The Effects of Teaching Style on Creativity

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Abstract: In an attempt to associate student creativity and the use of interactive software, an action research project was designed and implemented in an elementary school. The action research compared the effect of using two types of instruction, Discovery Learning and Direct Teacher Instruction, when teaching 5th grade students to use MicroWorlds software in order to create a multimedia presentation. Creativity assessment instruments were used to measure creativity levels of participants both pre-project and post-project. Projects themselves were also evaluated. Of the 36 gifted fifth graders who participated, there were thirteen in the Discovery Group, fourteen in the Direct-Instruction Group, and nine in a group who had no exposure to MicroWorlds software. The presentations of the Direct-Instruction Group were judged by the researcher and two other gifted education teachers to be more creative than the other two groups; however, the instruments employed to compare students' overall creative ability at the beginning and the end of the project did not show significant change despite the instructional style. Unexpected findings exclusively related to the Discovery Group included an increase in learner confidence, growth in learner independence, and a heightened sense of enjoyment related to discovering how to operate the software.

Introduction

The topic of creative ability and its development and enhancement is of importance to me due to the intense focus on academic knowledge and skills in the regular classroom and the subsequent exclusion of attention to creative expression. I am a Gifted Education teacher who works primarily with fifth grade students; consequently, I need to address the standards for Gifted Education that relate to creativity. Several years ago in my dual quest to do this and to expose my students to challenging technology, our school purchased a site license for MicroWorlds (MW). MW software uses the computer language LOGO. Through the use of LOGO programming language, students are immersed in the world of a turtle and guided through complex mathematical concepts (Papert, 1980). The MicroWorlds program takes the same LOGO mathematical concepts and encourages students to exercise their creativity in the production of visual/graphical presentations. Creativity, which is measured according to the four domains of originality, flexibility, fluency and elaboration, has been shown to be nurtured effectively through technology when that technology is used to promote higher level and critical thinking (Riley & Brown, 1998; Snider, 1995). One advantage of using technology to enhance creativity is evident in students who are capable of complex thought processes but have difficulty in the physical processes of getting them down on paper (Bracey, 1999). Furthermore, studies (Gerlic & Jausovec, 1999; Penuel & Yarnall, 2000) confirm that multimedia-based presentations require learners to employ visualization strategies like mental imagery, which are key for certain forms of problem solving, discovery and creativity.

Geoffrey Jones (1990) in his article *Personal Computers Help Gifted Students Work Smart*, writes that "computers are idea engines" (p. 2). He notes that computer simulations and particularly LOGO computer language "provide platforms for students to invent their own syntax, integrate knowledge, and share ideas. All students in gifted and talented programs should be introduced to such computer applications and programming" (p. 3). Similarly, Clements (1991) states that research shows children in LOGO environments are more apt to engage in self-directed exploration than students who are not exposed to this medium. Using technology to promote creative interaction between the gifted student and the assignment helps to ensure higher-level thinking.

Multimedia production software provides an effective environment for the expression of creativity and organization. Seymour Papert (1980), in his landmark work, *Mindstorms Children, Computers, and Powerful Ideas*, opened a whole new avenue of problem solving and constructivist learning to children. Papert's vision of the interaction between computers and children is not compatible with traditional computer-aided instruction, which he believes is simply the computer "programming" the child. In his landmark work, he envisioned the child programming the computer and at the same time forming associations and thought processes that are of the highest order. By designing the child-friendly LOGO programming language, Papert provided a tool that can enable children to delve into meta-cognition and higher order thinking unknowingly as they attempt to get the turtle to perform the moves they desire it to perform. His vision of student interaction with LOGO aligns with a constructivist approach to learning theory, which Fisher (2000) substantiates with his belief that children acquire concepts and exhibit real learning through exploration, such as in a discovery type of learning environment

In years past, I primarily used direct-instruction when working with students using the MicroWorlds software. As I explored research on Constructivist Learning, I found that several studies supported my belief that a balance between total reliance on students designing their own learning and teachers guiding the students provides the most ideal educational setting. It was noted that some structure must be provided by a teacher in order for students to avoid losing a sense of direction for their learning (Cohen, 1997; Ravaglia & Sommer, 2000; Ravaglia, Suppes, Stillinger, & Alper, 1995; Van Deur, 1996).

In a study by Ennis (1994), it was found that students who received instruction on problem solving methods in addition to instruction on programming were better able to problem solve than students who only received instruction on programming. This inspired me to wonder if the use of discovery learning to develop programming skills in MW would impact the creativity of students. In turn, I also wondered if using direct instruction to teach students the mechanics of MicroWorlds would influence their creativity. Participants in Ennis' study who received instruction on problem solving demonstrated more creativity with LOGO programming than did participants who had not received problem-solving instruction. The same students also interacted with each other more productively and applied detailed solutions more globally to programming tasks than did the participants who received only programming instruction.

My interest in Ennis' study led me to question if there might be a parallel between receiving instruction related to problem solving and receiving instruction related to programming. Without direct-instruction for MW procedures, would students be preoccupied with the mechanics of the software to the detriment of creative expression, or would they discover facets of the program specific to their needs, which might have been omitted during direct-instruction? Would they interact with each other more because they had to use each other as resources?

Purpose of the Study

The purpose of this project was to compare creative productions of gifted students who received direct instruction for MicroWorlds with those who were instructed to discover its workings on their own. The independent variable was the method of instruction used to teach the LOGO programming language.
The dependent variable was perceived levels of creativity of fifth grade students.

Research Questions

1. Is creativity enhanced through exposure to MicroWorlds?
2. How does method of instruction relate to student creativity in MicroWorlds?
3. Are there differences in the way students interact with the MicroWorlds software if they were taught Microworlds via discovery learning as opposed to teacher-directed instruction? What types of differences are there?

Method

Participants

The elementary school in which the action research was conducted is located in a suburb of a large Southeastern city with an enrollment of approximately 800 students. I am one of three Gifted Program teachers at the school and work with fifth grade and kindergarten students.

The participants in my research consisted of 36 gifted fifth graders, 19 girls and 17 boys. Twenty-six of the participants were Caucasian, 5 Asian, and 5 Middle Eastern. They were from five different regular education classrooms and were placed in their respective classrooms based on an attempt to balance 5th grade classes in regard to gender, ability, and diversity. I grouped them in three separate groups for gifted instruction based on scheduling needs. Figure 1, below, will explain the groups.

Group Name	Number Of students	Pre and Post Williams Scale	Pre and Post Self Perception	Instruction On Creativity	Interaction With MicroWorlds	Direct instruction On MicroWorlds	Project Score
Discovery	13	X	X	X	X		X
Direct-Instruction	14	X	X	X	X	X	X
Non-Intervention	9	X	X	X			

Figure 1: X's indicate that a group was exposed to the labeled intervention.

Procedure

Prior to any intervention, a permission form was sent home informing parents of the nature of the research, guaranteeing anonymity of all participants, clarifying that students' participation would not affect their grades, and seeking the guardian's permission for the student to participate in the action research.

Both the Discovery and the Direct-Instruction groups received the assignment of incorporating the theme of change into a multimedia presentation that included specified parameters. The parameters included the need to make a story with a beginning, middle and end that could be demonstrated using a title page and a minimum of four other pages. Each page was to have a button to progress to the next page, complete with a transition, and animation of at least one figure on each page. Each class brainstormed, as a group, topics relating to the theme. Students were encouraged to take notes. Multiple facets of creativity -fluency, flexibility, originality, and elaboration- were discussed with all of the students. The basic assignment sheet, the rubric that was used to evaluate the presentation, and a planning/note-taking sheet were given to students in the Discovery and Direct-Instruction groups as handouts. We discussed the specifics of the project so that everyone would be clear on what the assigned task was and how it would be measured.

The Discovery group was told that they were to be "fearless explorers" of the software, MicroWorlds. Students were shown a variety of resources, including a Users Guide, a Project Manual, and several internet sites that offered lessons in the use of LOGO. Students were also shown projects that had been previously created using MicroWorlds. All of these resources could be used to help them achieve the assigned task. They were also encouraged to serve as resources for each other. I was only there to observe and record their behavior. If a student asked me what they should do in a situation my response was, "What resource might help you find the answer to that question?"

In the Direct-Instruction group, I presented eight step-by-step lessons on the MicroWorlds software. The students were required to demonstrate competence by performing the task while I observed. Upon competent demonstration of the tasks by all students, the group was instructed to begin work on the project. When students had questions or problems with programming, I helped them work through the problems by either serving as a resource myself or helping them find the appropriate resource to answer the question.

The nine students in the Non-Intervention group did not interact with MicroWorlds during this time. However, the creativity measures used on the Discovery and Direct-Instruction groups prior to and following the intervention, were also used to measure the students in the Non-Intervention group at the same points in time. This was done in an attempt to see if there was a fluctuation in creative ability that was not associated with interaction with MicroWorlds.

Measures

Creativity is a nebulous concept that I believe is very difficult to measure. However, as it is one of the four areas evaluated in placement of students in the Gifted Program, evaluation tools have been produced that attempt to do just that (Georgia Department of Education, 2001). In Georgia, the Williams Scale, a nationally normed creativity assessment, is used to measure creativity levels of students and place them in the Gifted Program. The instrument is completed by students' teachers and therefore reveals teacher perceptions of student creativity levels. For the participants in this study, both the Gifted Program teacher who worked with the students last year and I completed an assessment instrument for each student at the beginning and the end of the project. The students were asked to complete a pre and post-intervention Self-Perception of Creativity inventory, based on a researcher-constructed questionnaire. The questionnaire was intended to collect data related to traits exhibited by creative individuals and was based on knowledge gained from a recent review of the literature (Schaefer, 1991; Torrance & Safter, 1999) as well as from my experience working with gifted students for the past ten years. Before distribution, the questionnaire was evaluated and edited by three experienced gifted program teachers.

After accumulating pre-project data, the six-week intervention was implemented. Observations were made by the researcher during the intervention and recorded both on video and in a journal. These observations provided some of the most valuable information gained throughout the project.

Three Gifted Program teachers, two others and myself, evaluated the final MicroWorlds presentations of the 27 members of the Discovery and Direct-Instruction Groups using a teacher-made rubric that evaluated four domains of creativity; fluency, flexibility, originality, and elaboration. The rubric was designed to evaluate these creative domains as evidenced by the images, programming, backgrounds, and storyline of the students' MicroWorlds final projects. A scale of 1 to 4 was used to assess product components where 1 was assigned if the component was not at all present in the product, 2 if it was somewhat present, 3 if it was a good bit present, and 4 if it was present very many times. Students had been given a copy of the rubric prior to creation of their presentation. The rubric scores of the three evaluators were averaged together to ensure as much objectivity as possible. At the completion of the intervention, I interviewed the students regarding their perception of the experiences they had with MicroWorlds and any effect the experiences may have had on their thinking.

Data Analysis

As was suspected at the outset of this research, more value was found in the qualitative data than in the quantitative data. However, statistical analysis was performed on results from the rubrics and testing instruments used throughout the project and will be summarized in order to better describe the relation of the findings to the research questions.

Quantitative Data

Quantitative data was gathered using the Williams Scale, a Self-Perception Questionnaire, and a Product Evaluation Rubric. Measures of central tendency were examined for each instrument and the significance level was set at .05 for *t* tests.

Williams Scale. The pre-project and post-project scores on the Williams Scale were analyzed using a paired samples *t* test for each of the following four facets of creativity: fluency, flexibility, originality and elaboration. Scores from Teacher One and Teacher Two were averaged to create a single student score for each student across the four separate creativity components on the Williams Scale. An overall creativity score was also assigned to each student as a result of averaging teacher ratings. Results shown in Tables 1, 2 and 3 indicate no significant change in pre and post-intervention scores for any group.

Table 1: Williams Scale Data for the Discovery Group

	Discovery Group						
Creativity	Pre-Intervention			Post-Intervention		2-tailed	Significance
Domains	Mean	SD	n	Mean	SD	P value	question
Fluency	6.03	2.83	13	6.53	2.63	0.46	No
Flexibility	6.30	3.01	13	6.50	2.89	0.79	No
Originality	5.64	2.41	13	6.00	2.34	0.67	No
Elaboration	5.99	3.29	13	5.84	3.32	0.32	No
Overall score	22.96	9.68	13	24.88	9.91	0.48	No

Table 2: Williams Scale Data for the Direct-Instruction Group

Creativity Domains	Discovery Group: Pre-Intervention Mean	Pre-Intervention SD	n	Post-Intervention Mean	Post-Intervention SD	2-tailed P value	Significance question
Fluency	7.29	3.36	13	8.53	2.62	0.52	No
Flexibility	8.25	3.69	13	8.64	2.59	0.69	No
Originality	8.32	3.49	13	8.17	2.63	0.88	No
Elaboration	7.67	3.08	13	7.78	2.83	0.89	No
Overall score	32.17	12.99	13	33.14	10.04	0.78	No

Table 3: Williams Scale Data for the Non-Intervention Group

Creativity Domains	Discovery Group: Pre-Intervention Mean	Pre-Intervention SD	n	Post-Intervention Mean	Post-Intervention SD	2-tailed P value	Significance question
Fluency	6.05	2.00	9	6.38	1.38	0.72	No
Flexibility	6.00	2.73	9	6.38	2.02	0.72	No
Originality	5.50	2.33	9	6.50	1.41	0.34	No
Elaboration	4.61	2.13	9	6.00	2.37	0.10	No
Overall score	22.05	8.40	9	24.61	5.86	0.46	No

Self-Perception Questionnaire. Results shown in Table 4 of pre and post-intervention scores on the Self Perception Questionnaire for the Discovery Group indicate that no significant changes in the students' perception of their creativity occurred. There was actually a drop in perceived originality for the Discovery Group; however it was not within a statistically significant level. Table 5 shows a significant decrease in the Flexibility for the Direct-Instruction Group on the Self Perception Questionnaire from pre to post-intervention evaluations. A t of 2.3858 was obtained, with 13 degrees of freedom. Table 6 shows the results of the Non-Intervention Group's Self Perception Questionnaire. This group experienced a significant decrease in scores in the domain of Fluency. A t of 3.0509 was obtained, with eight degrees of freedom.

Table 4: Self Perception Data for the Discovery Group

Creativity Domains	Discovery Group: Pre-Intervention Mean	Pre-Intervention SD	n	Post-Intervention Mean	Post-Intervention SD	2-tailed P value	Significance question
Fluency	9.23	1.09	13	8.77	1.17	0.19	No
Flexibility	5.77	1.36	13	6.31	1.55	0.25	No
Originality	9.38	1.56	13	8.69	1.65	0.06	No-not quite
Elaboration	9.54	1.33	13	9.46	1.33	0.72	No
Overall score	34.00	3.72	13	33.23	2.89	0.38	No

Table 5: Self Perception Data for the Direct-Instruction Group

	Discovery Group						
Creativity	Pre-Intervention			Post-Intervention		2-tailed	Significance
Domains	Mean	SD	n	Mean	SD	P value	question
Fluency	8.50	0.76	13	8.79	0.89	0.34	No
Flexibility	5.86	1.41	13	5.21	1.25	0.03	Yes
Originality	9.50	1.61	13	9.64	1.22	0.75	No
Elaboration	9.57	1.74	13	9.93	1.27	0.49	No
Overall score	33.43	2.44	13	33.57	2.38	0.86	No

Table 6: Self Perception Data for the Non-Intervention Group

	Discovery Group						
Creativity	Pre-Intervention			Post-Intervention		2-tailed	Significance
Domains	Mean	SD	n	Mean	SD	P value	question
Fluency	10.00	1.00	9	8.78	1.64	0.02	Yes
Flexibility	6.56	0.88	9	7.22	1.20	0.22	No
Originality	9.67	2.00	9	9.22	1.30	0.38	No
Elaboration	10.22	0.83	9	9.67	1.66	0.42	No
Overall score	36.44	2.74	9	34.89	4.37	0.13	No

Project Data. The project scores for both the Discovery and Direct-Instruction Groups were analyzed using a paired samples *t* test for four facets of creativity: fluency, flexibility, originality and elaboration. Results shown in Table 7 indicate that the Direct-Instruction Groups' scores in the domains of Fluency and Flexibility were near a statistically higher level than that of the Discovery Group though not quite. The Direct-Instruction Group's scores in the domain of Originality were statistically higher than that of the Discovery Group. The mean score in the domain of Originality was 7.00 (sd = 1.83) for the Discovery Group and 8.93 (sd = 2.43) for the Direct-Instruction Group. A *t* of 2.8405 was obtained, with 12 degrees of freedom. The overall scores on the project were found to be significantly higher for the Direct-Instruction Group with a mean of 25.21 (sd = 4.68). The Discovery Group had a mean of 21.08 (sd = 5.71) on their overall project scores. A *t* of 2.4597 was obtained, with 12 degrees of freedom.

Table 7: Project Scores for Discovery Group as compared to Direct-Instruction Group

Creativity	Discovery			Direct-Instruction			2-tailed	Significance
Domains	Mean	SD	n	Mean	SD	n	P value	question
Fluency	2.31	0.95	13	2.86	.53	14	0.07	No - Not quite
Flexibility	4.92	1.80	13	5.93	1.21	14	0.07	No - Not quite
Originality	7.00	1.83	13	8.93	2.43	14	0.02	Yes
Elaboration	6.85	1.82	13	7.50	1,20	14	0.13	No
Overall score	21.08	5.71	13	25.21	4.68	14	0.03	Yes

Qualitative Data

Through my thirty-six hours of observation (eighteen for each group), four themes emerged.

1. Methods students used to interact with each other.
2. Methods students used to interact with me, the teacher.
3. Methods students used to interact with the software.
4. Attempts students made to address the assignment creatively.

Interacting with each other. At the beginning of the intervention, there was very little interaction between students in either group (two pairs of students interacting with each other for short spans of time in the Discovery Group and three students working next to each other and "visiting" with each other in the Direct-Instruction Group who interacted intermittently during class time). During week two, I asked students in the Discovery Group to display the thing they were most excited about having discovered concerning MicroWorlds programming. I then asked that they share with others the steps taken to achieve whatever programming example they were displaying. Eight of the thirteen students complied; displaying, questioning, and explaining. Five actually got up and walked around but did not ask for or offer help. As they became more comfortable with the software and with their lack of expertise in this area, they were better able to point each other to a particular resource that was available to solve a programming problem or simply ask another student how to perform whatever task they could not perform. Three of the five who were hesitant to interact with others in the situation described above eventually began to interact with other students in their quest to complete their presentations. Two students kept to themselves, neither asking for nor receiving help throughout the six-week intervention period.

Students in the Direct-Instruction Group exhibited very limited interaction with each other. Only after the eight lessons on MicroWorlds had been taught and students were working on their presentations, did they seek help from one another, and then it occurred only if I was busy helping another student. Occasionally (less than three occurrences per class period) the girls would discover a clip art image they were excited about, or program a turtle to perform a "cool" trick, and they would show a friend. They had not been encouraged to teach each other what they learned, which may account for the fact that they stayed in their seats and programmed the entire class time. They tended to interact only with students on either side of them.

Interacting with the Teacher. The second theme that emerged was the ways in which the students interacted with me, the teacher. In the Discovery Group three of the thirteen students would ask for my help even though they knew that I would not give it to them other than to remind them to consult their numerous resources (Help Menu, Users Guide, Project Guide, and websites I had provided). The other ten students only showed me programming feats they were particularly proud of and did not seek my help.

In the Direct-Instruction Group, the majority of the students asked for my help before they attempted to solve their own programming problems, or occasionally they asked another student. Only when no one was available to help them did students turn to the resources for assistance.

Interacting with the Software. The third theme involved the ways in which the students interacted with the software. During the first two weeks of the intervention half of the Discovery Group reacted negatively. Signs of frustration included heavy sighs, rubbing of foreheads, scowling, grunting and comments such as, "This is too hard!" and " Can't you just tell me how to do this?!?" As they began building on their knowledge and experiencing success, ten of the thirteen approached the assignment with energy and enthusiasm as exhibited by pleasant facial expressions, the "Yes" hand gesture, showing a neighboring student a newly acquired skill, and comments such as "Cool!!! I figured it out!" and "Hey! Check this out! I got it!". The other three appeared to maintain high levels of frustration and continued to seek my help. The majority of the students sat at the same computer next to the same students during each session and developed camaraderie with those in close proximity. Upon viewing the final presentations, the Gifted Education teachers who had not been in the room during the intervention, identified with a high degree of accuracy students who sat next to each other to complete their project work.

The majority of the students in the Direct-Instruction Group made comments that indicated their enjoyment of the experience. Upon entering my classroom eleven of the fourteen requested that we go to the lab, which is where the intervention occurred. They also made comments such as "This is fun!" and "I want to get this for my house!" Four students requested permission to work on their presentations during their recess time. Two girls exhibited some frustration at not being able to either find a clip art image that matched their theme or not being able to alter it in the way they envisioned. Three boys used the Help Menu to discover complex programming that was more sophisticated than what was taught during the instruction. Two girls and two boys were particularly adept at manipulating or creating images to enhance their presentations. They took what I had taught them to do and discovered ways to diversify and enrich their knowledge.

Project Creativity. The last theme noted was that of student attempts to address the assignment creatively. As a group, participants in the Discovery Group had significantly lower scores on the presentation rubric (which measured creativity), than the Direct-Instruction Group. I think that this occurred because they focused more on learning the intricacies of the software than they did on expressing themselves creatively. Even though they had been given the rubric and we had discussed that their presentations would be evaluated based on the level of creativity, the primary focus for the majority of the students in the Discovery Group was learning the required steps to operate MicroWorlds in order to complete the required components of the assignment. Based on the interviews conducted after the intervention it appeared that the majority of their energy that might have been devoted to creative thought was directed in the quest for conquering the software. Though I tried to allot the Discovery Group time to discover the programming patterns of MicroWorlds and then plenty of time to address the assignment creatively, they did not appear able to separate the two processes and creativity took a back seat.

The Direct-Instruction Group had the luxury of being “spoon-fed” the steps to programming with MicroWorlds and consequently were able to devote their energy and thoughts to expressing themselves in a more creative way in their presentations. They seemed to have a more pleasurable, low-key time during each session than did the Discovery Group, but the Discovery Group made more comments that displayed excitement over a discovery or an accomplishment.

Interestingly, during post-intervention interviews, ten in the Discovery Group and four in the Direct-Instruction Group stated that they preferred or would have preferred discovering MicroWorlds on their own. This was somewhat surprising in that, as noted above, frustration was apparent approximately one third of the time for the students in the Discovery Group. When asked to explain why they would prefer that style of learning environment, the following reasons were given: “It was like an adventure.” “ I got more confident when I learned that I could solve things on my own.” “ It’s boring for a teacher to tell you everything.” “It’s different from the way we are used to doing things in school.” When asked if they thought that their experience had changed anything about them, one girl stated that she felt like she would be better at solving problems in other settings, all by herself. Two others stated similar boosts in perceived ability to solve problems independently.

Three of the students in the Discovery Group and ten in the Direct-Instruction Group stated that they preferred or would have preferred to have the teacher teach them the software step- by-step. When asked to explain, the following reasons were given: “It would’ve been too hard to figure out.” “I couldn’t have done what I had planned to do without being taught how to do MicroWorlds.” “I’m lazy and didn’t want to have to figure it out on my own.” “ I didn’t want to have to read and try to find out how to do what I wanted to do.”

Discussion

This action research was conducted to determine if student creativity was affected by teaching style. The first research question posed was in relation to creativity and its possible enhancement through exposure to MicroWorlds. Since no significant increase was measured in either teacher perception of creativity or students’ own perception of their creativity in any of the three groups, no conclusive results were obtained.

The second research question sought to answer the way in which the method of instruction related to student creativity in MicroWorlds. The students in the Direct-Instruction Group were shown to have significantly higher scores on their MicroWorlds presentation than did the students in the Discovery Group. Given that experiences other than teaching style were the same for both groups, one would believe that teaching style did impact the level of creativity in the presentation.

The third research question concerned the differences in the ways students who were taught via discovery learning as opposed to teacher-directed instruction interacted with MicroWorlds. Observations showed that students in the Discovery Group were more likely to exhibit energy in their interaction with MicroWorlds. This energy was in the form of frustration when they were unable to solve programming problems and excitement when they were successful. The Direct-Instruction Group approached MicroWorlds in a more moderate fashion. These students exhibited less of the behaviors associated with extreme frustration or success.

What I set out to discover ended up being of less importance to me as a teacher than an inadvertent finding of this project. Measurable creative ability was not enhanced through exposure to MicroWorlds. This does not decrease this software’s value to the Gifted Program. Now I recognize MicroWorlds as a valuable tool that can enhance students learning experiences in ways that surpass my previously singular focus on creative expression. Although the Direct-Instruction Group did score significantly higher on the creativity of their presentations than did the Discovery Group, the independence and confidence in problem solving ability that the latter group exhibited and commented on in their interviews were much more far-reaching and valuable to me as an educator. Although I want to continue working to develop creative abilities in my students, I find it more important that I help them develop confidence in their abilities to solve their own problems. I will alter my teaching style to accommodate many more opportunities for my students to exercise their independence and guide their own learning in the MicroWorlds environment. Finding other learning situations that might be conducive to discovery learning would be a great subject for further research.

References

Bracey, B. (1999, December). Sharing the gift. *Technology and Learning, 20* (5) Retrieved June 19, 2001 from the World Wide Web: http://www.techlearning.com/content/about/archives/volume20/archives_v20.htm

Clements, D. H. (1991, Spring). Enhancement of creativity in computer environments. *American Educational Research Journal, 28,* 173-187.

Cohen, V. L. (1997, Summer). Learning styles in a technology-rich environment. *Journal of Research on Computing in Education, 29*. Retrieved June 18, 2001 from Wilson Web: http://wilsontxt.hwwilson.com/pdffull/02166/MHDZV/TSG.pdf

Ennis, D. (1994). Combining problem-solving instruction and programming instruction to increase the problem-solving ability of High School Students. *Journal of Research on Computing in Education. 26* (4).

Fisher, A. (2000). Natural Genius. *Popular Science. 256* (1). Retrieved October 21, 2001 From Academic Search Premier.

Georgia Department of Education, (2001). Gifted education. Retrieved August 10, 2001 from the World Wide Web: http://www.doe.k12.ga.us/sla/gifted/faq.html

Gerlic, I., & Jausovec, N. (1999). Multimedia: differences in cognitive processes observed with eeg. *Educational Technology Research and Development, 47* (3). Retrieved June 18, 2001.from Wilson Web: http://wilsontxt.hwwilson.com/pdffull/03447/KNW2R/3SX.pdf

Jones, G. (1990). Personal computers help gifted students work smart. *ERIC EC Digest* #E483. Retrieved June 17, 2001 from ERIC: http://www.kidsource.com/kidsource/content/pc.gifted.html

Papert, S. (1980). *Mindstorms children, computers, and powerful ideas*. New York, NY: Basic Books, Inc.

Penuel, B., & Yarnall, L. (2000). Do technology investments pay off? The evidence is in! *Leadership, 30* (1). Retrieved November 15, 2001 from Academic Search Premier:http://pluto.gsu.edu:80/cgi-bin/door/homepage.cgi?_id=d0d6bc06-1056960857-0781&_cc=1

Ravaglia, R., & Sommer, R. (2000, January). Expanding the curriculum with distance learning. *Principal, 79* (3). Retrieved June 18, 2001 from Wilson Web: http://wilsontxt.hwwilson.com/pdffull/01129/LOZAA/4ST.pdf

Ravaglia, R., Suppes, P., Stillinger, C., & Alper, T. (1995 Winter). Computer-based mathematics and physics for gifted students. *Gifted Child Quarterly, 39* (1). Retrieved June 20, 2001 from the World Wide Web:http://www-epgy.stanford.edu/Other/Research/gifted.pdf

Riley, T. L., & Brown, M. E. (1998, September/October). The magic of multimedia: Creating leaders of yesterday, today and tomorrow. *Gifted Child Today Magazine, 21* (5). Retrieved June 18, 2001 from Wilson Web: http://wilsontxt.hwwilson.com/pdffull/04914/M9GH7/7SU.pdf

Schaefer, C.E., (1991). Creativity Attitude Survey. Jacksonville, Illinois: Psychology and Educators, Inc. Retrieved July 21, 2001 from the World Wide Web: http://www.indiana.edu/~bobweb/Handout/create.doc.

Snider, S. (1995). Odyssey of developing creativity with computers: Speeding train or brick wall? *Texas Woman's University*. Retrieved June 18, 2001 from the World Wide Web:http://www.coe.uh.edu/insite/elec_pub/html1995/1313.htm

Torrance, E. P., & Safter, T., (1999). *Making The Creative Leap Beyond…*Buffalo, New York: Creative Education Foundation Press.

Van Deur, P. (1996, April). *Gifted reasoning and advanced intelligence*. Retrieved June 20, 2001 from The World Wide Web:http://www.nexus.edu.au/teachstud/gat/vandeur.htm