

High School Students' Affective Dispositions in Science: Scientific Inquiry with Information Technologies*

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Abstract: The purpose of this study was to investigate the effects of high school students' long-term authentic research projects with Information Technologies (IT) in small groups in and out of school time on their affective dispositions in science. This study was conducted in the context of a three-year NSF project, namely, Translating Information Technology into Classroom (TITiC). A survey consisting of Likert scale items and open-ended questions was administered to 45 students (29 females and 16 males) from Grades 9 to 12. The results of this study showed that on the average 79.37%, 90.83%, and 81.33% of the students developed better attitudes toward, perceptions of, and self-confidence in science, respectively. These increases were further supported by evidence from qualitative data.

Introduction

We have come to a period of the world's history when information technology (IT) is expected to be integrated into all content domains. It is a time when learners of all ages can equitably engage with the scientific data sets, instruments, models, and simulations that are available in the nation's Cyberinfrastructure (Computing Research Association, 2005). Cyberstructure coupled with theoretically informed authentic practice of empirical science involving "information technology embedded

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conceptualization, investigation, and communication,” the boundary between formal and informal learning becomes blurry. Information technology integrated science may raise a generation of American youth who are interested and motivated to enroll in advanced science courses in preparation for scientific and technical careers. It may also develop a literate society that will take part in the deliberations of socio-scientific affairs and make appropriate civic decisions. The research reported in this article was conducted in a project that provided students with IT embedded scientific research opportunities that had relevance and importance to their lives. Furthermore, students in this project had access to IT practitioners, their workshops, and collections of activities, observations, and comments not only to help with the projects but also point them to IT related educational and career pathways in science. In this learning environment, a research focus was the affective domain because it has important implications not only for the continuity of scientific endeavor but also for the scientific literacy of future generations.

In response to declining science enrollment, interest, and achievement among U.S. students moving from middle school to senior secondary over the last two decades, many innovative science programs have been developed across the country to provide enriching experiences to all students, including minority, underserved, and underperforming (see the goals for more recent NSF programs). Consistent with National Science Education Standards (National Research Council, 1996), these programs have emphasized inquiry science. The goals of innovative science programs have been primarily focusing on student understanding of scientific knowledge and achievement. Overall these programs continue to demonstrate significant positive results when success is measured by science achievement (Freedman, 1997; Harwood & McMahon, 1997; Romance & Vitale, 2001). To neglect the affective domain in the innovative science programs is to exclude consideration of a key characteristic of the sciences of learning that contributes to science learning. Hence, the motivation for our study is to address the student affective disposition in the context of *Translating Information Technology into Classrooms* (TITiC) project sponsored by the National Science Foundation-Information Technology Experiences for Students and Teachers program.

There are also a number of studies more specifically dealing with the changes in students' affective dispositions in science based on the implementation of new instructional strategies and curriculum materials (Chang, 2002; Chiappetta, Waxman, & Sethna, 1990; Ebenezer & Zoller, 1993a; Ellis, 1993; Shepardson & Pizzini, 1993). The results of these studies have also showed mixed results in terms of students' affective dispositions. None of these studies, to our knowledge, has investigated the effects of high school students conducting long-term scientific inquiry with Information Technologies (IT) on their affective dispositions in science. This study is timely, particularly when departments of education are mandating technology-infused science curricula.

Objectives

Radical changes have occurred in our understanding of multiple aspects of learning and this includes the “affective”--dispositions in attitude, perception, and self-confidence. *Attitudes towards science* refer to a person's positive or negative response to the enterprise of science or whether a person likes or dislikes science (Simpson et al., 1994). *Perception of science* refers to the degree of a person's understanding of the value of science in everyday life and to society as well as the relationships among nature, everyday life, and science (Ebenezer & Zoller, 1993b; Yager & Yager, 1985). Self-confidence in science refers to the degree of a person's own confidence in their abilities to learn and do science (Stake & Mares, 2001; 2005).

The purpose of this study is to better understand students' affective dispositions in science in the context of a three-year NSF project, namely, *Translating Information Technology into Classroom (TITiC)*. In phase 1, teachers are trained in information technology (GIS/GPS, probes and sensors, and communication tools). Phase 1 is preparation for phase 2 where the teachers engage small groups of students in in-school and out-of-school time long-term socio-scientific research projects using information technologies (IT). In Phase 3, the IT competent teachers because of their experience in Phases 1 and 2 integrate IT into the science curriculum. The data for this study were gathered from a survey we administered to the students at the end of the second phase. Focusing on the affective orientation, we frame one research question with three parallel components: What are high school students' (a) attitudes toward, (b) perceptions of, and

(c) confidence in science as the result of conducting long-term scientific research with Information Technologies?

Methods

Context of Inquiry

In Phase 1 (specially designed 2-week summer institute), 15 teachers, 5 from three school districts learned the capabilities of the GIS/GPS, Vernier probe wear, the CBL2 interface unit, the TI-84+ calculator, and the LoggerPro software by completing hands-on laboratory activity or experiment. It was a learner-centered atmosphere, with partners or small groups completing the work while expert facilitators remained accessible for guidance and help. The participants were also furnished with opportunities to perform activities and experiments in the field, including small projects that were presented at the end of the institute and water quality assessment both at the River Raisin and on a NOAA research vessel. At the end of the summer institute, the external evaluation led by Mark Jenness (SAMPI, 2005), asked the teachers rate their preparation to use specific technologies on a scale of 1(not well prepared) to 4 (well prepared). All technologies received high ratings: 3.14 for the Logger Pro Software, 3.14 for Vernier probes, 3.43 for the GPS, 3.14 for the Water Test kits, 3.36 for the Spectrophotometer for analyzing water quality, 2.29 for the GIS, and 2.36 for the TITiC Portal. The lessons learned were presented at the AERA Conference (Ebenezer & Hoffman, 2006), and at the 2006 SITE Conference. (Ebenezer, Fader & Speirs, 2006). Positive results and outcomes to date from the TITiC project lend support to the efficacy of the teachers being able to use IT in scientific inquiry. If high quality reform-based professional development of teachers is provided (Supovitz & Turner, 2000), then teaching practices are expected to have a high impact on student learning and education (Borko, 2004, Fullan, 1996). This includes the affective domain. With this leaning, at the end of Phase 2 of the TITiC project, that is, after each teacher had engaged a small group of 3-5 students in a long-term project, we surveyed students' experiences about their attitudes toward, perceptions of, and self-confidence in science.

Students' Research Projects

At the beginning of the 2005-2006 school year, the TITiC teachers taught their students how to use special technologies to conduct scientific inquiry. Then the teachers engaged students in a semester-long scientific research projects that were related to their everyday lives. For example, a small group of students investigated the “Algae in the River Raisin”. Another group studied “The surrounding rivers impact on Lake Erie and its Watershed”. A different group was involved with the “Monroe Munson Park Prairie Restoration Project.” Students, generally, identified research questions that had personal relevance. For example, this is clearly evident in the research paper on “Algae in the River Raisin”:

Most people in Monroe County depend on the River Raisin in some way. We depend on it as a source of water, food, and recreation. Last summer in 2005, that river was hit hard by a massive amount of algae. People were astonished by what they saw. People began thinking that the water was dirty and that we shouldn't use it. We decided to ask the question: Why did the algae form? And what do we need to do to fix it?.....“We chose this topic because it hits home with us. (Drewior, T., Mazur, H., Oetting, S., Jansen, M. & Nevel, K., 2006, p. 2-3)

Using the Internet, books, and expert knowledge of scientists and teachers, students studied the concepts and theoretical background guiding their research questions. Most research groups also connected with associations (agencies) such as EPA and NOAA. This phase helped students to refine their original research questions, make decisions on methods of inquiry, and identify the appropriate technology to answer their research questions. As noted in the following excerpt, the group of students who investigated the “Algae in the River Raisin” shaped their research project through e-mail and phone interviews and communications with Mr. Daniel Stenfanski, Monroe County Drain Commissioner.

Mr. Stenfanski, the drain commissioner, had done the tests when the algae were very prominent. We did the tests after the algae had gone away. We wanted to see if the water quality had improved.....We started the tests after most of the algae had disappeared so that could be a variable (Drewior, T., Mazur, H., Oetting, S., Jansen, M. & Nevel, K., 2006, p. 2-3).

Based on their understanding of scientific knowledge and logical reasoning, students set up their hypothesis. The “Algae” paper reflects this disposition.

We believe that the reason the algae came was because of our warm summer. The heat from the sun caused a quicker evaporation rate of the water. There was less water and therefore a slower flow rate than normal. The water couldn't move the algae along and so it all settled in one place. Also, when algae die all of the nitrates are pushed to the bottom. Algae feed on those nitrates and so it grows. So the slower the flow rate is the more algae you will have in an area. That is why all of the algae was on the dam. (Drewior, T., Mazur, H., Oetting, S., Jansen, M. & Nevel, K., 2006, p. 2)

After deciding on the tests that need to be conducted, students determined the necessary materials, supplies, and technologies necessary to investigate their research questions. For example, some materials and technologies, which "Algea" students used, were: CBL2 interface, TI graphing calculator, Datamate program, Temperature, PH, Salinity and Turbidity, Flow rate sensors, Hach programs, GPS units, Distilled water, Assorted beakers, Graduated cylinder, Chloride 2 indicator powder pillow, potassium per sulfate powder pillow and Turbidity standard 100 NTU.

Students then collected water samples and performed the tests using various information technologies as revealed in the following paragraph:

In order to conduct our research we completed the following: First we went on location at the River Raisin, fall 2005, where we conducted several water tests, among these were flow rate, temperature, and dissolved oxygen. All of these tests were done in multiple locations across the river from one bank to the other, and in two different locations, first at Veterans Park and next at the River Raisin Bridge. At all of these locations GPS points were collected. Next we collected a water sample from the river and brought it back to the laboratory and conducted tests such as the reactive phosphates, total phosphates, chlorides, nitrates, pH, total dissolved solids, alkalinity, and turbidity. Once all of this information had been collected we proceeded to examine several of the alga specimens under a microscope identifying some of the organisms which inhabited the samples (Drewior, T., Mazur, H., Oetting, S., Jansen, M. & Nevel, K., 2006, p. 4).

Students analyzed the data and proposed an explanation with strong evidence to make a conclusion. At this phase, they also compared their results with the historical findings as illustrated in the excerpt below:

The only thing that we found out about the algae from other sources was the name, which turned out to be Oedogonium, an invasive species. The new data that we collected was historical data from 1971 to 2000, average temperatures from 2005 and the climate for 2005. From this data we

can conclude that the algae wasn't here because of the temperature. In fact from the data that we collected Monroe had very low temperatures compared to past years. My theory would be that the cause of the algae growth was due to the low amount of precipitation we had during those months, the average rain fall in inches for May to August was 2.4 in, that is a low amount of rain fall for the four months of the year that we are suppose to get the greatest amount of precipitation. In addition to the amount of days it rained, there was very low wind speeds compared to the other months; in fact those four months had the lowest wind speed of the entire year (Drewior, T., Mazur, H., Oetting, S., Jansen, M. & Nevel, K., 2006, p. 8-9)

Students proposed to do a scale-up project on their research to gain a better understanding.

We will be doing the same tests that we did as earlier described during these times. We will also be taking several samples and examining the organisms under a microscope, as well as identifying there organisms, and seeing how these blooms have affected the life within the water. As a result hopefully from this data there will be variance from which we will be able to make a conclusion regarding the causes and effects of the algae” (Drewior, T., Mazur, H., Oetting, S., Jansen, M. & Nevel, K., 2006, p.9-10).

We think that the reason for the algae was because of the slower flow rate during that summer. The algae could come back if we have another summer with little rainfall. The project will go on all year. (Drewior, T., Mazur, H., Oetting, S., Jansen, M. & Nevel, K., 2006, p. 2)

All the students collaboratively participated throughout the research, and had specific roles and responsibilities in each phase of their project. The following excerpt of their research paper indicates how they collaboratively did their research.

In order to have gotten where we are today in our research the work has been completed by several people. Kellye, Meagan, Sarah, Hollie, and Tareasa collected the data on location at the river. Kellye and Meagan were in the water, Meagan using the instruments while Kellye recorded the data on the calculator. Hollie, Sarah, and Tareasa collected the GPS positions from all around both locations in order to make it possible to plot the location of the data collected. Also individually everyone has been doing their own research on the internet and using several book sources in order to gather information regarding the specific type of algae we have identified. The water tests were evenly conducted by the different group members. The pictures of the microscopic images collected were taken by Hollie, Kellye, and Meagan. (Drewior, T., Mazur, H., Oetting, S., Jansen, M. & Nevel, K., 2006, p. 10)

The TITiC students presented their research papers on May 15, 2006 at Wayne-RESA in the symposium specially organized for this purpose. Their peers and teachers as well as the members of the TITiC management and NAG committees were present at this symposium. At least, three groups of students from each school did paper presentations and other groups made poster presentation. Moreover, students of one school created their own WebPages to share their research. Another school published their research projects in their "Bolles Harbor Journal." The third school published a student research booklet. All of these publications are available to the public in TITiC Portal (TITiC, 2006).

Sample

The data were collected from 45 students (29 females and 16 males) from Grades 9 to 12. Their ages were 15 to 17. 8 students from Grade 9, 10 students from Grade 10, 16 students from Grade 11 and 10 students from Grade 12. The schools that participated in the TITiC project were public high schools. The population of students was from middle socio-economic status homes. 42 students were white American, two students were Asian and one was a Native American.

Data Collection

When we developed these Likert surveys, we considered pertinent attitude, perception and self-confidence questionnaires in the literature (e.g., Ebenezer & Zoller, 1993a; Francis & Greer, 1999; Gogolin & Swartz, 1992, Stake & Means, 2001). Attitudes toward Science (ATS) questionnaire consisted of 7 items focusing on specific feelings and interests in science careers. Perception of Science (POS) questionnaire consisted of 8 items focusing on the value of science in everyday life and to society. Self-confidence in Science (SCIS) questionnaire consisted of 5 items focusing on confidence in learning and doing science with technology. For all items on these scales, students were asked to rate "How much did the TITiC program change your attitudes toward, perceptions of, and self-confidence in science " on a 7-point scale anchored by 1 (not at all) and 7 (a great

deal). At the end of each Likert scale, a relevant open-ended question was asked so that students may elaborate their responses to the Likert scale items.

Data Analysis

The frequency (f) and % values for the students' responses on 7-point Likert scales were tabulated. Mean scores and related percentage values are presented in Tables 1-3. To analyze the results of the Likert surveys, we have grouped the first three options ("none at all", "hardly any at all", and "a little") to mean that students' affective dispositions were not positive. Similarly, we have grouped the last three options ("moderate amount", "a lot", and "a great deal") to mean that students' affective dispositions were positive. The option "some" is placed between "not positive" and "positive" with respect to affective dispositions in science. Students' responses to open-ended questions for each questionnaire were analyzed to clarify the results obtained from the Likert survey. The students' interview transcripts were carefully read and analyzed. Using an inductive process we identified themes to depict students' affective dispositions

Results

Attitudes toward Science

The results of the Likert survey indicated that the students exhibited positive attitudes toward science after their experience with the TITiC project (see Table 1). Seventy-three to 93% of the students reported that the TITiC Project had positively influenced their attitudes toward science. On the average, 79.37% of students reported that their enjoyment of science and interest in a science career positively developed after their experience with the TITiC project. On the contrary, 4% to 20% of the students stated that the TITiC project did not positively affect their attitudes toward science. From 2% to 13% of the students indicated "some" positiveness in terms of their attitudes towards science after their experience with the TITiC project. On the average, 7% of the

students stated that there was no or hardly any change in their attitudes toward science; 5% and 8% of students reported a little and some changes, respectively, in their attitudes toward science.

Table 1. Results of the effects of students' experiences in the TITiC project on their attitudes toward science.

After my experience with the TITiC Project...	none at all	at hardly any at all	a little	some	a moderate amount	a lot	a great deal
1. I find science more interesting.	1 (2.22%)	1 (2.22%)	0	1 (2.22%)	14 (31.11%)	13 (28.89%)	15 (33.33%)
2. I am more enthusiastic about science.	1 (2.22%)	1 (2.22%)	1 (2.22%)	5 (11.11%)	11 (24.44%)	11 (24.44%)	15 (33.33%)
3. I feel like taking more science classes in college.	1 (2.22%)	1 (2.22%)	4 (8.89%)	6 (13.33%)	5 (11.11%)	9 (20.00%)	19 (42.22%)
4. I feel science is more fun.	1 (2.22%)	1 (2.22%)	3 (6.67%)	2 (4.44%)	8 (17.78%)	14 (31.11%)	16 (35.56%)
5. I am more sure of wanting to do a career in science.	3 (6.67%)	3 (6.67%)	3 (6.67%)	4 (8.89%)	5 (11.11%)	9 (20.00%)	18 (40.00%)
6. I am more interested in a science career.	3 (6.67%)	2 (4.44%)	2 (4.44%)	3 (6.67%)	7 (15.56%)	11 (24.44%)	17 (37.78%)
7. I am more than before want to consider science careers.	2 (4.44%)	2 (4.44%)	3 (6.67%)	5 (11.11%)	8 (17.78%)	9 (20.00%)	16 (35.56%)
Average	1.71 (3.81%)	1.57 (3.49%)	2.29 (5.08%)	3.71 (8.25%)	8.29 (18.41%)	10.86 (24.13%)	16.57 (36.83%)

Of the seven items, the first 4 items pertain to the self-interest in learning science and the last three items focus on science career. Considering the first four items of the survey related to the students' enjoyment of science, 83% of the students, on the average, reported that science is more interesting and fun for them, and they were more enthusiastic about science and want to take more science classes in their college years after their experience with the TITiC project. However, on the average, 8.5% of the students expressed that their TITiC project did not improve their enjoyment in science. These strongly noticeable increases in their attitudes toward science revealed from the results because of long-term scientific research with Information Technologies is also supported by students' responses to the open-ended question "*With examples describe how your attitudes toward science have changed as a result of the TITiC Project.*". Excerpts illustrating specific interest in science are provided below:

My attitude towards science has changed during this TITiC Project in a positive way. Previously I thought it was a bit boring and I had little interest in it. Now I enjoy it and feel that it is very important to be knowledgeable about. In using the technology to test our water during our project I learned that it involves a lot of hard work and trial and error procedures. I realize how much work is involved to accomplish these tasks. (1)

I loved taking the class and getting hand on experiments, we got to go get our study material right outside our building, and bring it in and test it. It could have been from the water or the woods. I really enjoyed having hands on experience. (2)

The complete result from the program has made me more enthusiastic about science. It has given me an idea about what I will be doing in my future in being out in the field of science. When out taking the measurements of the roadkill, I have learned a great deal about how scientists work out in the field. (3)

My attitude toward science has changed dramatically because I realized there is more to science than just the basics; science is about going beyond the present state of knowledge and developing your own personal theories. In knowing this, I am more optimistic about learning about science because I want to try and develop extended theories. (4)

At first I thought science was really frustrating, but in doing TITiC I realized how much fun it can be, especially when I write out an experiment then conduct it (5)

I've always known that I loved science. It was partly the reason why I chose to take this course. But after doing so many hands on activities such as actually traveling to different sites and getting dirty try in to get samples I've learned that this is definitely a field that I will pursue. (6)

I really liked completing the experiment; it was a lot of fun. This got me more interested in having a career in some type of science field. I also plan on taking more science class during high school. (7)

I am more interested in science because of the TITiC Project. Science was never something I was extremely interested in, but this project has helped me like it more. I am still not very inclined towards a career in science, but now I better understand the purpose and benefits of scientific research. (8)

Students have come to this project with no interest, lack of extreme interest, with frustration and with boredom in science. One student realizes that there is more to science than the basics she can be taught. A student has come to this class with love for science, Students give different reasons why they like science more. They are: science is important to know (1), hands-on experience by collecting and testing in and out of school (2), insights into how scientist work (3), developing personal theories (4), writing and conducting my own experiment (5), traveling to sites (6), getting hands dirty (6), completing the experiment (7), and better understand the purpose and benefits of scientific research. (8)". To express their attitudes toward science, students use phrases such as "I enjoy it," "I really enjoyed," "how much fun," "more enthusiastic," "changed dramatically," and "more optimistic about learning science," "I have always loved science," "it was lot of fun," and "like it more." Such phrases point to students' positive attitudes toward science. While one student is not still keen on a scientific career, some others state that they will pursue a career in science. One student aptly puts, "*It has given me an idea about what I will be doing in my future in being out in the field of science. (3)*" Another student after giving reasons why she loves science states, "*I've learned that this is definitely a field that I will pursue.*" (6) Yet another student reasons, "*This (completing an experiment) got me more interested in having a career in some type of science field.*" (7). She underscores, "*I also plan on taking more science class during high school.*" (7)

Perceptions of science

The results of the Likert survey indicated that the students had better perceptions of science after their experience with the TITiC project (see Table 2). Eight-seven to 93% of the students reported that the TITiC Project work had positively influenced their perceptions of science. On average, 90.84% of the students reported that their perceptions of the value of science in their everyday life and to society positively developed after their experience with the TITiC project. On the contrary, 2% to 13% of the students stated that the TITiC project work did not affect their perceptions of science to an acceptable positive level. From 0 to 4% of the students reported “some” increase in their perceptions of science after their experience with the TITiC project.

Table 2. Results of the effects of students’ experiences in the TITiC project on their perceptions of science.

After my experience with the TITiC Project, I have better understanding that science is important...	none all	at	hardly any at all	a little	some	a moderate amount	a lot	a great deal
1. To examine environmental issues.	0		1 (2.22%)	1 (2.22%)	1 (2.22%)	8 (17.78%)	11 (24.44%)	23 (51.11%)
2. To deal with local issues such as the quality of water in different ways.	0		1 (2.22%)	0	2 (4.44%)	6 (13.33%)	15 (33.33%)	21 (46.67%)
3. To be successful in the future.	0		2 (4.44%)	2 (4.44%)	1 (2.22%)	8 (17.78%)	10 (22.22%)	22 (48.89%)
4. To deal with my life outside of school.	2 (4.44%)		1 (2.22%)	3 (6.67%)	0	7 (15.56%)	11 (24.44%)	21 (46.67%)
5. To make sensible decisions.	1 (2.22%)		2 (4.44%)	2 (4.44%)	0	9 (20.00%)	9 (20.00%)	22 (48.89%)
6. To understand the world in which we live.	0		1 (2.22%)	1 (2.22%)	1 (2.22%)	5 (11.11%)	14 (31.11%)	23 (51.11%)
7. To make better decisions about environmental issues.	0		1 (2.22%)	1 (2.22%)	1 (2.22%)	4 (8.89%)	10 (22.22%)	28 (62.22%)
8. To make better choices about various things that affect my life (e.g., quality of my drinking water)	0		1 (2.22%)	2 (4.44%)	2 (4.44%)	4 (8.89%)	6 (13.33%)	30 (66.67%)
Average	0.38 (0.83%)		1.25 (2.78%)	1.50 (3.33%)	1 (2.22%)	6.38 (14.17%)	10.75 (23.89%)	23.75 (52.78%)

Out of 8, 5 items (i.e., items 1, 2, 6, 7, and 8) in the survey focused on changes in students’ perceptions of science in terms of environmental issues and effects of these problems on the life. When those items of Likert survey were analyzed separately, it was observed that on the average, 92% of the students had a better understanding of examining environmental issues, dealing with local problems, making better decisions about environmental issues, and making better choices about various things that affect

their lives. The remaining three items of the survey (i.e., items 3, 4, and 5) also indicated that on the average, 89% of the students had a better understanding of the value of science in their lives. This finding is not surprising because all of the student research projects were related to their local environmental problems that are directly connected with their lives and community. For example, the long-term student research projects in which students became more aware of the value of science include “Algae in the River Raisin,” “The Surrounding Rivers Impact on Lake Erie and IT Watershed,” “Lake Erie Dead Zones,” “Dissolved Oxygen/Thermal Pollution Relationship,” “Lake St. Clair Sedimentation,” “Aquatic Macroinvertebrate Communities as Indicators of Pollution in the Frank and Poet Creeks,” “Fecal Coli form Bacteria in the Lower Ecorse Creek and Detroit River,” “Marina Pollutants Along the Detroit River,” “Seasonal Changes in Chloride Concentrations and Total Dissolved Solids in the Lower Ecorse Creek and Detroit River Watersheds,” “Study of pH Levels in Lakes, Rivers and Ponds Surrounding the Lake Erie Watershed,” and “Sedimentation and growth on Lakeshore; Analysis of water and sediment samples from various Lake St. Clair areas and make correlations.” The quantitative results were also supported by evidence from students’ responses to the open-ended question *“With examples describe how your perceptions of science have changed as a result of the TITiC Project.”*

Using students excerpts, we want to show how students are becoming aware of what science is, what science can do, how it affects the environment, their place in the environment, how human beings affect the environment, and in turn, how the environment affects human beings and what role human beings can reclaim what is lost and take care of personal health and surroundings. We will begin with a student’s awareness that science is part of life: *“I’ve seen that science is part of our everyday life not just the work done in science laboratories. For our experiment we tested pH levels in rivers streams and ponds. I’ve seen that water on the side of the road is science. Almost anything that u can think of relates to science in some way. A student has opened her eyes to the little things they do and the impact it has: “I just have a better understanding of how little things we do and forget about can affect us in such a big way.” Another student admits that she did not care about “what went into the water and how bad it was for you.” Now she realizes, “I get to see what happens when you put certain things in*

the water. How bad things can actually get.” She feels that she is part of the quality web because she now knows, “And how we can help improve our water quality.” To another student, “It (is) much more important to focus on science to help you in the environmental issues because there important to us.” “My perception of science has changed” claims another student “ because during all of the other students’ presentations, some of them discussed issues I was not aware of. For example, road kill is very common in the state of Michigan, and the water quality is not necessarily satisfactory. This project has made me think twice about certain matters.” A student claims, “I have a better understanding as to how much science impacts our daily lives and how to use this information to make educated, informed decisions.” Focusing on the impact of science and environmental issues on himself, immediate others, and around the community, the student states, “I have realized how much science affects me and the others around me. I have discovered how much environmental issues can affect a community.” Realizing how his health is affected by the environment, he states, “I now realize how much my environment affects my life and health. What I learned will allow me to make more informed decisions in the future.” A student provides an example of how she can be affected: “I row on the Detroit River and I had never realized how it could harm me. I will now be more conscience of my environment.” On becoming aware of what is lost because of the environmental problems and science, she states, “I am more aware of the environmental problems in the local community. Especially because I realize how hard it will be in the future to recover what we have already lost in the environment and science is a key part in this.” “This project has made me realize the importance of science” echoes a student, To him, “Science is necessary to make the world a better, safer place, and scientific research is essential in making good decisions. This project has showed me how decisions made based on scientific research can impact my life and the environment around me.” He is appreciative of the work scientists’ work to care for the community when he states, “While working out on the lake I learned that scientists have to do this all the time. I didn't realize how important water levels are or how much it affects the community.”

Learning to use high-end information technologies has led the TITiC community to undertake community-based environmental issues. By engaging students in conducting

research on local environmental issues, students have naturally become aware of their environment. Students' perceptions of their impact on the environment and vice versa are more vivid because of the TITiC project. There is much value when problems close to the students are studied. The problems they are researching have paved a path of reflection that enable them to understand that they have to make informed decisions. In fact, the current reform in STSE learning connectives involve an effort to develop students' capabilities: Inquiry (question asking), critical systems thinking (linking science, technology, environment and society), decision making and problem solving. The higher-order thinking skills are taught instead of the lower order cognitive skills which do not lead to evaluative thinking and transfer. Committing to work within community contexts involves personal responsibility, collective agreement, decision-making, and action taking (Solomon & Aikenhead, 1994). Such an educative process is promising through curricula that characterize the multi-disciplinary nature of community contextual studies that integrate science disciplines, technology, engineering design, and mathematics, encouraging students to think critically about problems, to form opinions, to shape beliefs, and to make choices that contribute to quality of life. To inaugurate this process of helping students in making defensible choices, we need to engage school learners to conduct STSE learning connectives inquiry projects pertaining to their community contexts. Because Detroit and its suburbs are surrounded with the Great Lakes, students have had opportunities to engage in STSE learning connectives that involve socio-scientific issues pertaining to the health of water sheds. School learners are intellectually stimulated, excited, and challenged because the projects that they have selected are based on interdisciplinary inquiry. They connect the community and school. The study of the environmental issues has quickly shown students the relevance of their classroom-based education to their natural and social worlds. Engaging in complex science studies allow the teacher and students to break the paradigm of activities that have simple, predetermined answers and substitute real situations with real problems that may have complex solutions.

Self-Confidence in Science

The results of the Likert survey showed that the students are more self-confident in science after their experience with the TITiC project (see Table 3). Seventh-three to 87% of the students reported that the TITiC Project work had positively influenced their self-confidence in science. On the average, 81.33% of students reported that their self-confidence in science positively increased after their experience with the TITiC project. On the contrary, 7% to 15% of the students stated that the TITiC project work did not affect their self-confidence in science to an acceptable positive level. From 4% to 11% of the students reported “some” increases in their self-confidence in science after their experience with the TITiC project. On the average, 5% of the students stated that there was no or hardly any change in their self-confidence in science; 4% and 9% of students reported a little and some changes, respectively, in their self-confidence in science.

Table 3. Results of the effects of students’ experiences in the TITiC project on their self-confidence in science.

After my experience with the TITiC Project...	none all	at	hardly any at all	a little	some	a moderate amount	a lot	a great deal
1. I feel more confident in learning science with technology.	1 (2.22%)		1 (2.22%)	1 (2.22%)	5 (11.11%)	4 (8.89%)	16 (35.56%)	17 (37.78%)
2. I am more confident to do science with technology.	1 (2.22%)		1 (2.22%)	1 (2.22%)	5 (11.11%)	5 (11.11%)	12 (26.67%)	20 (44.44%)
3. I am more confident that I can succeed in technology-related science careers.	1 (2.22%)		0	3 (6.67%)	4 (8.89%)	7 (15.56%)	9 (20.00%)	21 (46.67%)
4. I feel more confident that technology-related scientific career for me is a possibility.	3 (6.67%)		3 (6.67%)	2 (4.44%)	4 (8.89%)	6 (13.33%)	13 (28.89)	14 (31.11%)
5. I am more confident that I can learn college science courses that use technology.	1 (2.22%)		0	3 (6.67%)	2 (4.44%)	9 (20.00%)	11 (24.44%)	19 (42.22%)
Average	1.40 (3.11%)		1.00 (2.22%)	2.00 (4.44%)	4.00 (8.89%)	6.20 (13.78%)	12.20 (27.11%)	18.20 (40.44%)

Considering the first item, 82% of the students reported that they felt more self-confident in *learning* science using technology; however, 7% of the students expressed that their TITiC project work did not improve their self-confident in *learning* science with technology in an acceptable positive direction. The second item of the survey

indicated that 82% of the students were more self-confident in *doing* science with technology, but 9% of the students did not see any important changes in their self-confidence in *doing* science with technology. Results of the following two items in the survey indicated that 78% of the students reported positive changes in their self-confidence in *a technology-related scientific career*, while, on the average, 4% of the students stated that there was no change, and 3% and 5% of students reported a little and some changes, respectively, in their self-confidence in *a technology-related scientific career*. The last item of the survey dealing with students' self-confidence in learning college science courses that use technology showed that 87% of the students were more self-confident to be able to pursue college science courses that use technology. In contrast, only four students expressed that their TITiC project work did not increase their self-confidence in *learning (or pursuing)* college science courses that use technology in an acceptable positive level. These improvements in the students' self-confidence in science revealed from the results of Likert survey after they conducted long-term scientific research with Information Technologies were also supported by evidence from students' responses to the open-ended questions "*With examples describe how your confidence in science with technology has changed as a result of the TITiC Project.*" Excerpts illustrating the change in students' self-confidence in science are provided below:

My confidence in science and technology had increased a great deal in working on this project. I used tests and programs that I had never used before so it was a bit of a challenge. In doing the turbidity test I learned the different approaches that must be taken. You don't always get perfect results the first time.

I am more confident in my capabilities to study and use science technology. For example, I can use LabPro's quite easily.

In this class we used different types of probes, and learning how to use these probes makes me feel like I will be able to excel with science technology better now than before.

When I go to college and we use some of the equipment that we used in this class, I will feel like I have an upper hand.

My confidence has changed significantly since the TiTiC project because I had the courage to try and test my ideas and hypothesis' in a project, and then present them in front of professors and other students. It was a complete success and now I realize I have the possibly of pursuing a career in science.

I have become more comfortable with using technology to learn from this project. The GIS program has helped me to realize this and to have more patience. I feel much more comfortable about combining science and technology than I did and am looking forward to doing more of these types of projects.

I feel more confident now in other areas of science because I know how to use tools for labs and other applications on the computer.

Students are confident in using information technologies in science for several reasons: *I used tests and programs that I had never used before. My teacher really showed us how to get used to them and learned how to use them. I can use LabPro's quite easily. We used different types of probes, and learning how to use these probes makes me feel like I will be able to excel with science technology better now than before. When I go to college and we use some of the equipment that we used in this class, I will feel like I have an upper hand. Using probes and spectrs (spectrophotometer) helped me feel more confident that my results were more accurate. I can understand the equipment better so i can understand the results. I don't feel like I am going to mess everything up. The courage to try and test my ideas and hypothesis' in a project, and then present them in front of professors and other students. It was a complete success. Working with tools that students are not used to. Little help has helped them learn the tools. How to use tools*

in laboratory work .Use applications in the computer. Using the GIS in the TITiC project. Results on students' attitudes toward, perceptions of, and confidence in science is enlightening. Affective dispositions were cultivated in students because they were fully immersed in long term research projects in authentic settings. Such dispositions are precursors for learning and achievement in science. It is these dispositions that enable students to pursue advanced studies in and careers in science.

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