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THE INFLUENCE OF STL TEACHING AND SCIENCE TEACHERS' TEAMWORK ON CHANGE OF STUDENTS' CREATIVITY

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Abstract. *For any paradigm change, and certainly for reflecting on STL (scientific and technological literacy) ideas, it is essential for teachers to be involved in professional development. One form of professional development that was used to promote STL teaching was to guide teachers, through workshops, to create their own teaching materials, based on the STL philosophy. The current research was carried out during the 2002 school year with teachers of science subjects and their 9th grade students in different Estonian schools. The experimental schools were divided into three groups (3 schools per each): in Group 1, one teacher participated, in Group 2 two teachers participated and in Group 3 three teachers participated in the courses and taught the same students, at the same time, in different science classes.*
The experimental teachers enrolled in the 8-month STL teaching intervention study and in the course of that their students were exposed to an 8-week STL teaching module. The results of creativity tests, undertaken before and after the intervention study, showed, that the students' creativity mean changes during the 8-week STL teaching module, depended upon the number of teachers. Of importance is that the collaboration of two or three teachers can significantly more increase the creativity f students – a further aim of the STL teaching approach.
Key words: *STL teaching, collaboration of teachers, creativity.*

Introduction

Schools generally undervalue creativity. Perhaps teachers think creativity is no different from general intelligence or that schooling cannot or should not value creativity. The fact is, that teaching in a way that encourages and rewards creativity, can improve school performance (Sternberg, 2003). Practically every curriculum guide asks teachers to promote creativity in every subject area. It is believed that the proper way to teach creativity is through the content areas - reading, math, science etc. Science especially gives teachers ways to combine creativity and critical thinking (Helgeson, 1998). That is why in science education an increasing amount of attention is being drawn to the importance of fostering students' higher-order thinking and problem solving skills. 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. It involves departure from existing facts and methods, finding new ways, inventing answers and seeing unexpected solutions. Genuine creativity requires a further element over and above mere novelty: an idea, a product or a response must be relevant to the issue at stake and must offer some kind of genuine solution, it must be effective (Cropley, 1999).
For any paradigm change, and certainly for reflecting on STL (scientific and technological literacy) ideas, it is essential for teachers to be involved in professional development (Gallagher, 1997). STL is 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).

In recent research on professional development, researchers have been criticizing ''traditional'' approaches and advocating for newer, more collaborative models (Simmons et al., 2000). One form of professional development that was used to promote STL teaching was to guide teachers, through workshops, to create their own teaching materials, based on the STL philosophy. This approach was utilised in regional workshops around the world (Holbrook, 2003). Many of the characteristics of scientific and technological literacy require considerable intellectual freedom if they are to be achieved. Intellectual freedom requires a safe and motivating environment where the student feels comfortable suggesting possibilities, asking questions without fear of humiliation and of initiating actions to test personal ideas (UNESCO, 2001). The ideas presented so far suggest it is possible to nurture creativity by providing a conducive environment that could be organised within science education in school 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 it and process it in order to engage creatively with their existing reality in the nowadays society where the creativity has become a life-skill (Garg, Garg, 2001).

Collaboration is essential for not only reducing the isolation of teachers, and for enhancing individual teacher's professional growth, but also for the impact it can have on students. Participants on the in-service course reported that the team-based approach, used in the course had a positive impact. For the individuals, it appears the process increased their knowledge of teaching, altered their philosophy, improved their teaching, and increased connections with other educators (Huffman, Kalnin, 2003). Collaborative support from research and professional teams is seen also to be critical as teachers begin to incorporate new approaches in their teaching. It seems teachers need ample time and support for reflection, interactions with other teachers, and further learning opportunities. At the same time, teachers, as well as students, need to be challenged to become skilful thinkers and problem-solvers; and for this to work together within groups and teams; be creative; communicate effectively; apply what they learn to authentic needs within their own practices; and be flexible and adaptable to changes and discoveries (Davis, 2003).

The ***aim*** of the present research was to find out the relationships between the teachers' teamwork during the STL in-service courses and the change of students' creativity.

Methodology

Sample

The current research was carried out in 2002 with teachers of science subjects and their 9th grade students in different Estonian schools. 18 volunteer teachers from 9 schools formed the experimental group for this study. 13 volunteer teachers from 8 schools formed the control group for the study. The sample of students was formed from those taught by the experimental and control teachers; in total 447 students (composed of 236 students of experimental group teachers and 211 students of control group teachers).

The experimental schools were divided into three groups (3 schools per each): in Group 1, one teacher participated, in Group 2 two teachers participated and in Group 3 three teachers participated in the courses and taught the same students, at the same time, in different science classes.

The experimental teachers enrolled in the 8-month STL teaching intervention study and in the course of that their students were exposed to an 8-week STL teaching module. Before the STL in-service courses of STL teaching and after the 8-week teaching module all students carried out pre- and post-tests of creativity.

Instruments

The instrument for assessing the creativity of students was selected from the Instrument Package & User's Guide (1997) of the Iowa Chautauqua Program (ICP), a teacher in-service project. Assessment of Discrepant Events (pre- and post-test) — a three activity exercise, based on described discrepant situations for students to assess their creativity. In the first activity (5 minutes), as many questions as possible should be asked about the discrepant situation. In the second and third activities (both 5 minutes), the causes should be suggested and consequences should be predicted about the discrepant situations, accordingly. Scoring in this section refers to creative strength of students. The total number of pertinent questions, causes and consequences is counted and the average is calculated for each activity and for the whole (the irrelevant responses that do not relate to the situation described, are not counted) (Enger, Yager, 1998). 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*".

For current study the test of discrepant situations was chosen to assess creativity because of its close relationship to divergent thinking and problem solving.

Results and discussion

The students' creativity was investigated through the discrepant situation "*Imagine the situation on the Earth if Mankind had not invented paper*", using three scales as shown in Table 1. The average results were highest on the scale of *Asking questions* and the lowest on the scale of *Suggesting causes.* The pre-test data indicate that there were not significant differences of students' creativity within the three experimental groups.

Table 1. Creativity of students in the 9-th grade (pre-test).

Scale of creativity	Students of Group 1 Mean (SD) N=65	Students of Group 2 Mean (SD) N=85	T-test p (Gr.1/Gr.2)	Students of Group 3 Mean (SD) N=86	T-test p (Gr.2/Gr.3)
Asking questions	6.46 (3.28)	5.38 (3.05)	0.78	5.78 (2.70)	0.25
Suggesting causes	3.54 (2.89)	3.51 (2.03)	0.69	3.62 (2.80)	0.43
Predicting consequences	4.11 (2.83)	4.15 (2.24)	0.16	4.18 (2.23)	0.21
Total	13.53 (5.82)	13.05 (5.49)	0.23	13.57 (5.24)	0.37
Average	*4.70 (2.35)*	*4.35 (1.83)*	*0.19*	*4.57 (2.66)*	*0.15*

A comparison of the creativity of male and female students in all experimental groups shows that the mean creativity of female students, according to the pre-tests (Table 2), was higher on all scales of measuring than the mean of male students' creativity.

Table 2. Comparison of male and female students' creativity (pre-test)

Scale of creativity	Group 1 Mean (SD)		Group 2 Mean (SD)		Group 3 Mean (SD)	
	Male	Female	Male	Female	Male	Female
Asking questions	6.00 (3.46)	6.84* (3.13)	5.05 (3.27)	5.65* (2.87)	5.84 (3.34)	6.50* (2.76)
Suggesting causes	3.27 (2.27)	3.77* (3.33)	3.13 (2.12)	3.83* (1.91)	3.22 (2.59)	3.94* (2.94)

Scale of creativity	**Group 1 Mean (SD)**		**Group 2 Mean (SD)**		**Group 3 Mean (SD)**	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
Predicting consequences	3.62 (2.43)	4.52* (3.10)	3.68 (1.97)	4.54* (2.38)	3.60 (2.98)	4.73* (2.94)
Total	12.38 (6.08)	14.48* (6.16)	11.87 (5.71)	14.02* (5.17)	12.35 (6.27)	14.17* (5.80)
Average	*4.29 (2.23)*	*5.04* (2.43)*	*3.96 (1.90)*	*4.67* (1.72)*	*4.45 (2.09)*	*5.12* (2.93)*

* Significant difference at the 0.05 level of confidence

During the intervention period of the 8-week STL teaching module, significant positive changes occurred in the mean creativity of students on all scales of creativity within all experimental groups. During the same time period, there were no significant changes in the mean creativity of the students of the control group.

The mean changes of students' creativity differed within the three experimental groups, depending on the number of teachers collaboratively participating in the schools' teamwork.
Figure 1 illustrates the mean changes of three experimental groups of students' creativity: the lowest mean change occurred among the students of Group 1, where only one teacher was involved in the study. The mean changes within Group 2 and Group 3, with two or three teachers involved, were significantly higher than in Group 1.

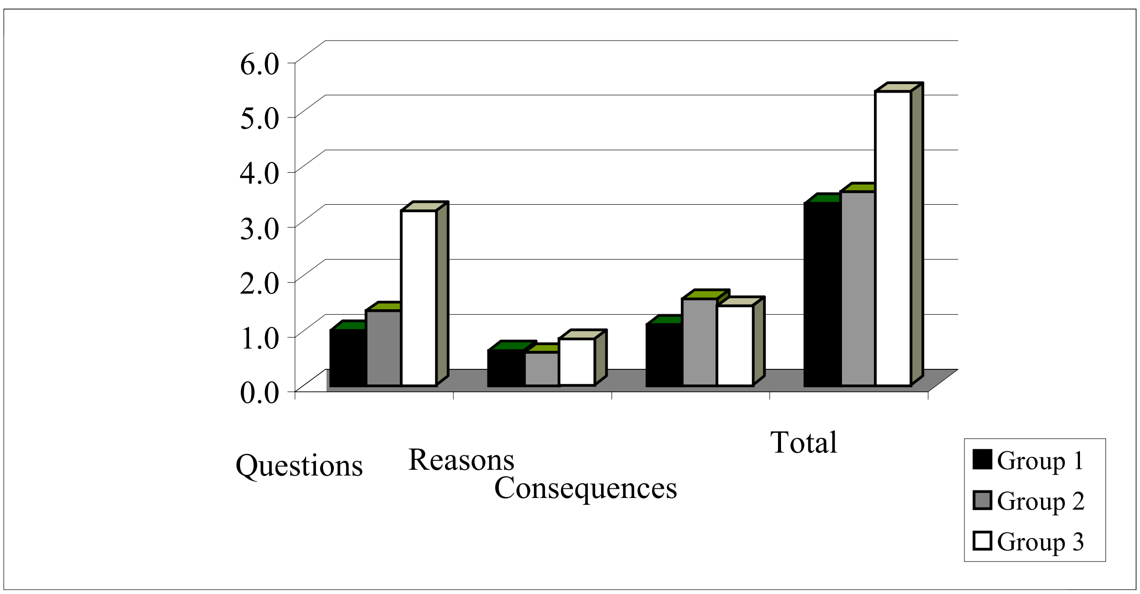

Figure 1. The differences in means of students' creativity within experimental groups.

Figure 2 illustrates the mean changes in the creativity of male and female students of the experimental teachers. According to the pre-test, the means of the male students are lower than those of the female students, but the significant positive changes in the means are more obvious with the resulted of creativity of male students on all scales during the experimental period. The means of female students' creativity shows a significant increase on the scales *of Asking questions* and

Predicting consequences. The lowest increase in means occurs on the scale of *Suggesting causes,* especially with female students.

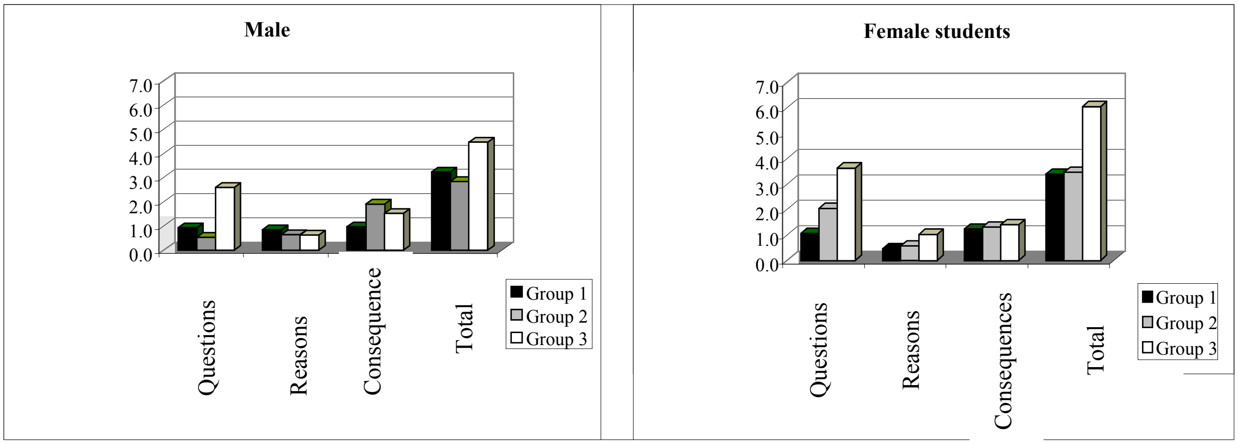

Figure 2. The differences in means of male and female students' creativity.

The results of creativity tests, undertaken during the intervention study, showed, that the least students' mean change occurred with one teacher being involved in the 8-week STL teaching module, although the teacher taught two or three science subjects at the same time. In particular, the weakest influence of one teacher on students' creativity mean change appeared on scales of guessing reasons and the biggest effect occurred on the scale of predicting consequences. Two teachers, working as a collaborative team, affected the students more significantly. The influence of two teachers on their students' mean change was also the biggest on scale of predicting consequences and the weakest on the scale of guessing reasons. In case of three teachers, involved in teaching, the most significant influence occurred on the scale of asking questions and the weakest again on the scale of guessing reasons. Thus, as a result of the STL teaching, the students became more creative in asking questions, guessing reasons and predicting consequences. Of importance is that the collaboration of two or three teachers can significantly increase the creativity of students – a further aim of the STL teaching approach (Davis, 2003; UNESCO-CASTME, 2001). This outcome is in agreement with several researchers who have reported a positive influence of teachers' collaboration (Davis, 2003; Shachar, Shmuelevitz, 1997).

It can be claimed that teamwork by teachers had a greater impact on their students than the single teacher working alone teaching several science subjects. It is worth adding that the students, taught by three teachers, underwent the highest change of creativity on the scale of asking questions, whereas the students, taught by one or two teachers, underwent the largest mean changes on the scale of predicting consequences. At the same time, the students of all experimental groups had the weakest increase on the scale of guessing reasons, insuring? suggesting the fact, that reasoning is the most difficult skill to improve and this 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).

Conclusions

The STL teaching in-service intervention was clearly an effective tool with significant impact. There was a consistent positive change of teacher's understanding and ownership of STL teaching philosophy.

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.

The female students demonstrated larger increases in creative abilities, especially on the scale of asking questions.

As there were no significant changes over the study period within the control group of teachers and students, this showed that the STL teaching was an effective tool for nurturing students' creativity.

The impact of the STL teaching intervention and the obtaining of teachers' ownership of the STL philosophy turned out to be significantly higher in collaborative team-work of different science teachers of the school. The impact of supportive colleagues gave the teachers the continuing and long-lasting willingness to adopt the new methods of teaching.

This research revealed that the impact of several teachers, teaching different science subjects, was significantly higher on their students than the influence of one teacher, teaching several science subjects in the same class. This showed that in order to obtain the ultimate positive effect, integrative team-work of all science teachers of the school was necessary to improve their students' personal skills such as creativity.

Limitations of the Study

The teachers involved in this study were motivated volunteers and cannot represent all science teachers in Estonia. They represented the more dedicated teachers who were ready to perceive and adopt new approaches and philosophies of teaching science subjects.

The students involved in the study were taught by the target teachers and thus were representative against these teachers, but not against all students in Estonia. But compared to control students, the positive change tendencies were obvious, drawing attention to the practices of teachers who were using a new approach in teaching science subjects.

The current study was evidently limited by the availability of motivated teachers to participate in the in-service courses, develop STL materials and carry out the STL teaching module. Mostly because of the lack of free time, the number of experimental teachers was comparatively low. The number of control teachers was therefore low also.

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Резюме

ВЛИЯНИЕ ОБУЧЕНИЯ ЕНТГ (ЕСТЕСТВЕННОНАУЧНАЯ И ТЕХНОЛОГИЧЕСКАЯ ГРАМОТНОСТЬ) И СОТРУДНИЧЕСТВА УЧИТЕЛЕЙ ЕСТЕСТВЕННЫХ НАУК НА КРЕАТИВНОСТЬ УЧЕНИКОВ

Анне Лайус, Мийа Ранникмае

Для всякого изменения парадигмы, особенно, что касается идеи ЕНТГ (естественнонаучная и технологическая грамотность), окажется важнейшим для учителей повышение их профессиональности. Одной эффективной формой использованной в развитии учителей оказались семинары, базированные на ЕНТГ философии, в течении которых учителя сами готовили учебные материалы. Данное исследование проведено в 2002 году в 31 школе Эстонии на уроках естественных наук (биология, химия, физика). В исследовании приняло участие 447 учащихся 9-ых классов (из них 18 учителей и 236 учеников в экспериментальной группе и 13 учителей и 211 учеников в контрольной группе). Экспериментальные школы были разделены в три группы: Группа 1 - школы (3), где один учитель учил все три предметы естественных наук (биологию, химию, физику) в одном классе; Группа 2 - школы (3), где два учителя учили два предмета естественных наук (биологию, химию или физику) в одном классе; Группа 3 - школы (3), где три учителя учили по одному предмету естественных наук (биологию, химию или физику) в одном классе. Учителя экспериментальной группы участвовали в 8-месячных курсах повышения профессиональности по методике ЕНТГ и затем учили своих учеников в течение 8 недель по методу ЕНТГ, используя приготовленные учебные материалы. Перед и после эксперимента измерили креативность всех учеников, используя для этого тест несходной ситуации, где задача для учеников была задавать как можно больше вопросов, угадать причин и предсказывать последствие об этой ситуации.

Исследование показало, что повышение креативности учеников зависит от количества учителей, которые участвовали в учение этих учеников во время эксперимента. Самое низкое повышение креативности учеников установлена при ситуации, когда работал один учитель. Самое высокое было повышение креативности учеников при ситуации, когда работали три учителя естественных наук одновременно (каждый преподовал свой предмет). В итоге оказалось, что совместное сотрудничество учителей естественных наук является очень эффективным явлением для повышения креативности учеников. Исследование показало, что у учеников контрольной группы результаты тестов креативности не изменились (статистически значимых различий не установлено). Следовательно, метод ЕНТГ является тоже эффективным способом повышения креативности учеников.

Ключевые слова: естественнонаучное и технологическое образование, сотрудничество учителей, творчество.

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