The Influence of STL Teaching on Students' Creativity

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Abstract

This research attempted to determine the influence of STL (Scientific and Technological Literacy) teaching on ninth-grade students' creativity. Science teachers taught an eight-week STL teaching module, while they were involved in an eight-month in-service course during the school-year 2001/2002. The experimental group consisted of 18 voluntary science teachers and their 236 ninth-grade students, and the control group was formed from 13 teachers and their 211 students. A test of discrepant situations, taken from an instrument package of the Iowa Chautauqua project, was used to assess students' creativity and consisted of three parts: asking questions, guessing causes, and predicting consequences. According to the pre-test, the average results of creativity were highest on the scale of asking questions and lowest on the scale of suggesting causes, while a comparison of male and female students' creativity indicated that the female students had significantly higher achievement on all scales of creativity. The post-test showed the experimental group made significant gains, with female students gaining higher results.

Key words: creativity, STL teaching, teaching intervention.

INTRODUCTION

In science education, an increasing attention is being drawn to the importance of fostering students' higher-order thinking and problem-solving skills. With this focus, a number of articles have been published on a STL philosophy and its applicability to the teaching of science (Holbrook, 1996, 1998; Holbrook & Rannikmäe, 2000). Although the concept of scientific literacy is widely accepted, it is still poorly defined. STL can be taken to mean "developing the ability to creatively utilise sound science knowledge in everyday life to solve problems, make decisions, and hence improve the quality of life" (Holbrook & Rannikmäe, 1997), or "the ability to acquire scientific knowledge and to comprehend, apply, and evaluate that" (Lutz, 2002). If these represent the target, then STL within formal schooling can be defined as "that science education, which is intended within the school curriculum to maximise its role in aiding students to acquire the goals of general education, as stipulated by society within a country" (Holbrook & Rannikmäe, 2000). The effectiveness of STL teaching has been measured in terms of promoting students' problem solving and decision making skills, motivation to learn, and teachers' ownership (Rannikmäe, 2001a; Rannikmäe, 2001b). Laius (2003) has tried to evaluate the effectiveness of STL teaching by focusing on the attitudinal domain, using instruments from the Iowa Chautauqua project (Yager, 1999). The outcomes of the study showed improvement in the learning environment and its positive influence on students' attitudes towards science (Rannikmäe & Laius, 2003). These results correlate with those of the Iowa Chautauqua project (Kimble, 1999; Yager & Weld, 1999).

Of many different thinking skills required by students following a science and technology curriculum, creative thinking skills are considered valuable and essential (Howard-Jones, 2002). From the scientific perspective, creativity is nowadays widely defined as *the production of relevant and effective novelty* (Amabile, Collins, Conti, Phillips, Picariello, Ruscio, & Whitney, 1996; Cropley, 2001; James, Clark, & Cropanzano, 1999; Smith & White, 2001). Creativity involves departure from existing facts and methods to finding new ways, inventing answers, and seeing unexpected solutions. Genuine creativity, however, requires a further element over and above mere novelty. An idea, a product, or a response must be relevant to the issue at stake, must offer some kind of genuine solution, and it must be effective (Cropley, 1999).

Nurturing the attitudes and traits that characterise creative people can also serve to promote creativity in young children. For example, the traits of original thinking, curiosity, asking questions, independence and risk taking, being thorough, open minded, being attracted to fantasy, complexity and novelty, perceptiveness and intuitiveness, and, above all, ethical thinking and behaviour can be nurtured in children at all stages of development. The challenge lies in how to do it. The ideas presented so far show that it is possible to nurture creativity by providing a conducive environment that can be organised within the school science education in a variety of ways. In the ultimate analysis, what is important is not to overload students with information, but to teach them how to get hold of it, make sense of, and process it in order to be engaged creatively with their existing reality, in the nowadays society where the creativity has become a life-skill (Garg & Garg, 2001).

Individual studies have explored a wide range of different correlates to creativity, such as personality characteristics (Alter, 2001), age (Haslett, 1998), gender (Hill, 2000; Simpson, 1999), attitude and leader influences (Williams, 1999), achievement and school grade (Alrwais, 2000), leader and social power (Medina, 1999), group interactive brainstorming (Park-Gates, 2001), etc. The current paper focused on the influence of STL teaching on students' creativity.

METHODOLOGY

The research was carried out during the 2001/2002 school-year. Physics, Chemistry, and Biology teachers and their ninth-grade students in different Estonian schools participated in the study. In September 2001, a questionnaire surveying the learning environment (CLES) was sent to 250 randomly chosen Estonian schools from the database of the Estonian Ministry of Education, with a request to be completed by all science teachers of the ninth-grade. Three hundred and thirty Physics, Chemistry, and Biology teachers responded. To form the experimental group of teachers, invitations were sent to ninth-grade teachers in 15 randomly chosen Estonian schools (from CLES sample) to take part in a STL teaching in-service course. To this invitation 18 teachers, from 9 schools, responded and these were enrolled on an eight-month STL teaching intervention study. The content and time schedule of the 8-month STL teaching intervention are illustrated in Table 1. Every subsequent workshop was planned based on the results and analysis of the previous seminar, and after-workshop involvements. During the intervention, the teachers engaged their 236 students in an eight-week STL teaching module.

Among the schools, from which three different science teachers had responded to the CLES questionnaire, 10 schools were chosen, according to a similar mean response to the questionnaire against the experimental group of teachers. Teachers in these schools were asked to participate in this study. Thirteen volunteer teachers from 8 schools responded and formed, with their 211 students, the control group for the study.

Students from both the experimental and control group carried out a pre- and post-test on creativity, and, in each case, a three-activity exercise, based on a discrepant situation, was used. The following discrepant situation was created to be universal for different science subjects: *"Imagine the situation on the Earth if Mankind had not invented paper."* In the first activity, the students had to ask questions about the discrepant situation. In the second activity, they were asked to suggest causes, and, in the third activity, the students were asked to predict consequences related to the discrepant situation. The total number of pertinent questions, causes, and consequences were counted, and the average calculated for each activity and also for the whole (irrelevant responses, which did not relate to the situation described, were not counted) (Enger & Yager, 1998).

The pre- and post-test results were scored, and the changes in teachers' and students' mean test results were computed. The t-test, controlled by the Wilcoxon signed rank test (Gall, Borg, & Gall, 1996) was used to determine statistically significant differences in the results. Standard deviations were given to indicate the distribution of mean results.

RESULTS

The students' creativity was measured on three scales as shown below. According to the pre-test, the average results of creativity were highest on

Table 1

Time Schedule and Contents of STL Teaching Intervention In-service

Time	Contents of workshops	After-workshop involvement	Methods of data collection
Oct. 2001	1. Introduction of intervention in-service; 2. The introduction of STL philosophy.	Pre-testing of students' creativity.	1. Administering the tests of students' creativity.
Nov. 2001	1. Discussion of pre-test outcomes; 2. Critical analysis and modification of goals; 3. Combining the teams of schools for collaborative work and discussing the possible integrative themes in science subjects for STL module; 4. The introduction of the structure of STL teaching materials.	Determining the themes for collaborative STL teaching module.	1. Recording the discussion of teachers' team-work; 2. Analysis of teams' written reports for future planning.
Dec. 2001	1. Comments and analyses of previous workshop, based on teachers' team-work reports; 2. Discussion in collaborative groups and developing an integral scenario for STL module; 3. Introducing the exemplary scenarios of STL teaching.	Developing a team-based scenario for the STL teaching module.	1. Recording the discussion of teachers' team-work; 2. Analysis of team-based scenarios.
Jan. 2002	1. Analyses and introduction of the team-based developed scenarios of schools; 2. Choosing the theme and scenarios and planning the 8-week STL teaching module.	Accomplishing the structure of the collaborative STL teaching module of schools.	1. Recording the discussion of teachers' team-work.
Feb., March 2002	1. The learner-centred methods of teaching within STL approach and creating teaching consequence maps; 2. The survey of possible ways of changing creativity within STL teaching; 3. The survey of possible ways of changing attitudes toward science within STL teaching.	An 8-week STL teaching module in the 9th grade science classes (at least in two science subjects, but not more than 4 lessons per week).	1. Analysis of teaching consequence maps created by teachers; 2. Teachers' written reports of STL teaching module.
April 2002	1. The discussion and analysis of the 8-week STL teaching module.	Post-testing the students' creativity.	1. Administering the tests of students' creativity.
May 2002	1. Evaluating the in-service courses; 2. Making final conclusions of the experiences about STL collaborative teaching.	Improving and disseminating the STL ideas in science classes.	1. Recording the discussion of teachers.

the scale of asking questions, and the lowest on the scale of suggesting causes. In a comparison of the male and female students' creativity, the results indicate that the female students had significantly higher results on all scales of creativity (Figure 1).

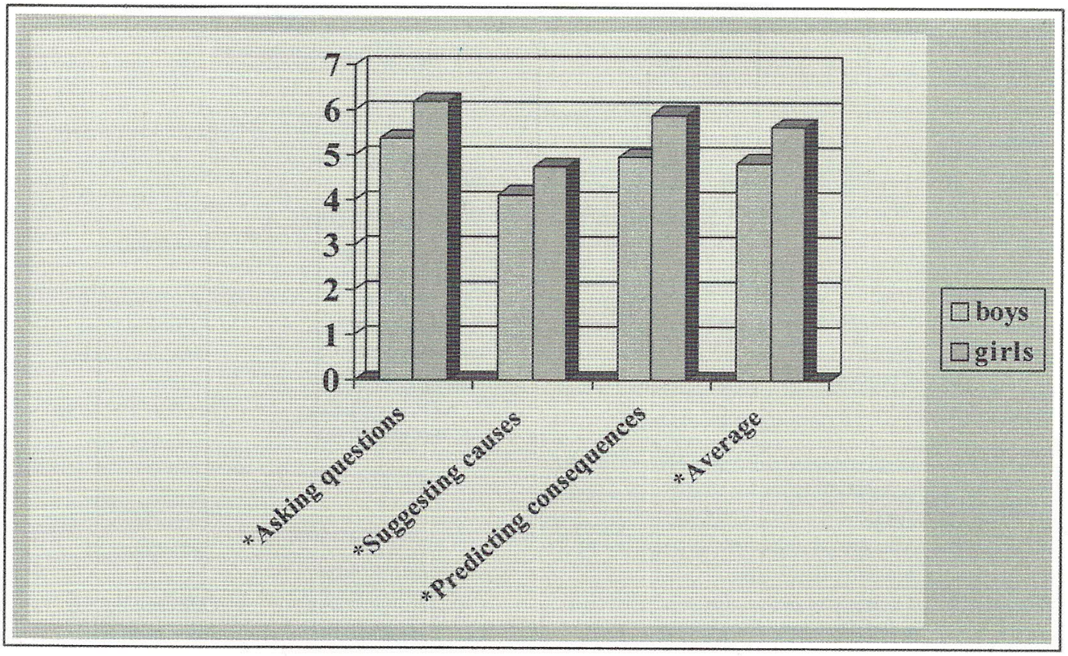

Figure 1. Creativity of the Ninth-grade Students (pre-test)

* p<0.05

During the intervention period of the eight-week STL teaching module, significant positive changes occurred in the mean creativity of students on all scales of creativity. The lowest mean increase of creativity appeared on the scale of suggesting causes, but there was a significant improvement (Table 2).

Table 3 indicates that the mean creativity test results of the control teachers' students were higher than those of experimental teachers' stu-

Table 2

Creativity Change of Students of Experimental Teachers

Scale of creativity	**Students of experimental group** **Pre-test** **Mean (SD)**	**Students of experimental group** **Post-test** **Mean (SD)**	**Difference in means** N=236	**t-test** **p**
Asking questions	**5.42** (3.06)	**7.38** (3.50)	**1.96**	**<0.001****
Suggesting causes	**3.94** (2.61)	**4.62** (2.95)	**0.68**	**0.01***
Predicting consequences	**4.88** (3.39)	**6.41** (3.45)	**1.53**	**<0.001****
Average	***4.75*** *(2.32)*	***6.13*** *(2.58)*	***1.38***	**<0.001****

Table 3
Change of control Students' creativity in the Ninth Grade

Scale of creativity	Students of control group Pre-test Mean (SD)	Students of control group Post-test Mean (SD)	Difference in means N=211	t-test p
Asking questions	**6.18** (3.56)	**6.40** (3.94)	0.22	0.53
Suggesting causes	**4.97** (3.41)	**4.87** (3.19)	-0.10	0.75
Predicting consequences	**6.04** (4.52)	**6.33** (4.73)	0.29	0.51
Average	***5.73 (3.33)***	***5.86 (3.50)***	*0.13*	0.68

dents. However, there were no significant changes in the mean creativity of the students of the control group during the intervention period. A comparison of the creativity of the male and female students in the experimental group, showed that the mean creativity of female students, according to the pre-tests (Table 4), was significantly higher on all scales of measuring than the mean of male creativity. After the intervention study, the post-tests indicate that the significant differences of mean creativity had disappeared on the scale of suggesting causes. During the experimental period, statistically significant positive changes occurred in the means of all cre-

Table 4
Comparison of experimental teachers' male and female students' creativity

Scale of creativity	Pre-test Mean (SD)		t-test p	Post-test Mean (SD)		t-test p
	Male	Female		Male	Female	
Asking questions	**4.85** (3.11)	**5.89** (2.92)	**0.01***	**6.24** (2.74)	**8.30** (3.78)	**<0.001****
Suggesting causes	**3.56** (2.37)	**4.24** (2.76)	**0.048***	**4.27** (2.60)	**4.90** (3.18)	**0.11**
Predicting consequences	**4.26** (2.60)	**5.38** (3.85)	**0.01***	**5.77** (2.64)	**6.92** (3.93)	**0.01***
Average	***4.22*** *(2.05)*	***5.17*** *(2.44)*	**<0.001****	***5.43*** *(2.02)*	***6.70*** *(2.84)*	**<0.001****

* p<0.05, ** p<0.01

ativity scales of male students, but the means of female students' creativity showed a significant increase only on the scales of asking questions and predicting consequences. Thus, the lowest increase in means occurred on the scale of suggesting causes, especially with female students.

DISCUSSION AND CONCLUSIONS

The overall creativity of students increased significantly during the eight-week STL teaching module, and on every different scale of creativity measured. The most significant increase appeared on the scale of *asking questions* (both with male and female students). It seems that the STL teaching approach was most effective in encouraging the students to ask different questions about the discrepant situations and increase the number of predicted consequences. The least increase was related to the ability to suggest causes, which is quite similar to the process of problem solving, in which the hardest situation is for the students to recognise a problem (Park-Gates, 2001; Haslett, 1998). Remarkable differences occurred in the creativity of male and female students. The average creativity of female students was significantly higher in the pre-test on every scale of creativity. According to the post-test, the female students still achieved significantly higher results on scales of *asking questions and predicting consequences,* but on the most difficult scale, *suggesting causes*, the difference between the male and female students' creativity had diminished. The STL teaching in-service intervention was clearly an effective tool with significant impact. The positive change of teachers during the 8-month STL teaching intervention had a positive effect on the student's creativity.

Student's creative abilities also increased in the STL teaching environment and this encouraged divergent thinking, measured in terms of forming questions (part of measuring creativity). The study showed that student's skills of compiling all types of questions increased, together with identifying meaningful causes and consequences that are essential components of divergent thinking. As there were no significant changes over the study period within the control group of teachers and students, it is suggested that the STL teaching was an effective tool for nurturing students' creativity.

The current study had some limitations because the teachers involved in the study were motivated volunteers from all science teachers in Estonia. They tended to represent the more dedicated teachers, who were ready to perceive and adopt new approaches and philosophies of teaching science subjects. Also the students involved in the study were taught by the target teachers and, thus, were not representative of all students in Estonia.

In conclusion, the STL teaching in-service intervention was an effective tool with significant positive impact both on teachers and their students. The STL philosophy used in this study could be introduced to science teachers as a means of increasing the relevance of science subjects from the students' point of view. According to the current research, the running of STL teaching modules can serve as an effective tool in improving students' creativity and divergent thinking, especially the ability of asking questions and predicting consequences, which are essential components of problem-solving (one of the goals for scientific literacy). For this reason, it seems very important to encourage teachers to allow their students to form as many suppositions as possible about all scientific situations dealt with in science classes. This points to a democratic and student-centred learning environment that should be created by teachers.

Future research directions include finding out the interaction between teachers' and students' creativity. Other desirable areas for future inquiry include the use of multilevel analysis on the structure of Estonian students' creativeness, and the most effective means of improving creativity in the course of science studies, using the STL teaching approach, the relationships between Estonian students' personal and social skills, and their cultural and ethnic background, comparing Estonian students' status in attitudinal and creativity domains of science education with those of students from other countries, where analogous instruments have been used for assessing attitudes and creativity.

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