Longitudinal Teacher Training Impact on Students' Attributes of Scientific Literacy

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Abstract

This study examines the impact of science teachers' STL (scientific and technological literacy) longitudinal training course on their 9th grade students' enhancement in their scientific literacy. Twelve science teachers (eight chemistry and four biology teachers) participated in two consecutive intervention studies, each running for 8 months, both designed to guide teachers on promoting students' scientific and technological literacy through raising the levels of scientific creativity and socio-scientific reasoning of their students. During the training courses, the teachers exhibited their learning by creating teaching materials for 4 integrative teaching modules and these were used in teaching their students using the designed STL teaching modules. The in-service resulted in remarkable teachers' professional change exhibited within 4 categories: content-oriented teaching, interdisciplinarity, pedagogical competence and confidence in socio-scientific teaching. The students' development was determined in terms of scientific creativity and socio-scientific reasoning skills, as indicators of scientific literacy gains, with an initial pre-test before and a post-test after the STL intervention. The results of the study revealed that the teachers' teaching level in promoting problem solving and decision making and its impact on student gains, as well as the number of teachers collaborating together in the teaching within a school, had a significant impact on their students' improvement in skills associated with socio-scientific reasoning and scientific creativity. Gender issues and knowledge in chemistry and biology had less influence on students' creativity and reasoning skills.

Keywords: scientific and technological literacy, socio-scientific reasoning, scientific creativity

1. Introduction

Enhancement of STL (scientific and technological literacy) is the major goal of science education, where STL is taken to mean the need to develop the ability to utilise sound science knowledge creatively in everyday life by solving problems and making reasoned decisions, involving value judgements and communication skills (Rannikmäe *et al.*,2010). In this definition the creative utilisation of science knowledge is highlighted pointing to the importance of students' creativity (Laius *et al.*, 2008). Creativity, in the sense of creative (divergent) thinking, is currently receiving increased attention in education; more and more school curricula now mention it, but the increased interest in creativity has occurred without reference to any value framework (Kaufman, 2006; Craft, 2006). The problem however, is how to get teachers prepared to improve students' creativity in their everyday work in the classroom and to assist their own development in this area.

Accepting that the conception of creativity is very broad, it is meaningful to focus research on scientific creativity. The definition of "scientific creativity" can be conceptualized as individual and social capacities for solving complex scientific and technical problems in an innovative and productive way (Banks Gregerson*et al*., 2013;Heller, 2007). In this article, as the research focus is science education, the term "creativity" is used, hereafter, in this more narrow meaning of scientific creativity.

While noting that the majority of students will neither become scientists nor need to have an in-depth knowledge of the way scientists work, nevertheless scientific creativity remains an important educational goal. Chang and Chiub (2008) refer to a number of researchers who consider the goal of science education to be not only learning specific scientific knowledge, but also developing skills of scientific thinking and skills of argumentation that play an important role in high-level brain-storming, such as critical reasoning, creative thinking, and problem solving.

The most powerful long-range predictors of professional success in science and technology are apparently domain specific problem solving abilities and problem solving which requires the production of innovative solutions. Such approaches to scientific problem solving also refer to the importance of students' scientific creativity (Casakin, 2008).

According to Zeidler*et al*. (2007), students' socio-scientific decision making is connected to reasoning. This is because students have to reflect on issues in order to evaluate claims, analyse evidence, and consider the variety of viewpoints regarding ethical issues and judgments on scientific topics through social interaction and discourse. This is the essence of the reasoning process. Decision making almost certainly involves students in analysing evidence and it is thus no surprise that it is considered important for students to learn how to interpret and evaluate evidence when making decisions and to present justified arguments that support their positions. No matter from which source people obtain their information, an important skill in handling information is to know how to disentangle opinions and interpretations from facts. The challenge for educators of future citizens is, therefore, to improve students' creative thinking skills so that they can analyse evidence that may be uncertain, or conflicting. That means using reasoning and argumentation (DeHaan, 2009; Maloney, 2007).

The problem solving and decision making skills in turn require students to develop the skills of reasoning and argumentation. Reasoning refers to the cognitive and affective processes involved in the negotiation of complex issues and the formation or adoption of positions. In addition, there is general agreement that the nature and development of scientific reasoning plays a central role in acquiring scientific literacy (Lee *et al*., 2012; Brown *et al.*, 2010; Lawson, 2004). Argumentation refers to the verbal expression of reasoning. The problem with this distinction lies in the fact that the constructs are practically indistinguishable from an empirical perspective. Some of the interest in argumentation stems from the need to teach students reasoning skills (Nussbaum, 2008).

Argumentation is the means by which researchers gain access to reasoning, but this must be done with some trepidation. While it is valid to assert that strong argumentation reveals strong informal reasoning, the opposite claim, weak argumentation denotes weak informal reasoning, is not necessarily the case (Sadler & Zeidler, 2005). Reasoning is a central component of cognition that depends on theories of comprehension, memory, learning, visual perception, planning, problem solving, and decision making (Dawson & Venville, 2009; Holvikivi, 2007). But, it is transmitted through communication, which means that promoting strong communication skills of students is recognised as import in written, oral and symbolic forms. According to sociological and philosophical studies of science, science educators have begun to view argumentation as a central scientific skill, which students need develop (Erduran *et al*., 2006; Sandoval & Millwood, 2005). According to the study of Coffin and O'Halloran (2008), argumentation skills can enhance an individual's democratic participation in the contemporary society. Research shows, however, that only if argumentation is specifically and explicitly addressed in the curriculum, students have the opportunity to explore its use in science (Simon & Johnson, 2008). Decision making almost certainly involves people in analysing evidence. In short, effective argumentation skills are central to sound decision making at a variety of different levels and argumentation may be important for learning scientific content as well (Maloney, 2007).

Fostering the above mentioned skills of students that enable them to become scientifically literate is needed. Already Piaget declared that the main purpose of education is not creating individuals who can repeat the same things characterizing their generation, but creating creative and innovative individuals who are capable of doing something new. The second purpose of education is to encourage creative brains which can make criticisms, investigate the accuracy of findings, and a person who will not accept everything he or she has been taught.

Quite often teaching is an isolating profession. It is ironic that new teachers enter the profession because they like to work with people. Instead of collaborating with other teachers and working together as a team to help educate students, many new teachers end up alone in their classroom feeling a sense of isolation (Sandholtz & Dadlez, 2000). Numerous studies have shown that teachers have very little time during the day to work with other teachers, plan lessons as a team, or even talk with their colleagues. It is the many authors' belief that we must increase collaboration in our schools. Collaboration is essential for not only reducing the isolation of the profession, and for enhancing individual teacher's professional growth, but also for the impact it can have on schools and students. Participants in the seminar reported that the team-based approach to in-service courses had an impact on both individual teachers and on the schools. For the individuals, it appears the process increased their knowledge of teaching, altered their philosophy, improved their teaching, and increased connections with other educators (Suntisukwongchote, 2006; Huffman & Kalnin, 2003).

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). In recent research on professional development, researchers have been criticizing "traditional" approaches and advocating for newer, more collaborative models (Williams *et al*., 2009; Hanley *et al*., 2008). 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 (Rannikmäe, 2001; Laius, 2011).

The main goal of this research was to investigate the effectiveness of the STL in-service courses in changing the teachers' professionalism and increasing their students' scientific creativity and socio-scientific reasoning skills. According to this goal the following research questions were put forward:

1) How does the longitudinal teacher training in-service course impact on students' scientific creativity and socio-scientific reasoning skills?
2) How does teachers' integrative teamwork influence students' scientific literacy components?

2. Methodology of Research

The phenomenographical methodology in this longitudinal study used for studying teachers concluded following activities: (1) The chemistry and biology teachers' 8-months in-service training courses "*The up-to-date trends in molecular and medical biology*"; (2) The chemistry and biology teachers' 8-months in-service training courses "*The development of students' creative and critical thinking skills through real-life situations in science classes*"; (3) Four workshops for teachers and the collaborative construction of STL teaching materials, including various educational technologies; (4) Four seminars of teachers for analysing the results of the first STL teaching modules.

The sample for the current research was formed from 248 ninth grade students in 8 different Estonian primary and secondary schools. The schools were chosen based on 12 science teachers (8 chemistry and 4 biology) from 30 teachers who had participated in before mentioned integrative in-service courses "*Modern trends in molecular biology and biomedicine*" and who voluntarily continued in the science teachers' in-service course "*The Development of Students' Critical and Creative Thinking Skills through Real-life Socio-scientific Situations*" in the following school year. All teachers in both studies were educated during Soviet times as single subject teachers.

By requiring students to undertake all pre- and post-tests, the number of students was reduced to 224 students when forming the final sample for longitudinal analysis. This approximately 10% dropout was not taken to adversely affect the demography of the sample.

2.1. Methodology for Studying Teachers

Data were collected from all teachers using: (a) pre- and post-questionnaires for teachers; (b) semi-structured interviews conducted before and after the intervention; (c) through analysis of teacher created teaching materials and lessons given, and (d) a-year-after delayed questionnaire and semi-structured interviews for teachers.

The study focused on promoting teachers' skills to foster students' scientific creativity and reasoning skills through using socio-scientific issues. For this an interdisciplinary background was seen as important factor. This is because, during the intervention, teachers would be better placed to understand teaching materials taken from everyday life, where the man-made divisions of science are not reality. Eight teachers (4 chemistry and 4 biology teachers) formed four school-based teams, working in pairs, while four chemistry teachers participated as individuals. The in-service course included four 2-day sessions. Supplementary teaching materials, each designed for 2–3 lessons (module) were introduced to teachers, although later they were guided to develop their own. Teachers were asked to assess student's socio-scientific reasoning skills and scientific creativity during every module. The interview outcomes were analysed, using a phenomenographical approach, to determine categories of change in teachers' views and understanding related to new teaching philosophy, methods and teaching materials. Categories were validated by four independent experts (Laius *et al*., 2009).

2.2. Methodology for studying students – the following instruments were used to investigate the levels of changes of students' skills during the STL intervention:

1) Scientific creativity test – to assess the students' creative thinking skills, a scientific creativity test developed by Hu and Adey (2002) was translated into Estonian and administered with 30 teachers and their 298 students during the first in-service year, analysed and modified into5-item test that was piloted again by 61 9th grade students.

The test was slightly modified (two items were dropped because they either lacked relevance to the Estonian curriculum or to students as determined by the results of 2005 pilot test, where most of students refused to solve these tasks as too unfamiliar because design is not taught as a subject in Estonian schools). The items in the test were scored and then standardized to five hierarchical levels (according to test score ranking) to make them comparable to the results of other test results of study.

2) Socio-scientific reasoning (argumentation) test–included two comparable real-life situations, with ties to both social and scientific issues, were compiled and piloted. The science teachers (14) validated these instruments during the in-service course. 619thgradestudents, in one randomly chosen secondary school, piloted the instrument. According to statistical analysis the results were not statistically different and this was taken to mean that the two tests were comparable. That in turn allowed them to be used as pre- and post-tests before and after the use of the 8-week STL teaching modules for students at a time when the socio-scientific teaching materials were used.

3) Biology and chemistry tests for students–were conducted to determine the students' levels of knowledge, both consisting of 4 factual, 8 conceptual and 4 analytical questions in the line of TIMSS test questions.

2.3. Data analysis–the research data obtained as a result of standardisation or categorisation was ordinal in character and to develop descriptive statistics (means and standard deviations) as well as undertake non-parametric tests. All data were analysed and figures created using the SPSS 18.0 statistical analysis program.

2.4. Validity and reliability – in this research, teachers' and students' questionnaires, interviews and observations of study materials were used as measuring instruments. All such instruments cannot be precise. Thus the validity and reliability of the instruments and the methodology must be carefully examined. The criteria for teacher categorisation were validated by the expert opinion method and triangulation was used in data collection between the interviews, questionnaires and created teaching materials permitted the validity and reliability of the research to be determined. In compiling the sample the following aspects were considered: (1) All the chemistry and biology teachers had graduated from University of Tartu; (2) None of the teachers were the authors of the published instructional materials; (3) All of the teachers had worked as chemistry or biology teachers for more than 5 years; (4) None of the teachers had taken part in prior training related social issue-based learning; and (5) All students involved in the study came from the 9thgrade, thus all of them had taken the same subjects from the same curriculum.

3. Results of Research

3.1. Change in the Professional Level of Teachers

The change of teachers' professional level (Table 1), measured in four hierarchical categories as an outcome of the longitudinal, collaborative in-service courses relates to 12 chemistry and biology teachers. Prior to the beginning of the in-service courses, outcomes from a pre-questionnaire showed that 5 teachers used explanations in their classes as the only type of socio-scientific reasoning, while 6 teachers used reasoning tasks and introduced the structure of argumentation to their students. Only one teacher declared, before the intervention, that she assessed the students' reasoning tasks. After the intervention, none of the teachers remained at the lowest professional level and all teachers added reasoning tasks for students to their teaching repertoire with 4 out of the 12 teachers adding assessment of such tasks also.

The results of the this study provided data to suggest that the teaching approach had moved towards interdisciplinary and problem-based teaching and the quality of compiling teaching materials indicated improvement, but only one third of teachers indicated that they had changed their science classes into totally student-centred learning environments. A further positive effect of the in-service is shown by the fact that the interdisciplinary and communication skills of teachers increased and the collaboration between them had a positive effect on their professional change.

Based on post-in-service interviews, all teachers highly appreciated the design of the in-service courses. All teachers valued the interdisciplinary theoretical background, which, as they declared, gave them an understanding and confidence to implement new types of teaching ideas in the classroom. More than half of the teachers agreed that they progressed in developing their own socio-scientific reasoning and scientific creativity skills as a product of collaboration during the workshops and classroom implementation feedback.

3.2. Change in Students' Scientific Creativity and Socio-Scientific Reasoning Skills

The effectiveness of the science teachers' professional change resulting from the STL in-service course, considering the impact on their 9th grade students, was considerable. In all participating schools, the increase in students' scientific creativity and socio-scientific reasoning skills were statistically significant (Table 2).

The detailed relationships between gender, number of teachers and level of knowledge on students' scientific creativity (SCr) and socio-scientific reasoning (SsR) are given in Table 3. According to the general linear model gender appeared to influence the pre- and post-test of scientific creativity but was not affecting the results of the socio-scientific reasoning test. The number of teachers, teaching concurrently the same students had a significant impact on both measured skills. The knowledge in biology had an impact on socio-scientific reasoning but not on scientific creativity and the test results of chemistry had no significant influence on neither of the measured skills. The possible reason for this can be the content of the tests that were not measuring the skills of creativity and reasoning.

4. Discussion and Conclusions

Research has shown that a paradigm shift in science education should start from teacher changes that bring about a change in learning environment, improve students' attitude towards science subjects and make science education more relevant in the eyes of students and the society (Holbrook *et al*., 2008). Promoting teacher change starts from carefully conducted, in-service professional development (Rannikmäe, 2005). In the current study, therefore, efforts were directed to STL in-service courses, highlighting the development of students' scientific creativity and socio-scientific reasoning skills as important components of scientific literacy. These important components of scientific literacy were shown to be neglected in the implementation of the Estonian Curriculum (OECD, 2006) and are further highlighted in a new curriculum that was about to operate in the 2011/12 academic year (Estonian Curriculum, 2011).

The longitudinal teachers' in-service courses were designed especially to deal with fostering students' scientific literacy and attitudes towards science classes, focusing on scientific creativity and socio-scientific reasoning skills through interdisciplinary and student-centred learning environments. In planning the in-service courses, a major goal, recognised from problems previously reported by Rannikmäe (2001), was to provide science teachers with sufficient knowledge from other science disciplines to create interdisciplinary teaching materials.

4.1. Change of Teachers – by the end of the longitudinal in-service courses, the teachers highly valued, as indicated in post-interviews, the interdisciplinary theoretical background provided, which they indicated gave them an understanding of and confidence to implement new types of teaching ideas in the classroom. However, teachers varied in their ability to include creativity and reasoning in their attempts to create teaching materials.

Phenomenographical categories of science teachers showed comparable components to those in the study by Rannikmäe (2001). This may be explained by the fact that similar samples of teachers had been chosen – chemistry and biology teachers with a Soviet pre-service background. In all courses, scientific literacy, as a goal for science teaching (Holbrook & Rannikmäe, 2007), was introduced to the teachers although only one third of the teachers reached the identified professional level so as to be able to create meaningfully their own teaching materials. The identified change of professional levels indicates the direction of a paradigm shift in science teaching, which, in the current study, means moving towards teaching which positively promotes scientific creativity and socio-scientific reasoning skills among the students.

After the teaching intervention, it was gratifying to note that all teachers increased their professional level, were able to add reasoning tasks for students to their teaching practice and were also capable of assessing them. These findings reinforce the importance of findings from studies by Sadler and his co-authors (2004; 2006), indicating the need to link content knowledge with socio-scientific reasoning. It also pointed towards a reason for the lack of a prior shift by teachers.

The availability of meaningful guidance in recognising the need for a change in learning environment is shown to be very important and points to the gains possible, at least for some teachers, through longitudinal in-service courses.

Of major importance was the fact that the four teachers, who had worked alone, did not show substantial positive change in their professional level, whereas the eight teachers, who were participating in collaborative teamwork between teachers in their schools, illustrated more substantial changes as a result of the in-service courses. Before the intervention, more than half of the teachers did not value the fostering of students' scientific creativity skills and only five teachers claimed to be using creative learning tasks in their lessons. After the teaching intervention, although one teacher remained at the lowest level on this scale, not valuing scientific creativity, nine teachers started, or continued to use creative learning tasks. The potential of the in-service was even more fully recognised by two teachers who began to assess these tasks, illustrating a change to the third level on the created competency scale.

Summative results from the longitudinal study showed that two teachers, when working as a team, induced a greater number of student change level, both in scientific creativity and socio-scientific reasoning skills. This result is in line with outcomes from previous research (Rannikmäe, 2005) and provides support for the interpretation which recognises motivation to work as a team as an important contribution for enhancing in-service programmes. It further suggests that motivation is important for teachers in developing scientific literacy in their students, in this case in terms of promoting teaching towards scientific creativity and socio-scientific reasoning.

Teacher collaboration has been pointed out as an important component for teacher change by Marks *et al.* (2008). In the current study, this finding was obtained both through teacher questionnaires and interviews, showing that teachers recognised, before the intervention, their lack of teaching ability to create interdisciplinary teaching materials and enhance their students' reasoning and creative thinking skills. Teacher collaboration was, by utterances of participating teachers, seen as a key positive factor effecting teacher change and the results of this study reinforced this. These findings confirmed outcomes from the author's previous study (Laius & Rannikmäe, 2004), indicating the crucial role of teachers' collaborative teamwork within the school. Similar results are also reported by other researchers: Watson *et al.* (2011), Jang (2006), Graham (2006) and Suntisukwongchote (2006).The current study revealed also that the teachers' teamwork was significantly more effective in influencing students' changes in scientific creativity and socio-scientific reasoning skills than the teachers working alone.

The teachers' enhanced competence during the longitudinal in-service courses, like ownership in creating teaching materials, had been considered important in directing teachers to adopt change in former studies (Rannikmäe, 2005). In the current study all teachers left the lowest professional level of content-oriented teaching and reached more interdisciplinary, competent and confident socio-scientific teaching abilities.

4.2. Change of Students – the changes in students' scientific creativity skills showed significant positive increase in all tasks, except for the science problem solving task. This task happened to be in the field shown to be the most difficult to improve and make substantial changes in these more difficult areas, like problem solving and the skills needed to solve such tasks.

The research revealed that the students' scientific creativity and argumentation skills at the beginning of the study were relatively low. These skills were not purposefully fostered in Estonian science classes. Even though the general part of the curriculum included the need for developing skills in students such as creativity, reasoning, problem solving and decision making, Estonian teachers chose pragmatism, faced with the dilemma of whether to increase these skills or put the main efforts on student performance as this is still the main factor used for assessing the teachers and schools (Burnard & White, 2008; Nicholl & McLellan, 2008; Simmons & Thompson, 2008).

The longitudinal in-service courses can be considered effective in increasing the degree of impact of the teachers on their students' scientific creativity and socio-scientific reasoning skills ($p < 0,000$). This showed the possibility, through teacher training, to make substantial changes in the learning environment and promote more seriously students' scientific literacy, related to scientific creativity and socio-scientific reasoning. This fits with prior research (Molnar, 2011, Furnham *et al.*, 2011; Sadler & Fowler, 2006; Erduran *et al.*, 2006) and encourages the hope that, with the implementation of a new Estonian national curriculum (2011), science classes will be more relevant to students in their school work, in their every-day and future lives and also fulfils the demands of society.

5. Conclusions

The professional level at which teachers could utilise the STL teaching approach impacted on the level in developing both students' scientific creativity and argumentation skills. This enabled students to solve problems and make well-grounded socio-scientific decisions in their every-day lives. As reasoning skills and scientific creativity were seen as very important premises for both problem solving and decision making abilities, there were signs that the students' problem solving and decision making improved alongside increases the degree of student-centred STL teaching undertaken by the teacher.

The development of students' scientific creativity and socio-scientific reasoning (argumentation) skills was influenced by the number of the teachers working with the students, the degree of their teachers' changes and also by the changed learning environment. The gender factor was important only within the change of scientific creativity. The students' chemistry and biology level of content knowledge influenced significantly their scientific creativity skills, but the impact of science knowledge on socio-scientific reasoning skills was not statistically significant ($p = 0,371$).

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Table 1. The change of teachers' professional levels during STL in-service by schools

School	Chemistry teacher professional level		Biology teacher professional level		The overall change of teachers' professional levels (chemistry /biology teacher)
	Before in-service	After in-service	Before in-service	After in-service	
1	3	4	2	3	**1 / 1**
2	2	2	-	-	**0 / -**
3	2	2	2	2	**0 / 0**
4	2	3	2	3	**1 / 1**
5	3	4	-	-	**1 / -**
6	2	2	-	-	**0 / -**
7	2	3	-	-	**1 / -**
8	1	2	1	2	**1 / 1**

Table 2. Change in students' scientific creativity (SCr) and socio-scientific reasoning (SsR) by schools

School	Mean change in		SD	t	df	Sig. (2-tailed)
1	SCr	1.04	0.61	8.51	24	0.000**
	SsR	1.68	0.90	9.33	24	0.000**
2	SCr	0.71	0.69	5.71	30	0.000**
	SsR	1.32	0.60	12.29	30	0.000**
3	SCr	0.63	0.56	6.24	29	0.000**
	SsR	1.47	0.82	9.81	29	0.000**
4	SCr	0.64	0.55	6.66	32	0.000**
	SsR	1.21	0.74	9.41	32	0.000**
5	SCr	0.47	0.51	4.03	18	0.000**
	SsR	0.95	0.78	5.30	18	0.000**
6	SCr	0.48	0.51	5.11	28	0.000**
	SsR	1.07	0.65	8.84	28	0.000**
7	SCr	0.76	0.44	9.38	28	0.000**
	SsR	1,21	0.62	10.49	28	0.000**
8	SCr	0.57	0.50	6.00	27	0.000**
	SsR	0.82	0.67	6.49	27	0.000**

******Significant difference at the 0.01 level of confidence

Table 3. The relationships of gender, number of teachers and level of knowledge on students' scientific creativity (SCr) and socio-scientific reasoning (SsR)

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	SCr_pre	50094.48	45	1113.21	2.06	0.000**
	SCr_post	53990.75	45	1199.79	2.81	0.000**
	SCr_change	8556.75	45	190.15	1.39	0.071
	SsR_pre	116.55	45	2.59	2.90	0.000*
	SsR_post	2.90	45	0.60	1.42	0.056
	SsR_change	88.67	45	1.97	2.61	0.000**
Gender	SCr_pre	3153.10	1	3153.10	5.85	0.017*
	SCr_post	2854.23	1	2854.23	6.69	0.011*
	SCr_change	7.44	1	7.44	0.05	0.816
	SsR_pre	0.21	1	0.21	0.23	0.630
	SsR_post	0.23	1	0.23	0.54	0.464
	SsR_change	0.72	1	0.72	0.95	0.331
Number of teachers	SCr_pre	9795.91	1	9795.91	18.16	0.000**
	SCr_post	15554.42	1	15554.42	36.45	0.000**
	SCr_change	662.71	1	662.71	4.83	0.029*
	SsR_pre	38.16	1	38.16	42.75	0.000**
	SsR_post	3.47	1	3.47	8.26	0.005**
	SsR_change	18.17	1	18.17	24.03	0.000**
Knowledge of chemistry	SCr_pre	16143.09	21	768.72	1.43	0.112
	SCr_post	12432.87	21	592.04	1.39	0.130
	SCr_change	3108.01	21	148.00	1.08	0.375
	SsR_pre	21.05	21	1.00	1.12	0.328
	SsR_post	10.78	21	0.51	1.22	0.238
	SsR_change	23.13	21	1.10	1.46	0.098
Knowledge of biology	SCr_pre	12129.77	20	606.49	1.12	0.329
	SCr_post	10440.84	20	522.04	1.22	0.240
	SCr_change	2973.20	20	148.66	1.08	0.371
	SsR_pre	38.90	20	1.95	2.18	0.004**
	SsR_post	9.36	20	0.47	1.11	0.340
	SsR_change	36.71	20	1.84	2.43	0.001**

*Significant difference at the 0.05 level of confidence

** Significant difference at the 0.01 level of confidence