively alter their students' achievement. Also, they may lack administrative support, open access to the resources, adequate training, or sufficient planning and implementation time. Too often when these issues arise technology integration suffers or comes to a screeching halt. However, as these issues come to light, instructional developers and designers, technology coordinators, and teachers can work together so that technology integration can improve.

Instructional developers, administrators, and fellow teachers must convince and encourage teachers to put the use and acquisition of digital images and scientific visualization in the hands of the students so that they can capture and analyze scientific concepts firsthand. Yet, convincing colleagues to do so is not an easy task. The changes that need to occur in educational settings to guarantee technological integration often happen very slowly. Educators need to work together with students, parents, and administrators to ensure that everyone understands the processes involved and that they are approached systematically. Opposition to change for educators typically arises from apprehension about altering how they work with students, showing less than adequate technical aptitudes, and appearing out of control. Teachers that are habitually resistance to change usually list the following items as reasons: lack of planning time, lack of staff development, lack of technical support, lack of financial resources, and lack of administrative support. In order to account for these obstacles and eventually overcome them, instructional designers and administrators must work in conjunction with teachers to make these reasons disappear.

Description and Rationale of Research Question

With the governmental demands on public school teachers and students requiring teachers to prepare students for a future dominated by technology, teachers of all grade levels and subject matters are integrating technology across the curriculum (NCDPI, 2004). In order to determine how to best address student needs, students take online learning style assessments. In doing so, it's often found in this particular research setting that more and more students each year are predominantly visual and kinesthetic learners. This means that they prefer learning and teaching methods that appeal to the visual learners' sense of sight and the sense of touch for the kinesthetic learners. In order to better prepare these students to understand and apply integrated, multidimensional scientific, technological and mathematical concepts and skills, this study examined the existing research studies, articles, books, and websites pertaining to the integration of computer-assisted instructional technologies, specifically scientific visualization and digital imagery. Thus, the research question was "How does using computer-assisted instruction, such as digital imagery and scientific visualizations, affect student achievement and attitudes toward science and technology education subject matter?

Methods of Research

For the initial part of the research project surveys were distributed and collected to seven faculty members at a public middle school in rural northeastern North Carolina in the United States. Then, as a follow-up, semi-structured interviews were conducted and these teachers were observed at work in a wide variety of classroom settings. The survey, interview, and observation results are discussed elsewhere in the article.

As a continuation of this research project, two groups of twenty-five students were chosen using a quasi-experimental research design. All students were given standardized pre-tests on flight-related topics determined by state technology education curriculum. They were then introduced the required unit information through two different types of curriculum materials. The control group was given the standard curriculum materials and the experimental groups were allowed to explore and implement computer-assisted instruction, containing scientific visualizations and digital imagery, at their own pace over several days in the computer lab.

For this project, two student groups with twenty-five students in each were taught flight-related information integrating digital imagery and scientific visualization instructional technology for one group and not integrating these technologies in the other's instruction. Using the control group and experimental group of students, the implications of incorporating digital imagery and scientific visualization educational technology into their lessons over a ten-day period was studied.

The null hypothesis was that the experimental group would have higher post-test gains than the control group. Also predicted was on surveys the students in the experimental group would have more positive reactions to the curriculum materials that integrate digital imagery and scientific visualization educational technology. Students will be given post-tests after being given either the standard curriculum materials (the control group) or the visually enhanced versions (the experimental group). Their responses on worksheets and surveys will also be collected, observed, and analyzed. At the end of the unit, both groups were debriefed and the control group was retaught the concepts using digital imagery and scientific visualization educational technology.

Description of the Results

Teachers' Attitudes toward Computer-Assisted Technologies

Advanced digital photography, the acquired digital images, and animated scientific visualizations are technological devices that may or may not be familiar to many learners and their teachers. As indicated in the description and rationale section, seven middle school teachers were randomly surveyed and then interviewed and observed as follow-up to the survey analysis. The results indicated that 71.4% of the respondents have used digital imagery in their classroom instruction. Revelations about uses of scientific visualizations (SciVis) showed that only 28.5% of the teachers have used this type of instructional technology with their students. The two most utilized instructional technologies were PowerPoint slideshows with animation and websites enhanced with digital imagery and SciVis, which were used by 85.7% of the teachers (See Table 1).

Table 1: Type of Technology Used by Teachers

Type of Technology Used by Teachers
Digital Imagery 71.4%
Scientific Visualization 28.6%
PowerPoint 85.7%
Websites 85.7%

These uses often coincided with the teachers' primary learning style. Those teachers who were predominantly visual learners (85.7%) also used technology with their students at least once a class (42.8%) or several times during each class (42.8%). Those teachers who did not consider their learning style as visual in nature had a tendency to integrate technology less often—usually only once a week (14.3%). When asked "Do you think that incorporating digital imagery and scientific visualization instructional technology can increase student learning," 100% of the teachers responded in the affirmative. Yet, when asked if they thought that integration of these same technologies could affect student test scores, only 71.4% responded positively.

This prompted me to further investigate the implications of these perceptions and the uses of digital imagery and scientific visualizations in various classrooms as well as cross-tabulating the results to compare years of experience teaching to amount of incorporating technology. The teacher who had 0-5 years of teaching experience incorporated technology several times during a class period. The teacher with 6-10 years only used these types of technology once a week. One of the teachers with 11-15 years in teaching used these technologies once a week, while the other indicated that technology was integrated several times per class. Teachers in the last category of teaching experience (16 or more years) revealed the most use of technology with two of three experienced respondents indicating that they used these technologies once a class and the third informing me that these instructional technologies are used several times a class. This demonstrates that as a teacher feels more confident in his/her area, they are more willing to branch out and embrace the use of new technologies in their subject areas.

The results of the observations and interviews revolved around several themes including the positives and negatives of integrating digital imagery and scientific visualization into lessons. The time consuming technological application and analysis of scientific concepts and data was one obstacle several of the teachers had difficulty justifying. It is true that the obstacles that need to be overcome often are daunting. According to the interviews and observations, teachers who felt confident using digital imagery and scientific visualization technologies on their own, still experienced anxiety about employing these technologies with their students. Problems with adequate training, administrative support, time to plan and implement, and open access to the computers needed to run the programs are the most significant obstacles to seamless integration of these technologies. Also, these teachers felt pressed to do only those activities that would significantly increase standardized end-of-grade or end-of course test scores. This apprehension and a lack of time are indicated by how often the teachers are able to incorporate technology. (See Table 2)

Table 2: Percentage of Teachers and How Often They Incorporate Technology

How Often Teachers Incorporate Instructional Technologies
Once a Class 42.8%
Several times during a Class 42.8%
Once a Day 0
Once a Week 14.3%

When discussing the regular use of digital imagery or scientific visualization specifically in the classroom, a teacher responded: "It is a great support to enhance learning; however, due to constraints (required material and items that must be covered) you can not fully utilize this as an effective teaching tool." Too often overcoming these obstacles dissuade teachers from implementing them unless they are coerced. When teachers move from no longer being the focus of a lesson to guiding students through the process, preparation guidance should accompany this fundamental paradigm shift. When teachers are no longer teaching the way they were taught, time to change and training to know how must be given. Technology that is forced upon teachers and students has little positive effect on the overall educational process. Instead, strategies must be in place to properly train, plan, access, and integrate technologies, if students' success and increased student achievement are the goals.

When interviewed, various teachers agreed that using multiple instructional technologies, such as scientific visualization and digital imagery, appeals to students' different learning styles. They also insisted that the more approaches a teacher can use to help gain and retain students' attention, the more likely students are to retain and transfer the information to other areas. One teacher commented, "I think any variety in instruction will benefit students by being more prepared for 21st century life.

Student Achievement and Attitudes toward Science and Technology-related Concepts

After administering the pre-tests and analyzing the data according to specific directions, the teachers set out to instruct their students in the science and technology of flight. While the control group was given standard text-based materials, the experimental group had multiple opportunities to experience their flight-related topics through the uses of digital imagery and scientific visualization. The students in the control group had an average pre-test score of 46.56 out of a possible 100. The students in the experimental group had an average pre-test score of 45.32 out of a possible 100. Since the difference was only 1.24 points, it was determined that it was negligible considering the groups were closely matched in age, grade level, percentage of boys versus girls, and number of students who have an IEP.

After conducting ten days of classes using the enhanced curriculum or standard curriculum, the groups were given post-tests with content identical to the pre-tests. Each student’s results are delineated in Tables 3 and 4. Students not using the instructional technologies who were identified as needing special modifications through IEPs had significantly less growth than those students who were not identified in the control group. In the experimental group, students who used the instructional technologies and were identified through IEPs had growth on their post-tests within the same range as their non-identified classmates.

Frequencies of scores were examined for both groups as well as other pertinent data (see Appendices A, B, C, and D). The pre-test scores of the experimental group indicated a mode of 23, a mean of 45.32, a median of 43, and a standard deviation of 21.316 (see Appendix E). The post-test scores of the experimental group had a bimodal distribution of 90 and 79, a mean of 83.92, a median of 86, and a standard deviation 10.83 (see Appendix F). The pre-test scores of the control group indicated a mode of 23, a mean of 46.56, a median of 49, and a standard deviation of 20.15 (see Appendix G). The post-test scores of the control group had a mode of 86, a mean of 78.12, a median of 86, and a standard deviation 4.10 (see Appendix H). The results indicated an average growth of 31.56 points in the group not using scientific visualization and digital imagery (see Table 3). The experimental group had higher post-test growth with an increase of an average 38.6 points (see Table 4).

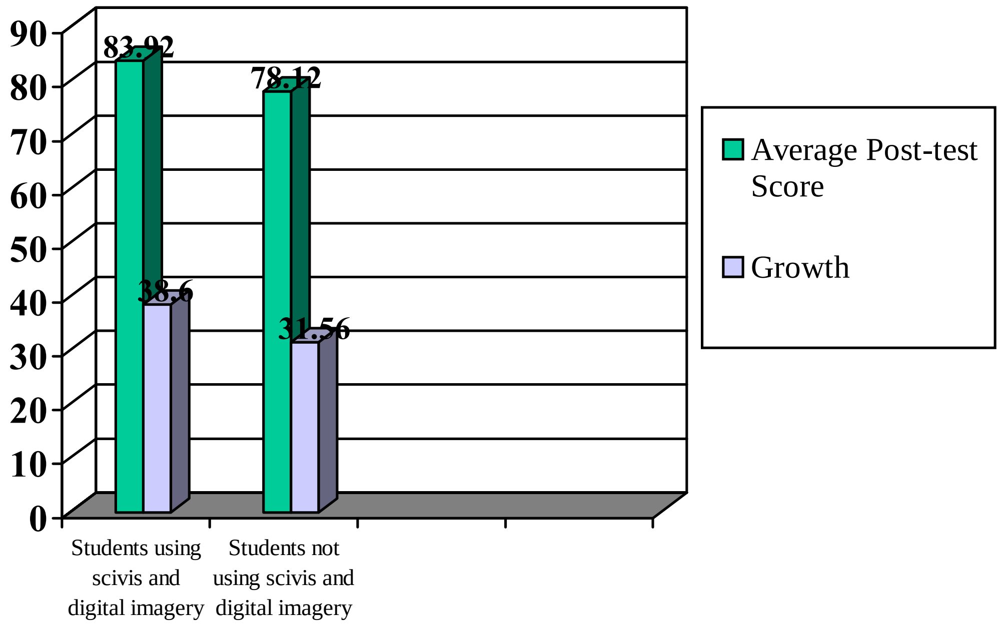
Table 3: Students Not Using Scientific Visualization and Digital Imagery Scores

Student	**Pre-test Score**	**Post-test Score**	**Growth**
1	57	91	34
2	54	100	46
3	60	83	23
4	31	94	63
5	40	86	46
6	69	91	22
7	57	89	32
8	57	80	23
9	26	63	37
10	29	60	31
11	31	60	29
12	37	77	40
13	43	86	43
14	80	89	9
15	9	57	48
16	37	66	29
17	49	71	22
18	60	91	31
19	57	86	29
20	97	97	0
21	9	26	17
22	49	86	37
23	43	80	37
24	60	90	30
25	23	54	31
Sum	1164	1953	789
Average	**46.56**	**78.12**	**31.56**

Table 4: Students Using Scientific Visualization and Digital Imagery Scores

Student	**Pre-test Score**	**Post-test Score**	**Growth**
1	94	100	6
2	37	95	58
3	70	98	28
4	54	92	38
5	23	82	59
6	49	85	36
7	23	79	56
8	23	90	67
9	54	92	38
10	49	90	41
11	66	79	13
12	34	79	45
13	20	80	60
14	31	90	59
15	43	89	46
16	11	64	53
17	37	77	40
18	37	69	32
19	94	97	3
20	51	86	35
21	23	71	48
22	34	54	20
23	51	80	29
24	51	89	38
25	74	91	17
Sum	1133	2098	965
Average	**45.32**	**83.92**	**38.6**

Figure 1: Comparison of Average Post-test Score and Growth between Students Using SciVis and Digital Imagery and Those Not Using Them



As Figure 1 shows the 7.04 point difference between the two groups' post-test scores indicates that integrating scientific visualization and digital imagery into the flight curriculum had a considerable effect on the students' overall retention of the subject matter and flight-related material. While the scores are not radically or statistically significant in their differences, there are indications that the students' retention of the materials was better when they were able to use instructional technologies like scientific visualization and digital imagery.

Conclusions

Integrating instructional technology into science and technology education classes has a profound effect on students' achievement. However, the long term benefits of using such educational devices must continue to be monitored, analyzed, and adjusted in order to have considerable effect on students. When teachers move from no longer being the focus of a lesson to guiding students through the process, preparation guidance should accompany this fundamental paradigm shift. When teachers are no longer teaching the way they were taught, time to change and training to know how must be given.

Implications of This Study

The implications of this study indicate how important teachers' attitudes, administrative support, ample training, easy access to computer hardware and software, and sufficient planning and classroom time are to successful integration of instructional technologies like scientific visualization and digital imagery. Without the basic support factors in place, teachers will hesitate to use these technologies or avoid the use of them altogether. Teachers' perceptions about the technology and their students also can have significant affects on how often they use technology in their classrooms. As was shown by the results of this study, the more experience an educator has teaching full-time, the more likely he/she will integrate technologies like digital imagery and SciVis.

By giving administrative support, having training programs in place, and giving teachers time to plan for the use of instructional technology, administrators can foster successful technology integration at all levels across the curriculum. Also, students must also be gradually taught to use these technologies as educational tools not just entertainment devices. While they may enjoy learning using digital imagery and scientific visualization they must understand that sound educational information, practices and procedures should come first when using technology in the classroom.

Without the support programs in place, the problems that will eventually occur may become insurmountable for even the most dedicated teacher who wants to integrate technology. Research questions that have developed from this project include many in the instructional development realm as well as those focused on instructional technology usage. Future research questions to be explored are:

1. How do the instructor's predominant learning style and the students' learning styles affect instructional development?

2. How can scientific visualization and digital imagery affect literacy learning and writing instruction?

3. In what ways can satellite imagery be used in courses other than science?

4. How does the integration of scientific visualization technology affect students' achievement in vocational-technical courses and student vocational-technical organizations' competitions?

5. How does the integration of digital photography across the middle school curriculum improve test scores?

6. How is distance education instructional development and student achievement affected by the absence or integration of digital imagery?

7. How should training be conducted to entice more teachers to regularly use digital imagery and SciVis in their classrooms? What type of training or mentoring is the most effective?

In future explorations of these topics, the goal is to further define and develop technology integration programs that can adequately train educators to implement technology at greater rates than may be currently occurring and to do so more efficiently and effectively than current use indicates. Showing how a wider variety of technologies can be used in science and mathematics may enhance students' learning of these subjects.

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Appendix A: Frequency Table for Experimental Group's Pre-tests (Students Using SciVis and DI)

Raw Pre-test Score	Frequency
94	2
74	1
70	1
66	1
54	2
51	3
49	2
43	1
37	3
34	2
31	1
23	4
20	1
11	1

Appendix B: Frequency Table for Experimental Group's Post-tests (Students Using SciVis and DI)

Raw Post-test Score	Frequency
100	1
98	1
97	1
95	1
92	2
91	1
90	3
89	2
86	1
85	1
82	1
80	2
79	3
77	1
71	1
69	1
64	1
54	1

Appendix C: Frequency Table for Control Group's Pre-tests (Students Not Using SciVis and DI)

Raw Pre-test Score	**Frequency**
97	1
80	1
69	1
60	3
57	4
54	1
49	2
43	2
40	1
37	2
31	2
29	1
26	1
23	1
9	2

Appendix D: Frequency Table for Control Group’s Post-tests (Students Not Using SciVis and DI)

Raw Post-test Score	**Frequency**
100	1
97	1
94	1
91	3
90	1
89	2
86	4
83	1
80	2
77	1
71	1
66	1
63	1
60	2
57	1
54	1
26	1

Appendix E: Pre-test Information Calculating the Standard Deviation for the Experimental Group (Students Using SciVis and DI)

Raw Score (X)	**Mean ($\bar{X}$)**	**X-$\bar{X}$**	**$(X-\bar{X})^2$**
94	45.32	48.68	2369.74
94	45.32	48.68	2369.74
74	45.32	28.68	822.54
70	45.32	24.68	609.10
66	45.32	20.68	427.66
54	45.32	8.68	75.34
54	45.32	8.68	75.34
51	45.32	5.68	32.26
51	45.32	5.68	32.26
51	45.32	5.68	32.26
49	45.32	3.68	13.54
49	45.32	3.68	13.54
43	45.32	-2.32	5.38
37	45.32	-8.32	69.22
37	45.32	-8.32	69.22
37	45.32	-8.32	69.22
34	45.32	-11.32	128.14
34	45.32	-11.32	128.14
31	45.32	-14.32	205.06
23	45.32	-22.32	498.18
23	45.32	-22.32	498.18
23	45.32	-22.32	498.18
23	45.32	-22.32	498.18
20	45.32	-25.32	641.1
11	45.32	-34.32	1177.86
			Total = 11359.38
			Standard Deviation = The Square root of 11359.38 /25 = √454.37 **SD = 21.316**

Appendix F: Post-test Information Calculating the Standard Deviation for the Experimental Group (Students Using SciVis and DI)

Raw Score (X)	**Mean ($\bar{X}$)**	**$X-\bar{X}$**	**$(X-\bar{X})^2$**
100	83.92	16.08	258.56
98	83.92	14.08	198.24
97	83.92	13.08	171.08
95	83.92	11.08	122.76
92	83.92	8.08	65.28
92	83.92	8.08	65.28
91	83.92	7.08	50.12
90	83.92	6.08	36.96
90	83.92	6.08	36.96
90	83.92	6.08	36.96
89	83.92	5.08	25.80
89	83.92	5.08	25.80
86	83.92	2.08	4.32
85	83.92	1.08	1.16
82	83.92	-1.92	3.68
80	83.92	-3.92	15.36
80	83.92	-3.92	15.36
79	83.92	-4.92	24.20
79	83.92	-4.92	24.20
79	83.92	-4.92	24.20
77	83.92	-6.92	47.88
71	83.92	-12.92	166.92
69	83.92	-14.92	222.60
64	83.92	-19.92	396.80
54	83.92	-29.92	895.20
			Standard Deviation = The Square root of 2935.68/25 = √ 117.42 **SD = 10.83**

Appendix G: Pre-test Information Calculating the Standard Deviation for the Control Group (Students Not Using SciVis and DI)

Raw Score (X)	**Mean ($\bar{X}$)**	**$X-\bar{X}$**	**$(X-\bar{X})^2$**
97	46.56	51.44	2646.07
80	46.56	33.44	1118.23
69	46.56	22.44	503.55
60	46.56	13.44	180.63
60	46.56	13.44	180.63
60	46.56	13.44	180.63
57	46.56	10.44	108.99
57	46.56	10.44	108.99
57	46.56	10.44	108.99
57	46.56	10.44	108.99
54	46.56	7.44	55.35
49	46.56	2.44	5.95
49	46.56	2.44	5.95
43	46.56	-3.56	12.67
43	46.56	-3.56	12.67
40	46.56	-6.56	43.03
37	46.56	-9.56	91.39
37	46.56	-9.56	91.39
31	46.56	-15.56	242.11
31	46.56	-15.56	242.11
29	46.56	-17.56	308.35
26	46.56	-20.56	422.71
23	46.56	-23.56	555.07
9	46.56	-37.56	1410.75
9	46.56	-37.56	1410.75
			Total = 10155.95
			Standard Deviation = The Square root of 10155.95 /25 = √406.23 **SD = 20.15**

Appendix H: Post-test Information Calculating the Standard Deviation for the Control Group (Students Not Using SciVis and DI)

Raw Score (X)	**Mean ($\bar{X}$)**	**X-$\bar{X}$**	**$(X-\bar{X})^2$**
100	78.12	21.88	478.73
97	78.12	18.88	356.45
94	78.12	15.88	252.17
91	78.12	12.88	165.89
91	78.12	12.88	165.89
91	78.12	12.88	165.89
90	78.12	11.88	141.13
89	78.12	10.88	118.37
89	78.12	10.88	118.37
86	78.12	7.88	62.09
86	78.12	7.88	62.09
86	78.12	7.88	62.09
86	78.12	7.88	62.09
83	78.12	4.88	23.81
80	78.12	1.88	3.53
80	78.12	1.88	3.53
77	78.12	-1.12	1.25
71	78.12	-7.12	50.69
66	78.12	-12.12	146.89
63	78.12	-15.12	228.61
60	78.12	-18.12	328.33
60	78.12	-18.12	328.33
57	78.12	-21.12	446.05
54	78.12	-24.12	581.77
26	78.12	-52.12	2716.49
			Total = 7070.53
			Standard Deviation = The Square root of 7070.53 /25 = √282.82 **SD = 4.10**