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UNIVERSITY-SCHOOL PARTNERSHIPS: ON THE IMPACT ON STUDENTS OF SUMMER SCHOOLS (FOR SCHOOL STUDENTS AGED 17-18) RUN BY BRISTOL CHEMLABS

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Abstract: Chemistry summer schools for 17-18 year old school students in the UK were run by Bristol ChemLabS, a Centre for Excellence in Teaching and Learning in Chemistry at the University of Bristol. Students attending were all studying Chemistry at post-16 level (A level in the UK) and experienced not only new practical techniques but also lectures on cutting-edge science as well as interacting with postgraduate role models. The students completed pre and post summer school questionnaires to ascertain the impact of the summer school on them. Paired t-tests were used to ascertain significant changes at the 2σ level. There was no significant difference observed for self-concepts in Chemistry and Mathematics. For creative self-concept there was a significant increase (1σ) for females but not males and a significant increase in academic self-concept for the whole cohort. There was a high level of enjoyment of the summer school. There were a range of reasons for students attending the summer school and the benefits they produced and these are discussed. Interestingly, one of the main reasons for attending was to help students make choices of subject to study at University; however, the summer school opened the students' eyes to more possibilities rather than narrow the choices open to them.

Keywords: Attitudes to science**,** Bristol ChemLabS, Chemistry summer schools, School Teacher Fellow, University-School Partnerships.

1. Introduction

Bristol ChemLabS is a national Centre for Excellence in Teaching and Learning in tertiary level Chemistry in the UK and is housed within the School of Chemistry at the University of Bristol. Bristol ChemLabS Outreach is a sub-project within the overall programme and involves working with primary and secondary school students in the UK to provide opportunities to carry out hands-on activities that cannot be carried out by the schools for either cost or health and safety reasons [1, 2]. The Bristol ChemLabS Outreach project is lead by an academic within the department (Outreach Director) together with a full-time School Teacher Fellow (STF) [3-5]. The STF is an experienced secondary school science teacher who works full-time with the project. Combining the experience of the STF with the facilities of a well equipped undergraduate University laboratory provides an excellent combination and has led to numerous highly successful interactions between Bristol ChemLabS and School students [e.g. 5-7]. Many organisations run summer schools for post-16 students in the UK, e.g. The Sutton Trust [8] and The Salter's Company [9], in this paper we describe summer schools that have been delivered by Bristol ChemLabS in collaboration with Trinity College Dublin for post-16 students (16-18 year olds). We describe the activities undertaken and assess the impact of these on the students. Throughout the summer school there is an emphasis on practical chemistry and students are introduced to new practical techniques and equipment throughout the week. Another important facet of the summer school is the interaction with postgraduate chemists and the opportunity to experience a university science department. In the 2004 report 'Europe Needs More Scientists' [10] Professor José Mariano Gago and his committee commented on science practical

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work, 'Done well, practical work can both inspire and instruct pupils: done badly, it is a standard subject of complaint by uncomprehending, disaffected students….' and 'SET [Science, Engineering and Technology] laboratories and equipment are vital to pupils' education in these subjects – both in directly educating pupils about areas of science and technology and in interesting and enthusing them to study these subjects further. Also Recommendation 3 of the Rocard report [11], which looked at ways that the decline in the uptake of sciences and mathematics and the subsequent consequences on Europe's future economy, says 'Specific attention should be given to raising the participation of girls in key school science subjects and to increasing their self-confidence in science.

2. Description of the activities of the summer school

The University of Bristol/Trinity College Dublin Summer School is an opportunity for students interested in chemistry to spend a week in two university chemistry departments. The majority of students spend the first part of their week at the University of Bristol, UK, and the latter part of the week at Trinity College, Dublin, Ireland. The week consists of a variety of practical chemistry work, talks, lectures and demonstrations from university staff and postgraduate chemists, and social activities such as ten pin bowling, group and individual quizzes.

The practical work starts with some simple, short, fun exercises to familiarise the students with the undergraduate teaching laboratories and with each other; many of the students did not know each other. These experiments included the iodine clock experiment where students, working in pairs were challenged to get the colour change as close to a target time. The majority of the practical tasks used throughout the week were 2-3 hour experiments such as the extraction of caffeine from tea leaves, extraction of both carvone isomers from spearmint leaves and from caraway seeds. Other experiments included the synthesis of anaesthetic benzocaine, the hydrolysis of the PET polymer from plastic drinks bottles, the analysis of water and commercial bleaches. Practical techniques encountered included using electric heating methods (not Bunsen burners), Buchner filtration, solvent extraction, rotary evaporation in addition to the more usual titration. Many analytical techniques introduced in experiments early in the week were then expected to be used in others. Such techniques ranged from the use of melting point apparatus, diamond infra-red spectroscopy, visible and Ultra Violet-Visible spectroscopy.

The topics of the lectures experienced included atmospheric chemistry, perfumes, extremophiles, the use of computational chemistry in drug design and toothpaste chemistry.

3. Objectives

The summer school provides an opportunity to use equipment and techniques not usually on offer in schools, and provides an insight into university-level chemistry as we have stated already. Students attending these residential courses already have an interest in studying chemistry or science related subjects further and developing their abilities. Therefore this kind of interaction is different from the aspiration raising workshops we run for younger students [e.g. 5-7]. It is an opportunity for them to improve their understanding and skills, and gain an insight into what studying a science such as chemistry at a university would be like. The students are able to experience two different university chemistry departments, as well as more general aspects of the university such as student accommodation and working with like-minded peers. The purpose of this paper is to describe the activities and set up of the summer school but also to answer the following questions;

- What are the effects, if any, on students' attitudes towards chemistry?
- What are the reasons behind students' interest in attending the summer school?
- What do students perceive to be the main benefits of attending the summer school?

4. Methods

Sample

Two summer schools were run in July 2009, with a total of 43 students attending over both weeks. Students were asked to complete a questionnaire upon arrival at the summer school, and another after their final day in the laboratory. 31 students completed both questionnaires. The students were aged between 16 and 21; the majority were 16-18 and studying A-levels (or equivalent). All students were studying A-level (or equivalent) Chemistry. The students were a mix of British, Irish and French.

Data collection

Students were given a questionnaire to complete at the beginning and end of the week-long summer school. Each questionnaire contained the Chemistry Self-Concept Scale devised by Bauer [12] which measures chemistry self-concept, as well as maths self-concept, creative self-concept, academic self-concept and academic enjoyment. This scale was chosen for a number of reasons. First, there is much debate in the literature about measuring attitudes in science, and most measures have been designed for a specific programme or piece of research. A review of the literature by Blacock et al, [13] compared measures and concluded the best approach for future research would be to take existing measures, and use in other contexts to test reliability and to provide further evidence. It was necessary to find a measure suitable for the age group being assessed, which narrowed down the number of measures available. Also, it was decided that a focus on finding a measure that assessed students' self-concept and self-efficacy in science, rather than their general attitudes would be most suitable. As these students had chosen to come on a chemistry summer school, and many were considering chemistry at university, they were already very likely to have positive attitudes towards chemistry. However, the fact they had chosen to attend a summer school specific to the subject could suggest an interest in improving ability, learning more, improving skills, knowledge, and/or confidence.

The Chemistry Self-Concept Inventory contains 40 statements, and participants indicate how accurately each one describes them on a 7-point scale (1 = very inaccurate, 7 = very accurate). It was developed based on the Self Description Questionnaire III (SDQIII) by Marsh & O'Neill [14]. Bauer [12] developed this scale to include a science self-construct specific to chemistry. The scale is useful for this evaluation as many science-related attitude and self-concept scales do not concentrate on each science specifically. Since the participants in this study were taking part in a chemistry-specific summer school, and were at an age when they were no longer studying the school sciences as one subject, it was useful to be able to measure their chemistry-specific attitudes and beliefs about themselves. It is also based on a scale (the SDQIII) that has been subject to reliability and validity testing and adapted for use in a number of studies (e.g. Trautwein et al, [15]).

Students were also asked in both pre and post questionnaires to list the subjects they were considering studying at university, as well as the subject they were most likely to study, in open text questions. The post-summer school questionnaire also included open-ended questions about students' reasons for attending and students' perceived benefits of attending.

Data analysis

The following statistical tests were run using SPSS to analyse the questionnaire data.

- Paired-samples t-tests were used to compare scores on self-concept scales before and after the summer school.
- Independent samples t-tests were run on each of the measures of self concept, to compare males and females' scores on each measure.
- Qualitative data from the open ended questions on the post-summer school questionnaire were analysed using a basic content analysis approach.

6. Results

Impact on self-concept

Table 1 contains the mean rating for students on each self-concept measure, both before and after the summer school. A paired-samples t-test was used to calculate the significance values of each set of average scores.

Table 1. Mean self-concept ratings before and after the summer school

	Mean self-concept rating		Sig (2-tailed)
	Pre summer school	Post summer school	
Chemistry Self-Concept	5.7	5.8	.326
Maths Self-Concept	5.6	5.6	.730
Creative Self-Concept	4.8	5.0	.109
Academic Self-Concept	5.3	5.6	.007*

* indicates difference is significant at the 95% confidence level or above

There was no significant difference in students' chemistry and maths self-concept scores before and after the summer school, although it is important to note that scores on these measures were fairly high to begin with. There was also no significant difference in students' creativity self-concept before and after the summer school. Consideration could be made here into the types of activities students were undertaking (lectures, talks, guided practicals) and whether these are activities that would have an impact on creative self-concept.

Academic self-concept scores were significantly higher after students had attended the summer school. Although statistical significance indicates the level of confidence in the results obtained in an analysis, it does not indicate the effect size of any result that occurs. Calculations of effect size can be used to give more information when a statistically significant result is obtained. There are a number of calculations that can be used to obtain a measure of effect size, this research uses the Eta squared calculation to calculate the effect size of significant results found in analysis using independent-samples and paired samples t-tests. As described by Cohen et al [16], the formulae for Eta squared for paired-samples t-tests is

$$\text{Eta squared} = \frac{t^2}{t^2 + (N1 - 1)}$$

Where t is t-test value returned and N1 is the number of students in the sample. The guidelines described by Cohen et al. (2007) suggest that an Eta squared value of 0.16 or over indicates a large effect size and in this study Eta squared =.23, indicating a large effect size.

Impact on Academic Enjoyment

Table 2. Mean academic enjoyment ratings before and after the summer school

	Mean enjoyment rating		Sig. (2-tailed)
	Pre summer school	Post summer school	
Academic Enjoyment	5.9	6.1	.166

* indicates difference is significant at the 95% confidence level or above

There was no significant difference in students' scores on the academic enjoyment scale of the Chemistry Self-Concept Inventory before and after taking part in the summer school.

Gender Differences in Self Concept and Academic Enjoyment

The mean scores for males and females on both the pre and post measures of the Chemistry Self-Concept Inventory were compared, as shown in Table 3.

Table 3. A comparison of mean attitude ratings on each scale for males and female.

	Pre summer school			Post summer school		
	Males	**Females**	**Sig (2-tailed)**	**Males**	**Females**	**Sig (2-tailed)**
Chemistry self-concept	5.9	5.5	.26	5.9	5.4	.06
Maths self-concept	5.6	5.5	.66	5.6	5.6	.92
Creativity self-concept	5.0	4.4	.11	5.1	4.8	.35
Academic Self-concept	5.4	5.2	.51	5.7	5.4	.30
Academic enjoyment	5.9	5.9	.87	6.0	6.2	.48

* indicates difference is significant at the 95% confidence level or above.
** indicates difference is significant at the 99% confidence level or above.

There were no significant differences (at the 2σ 95% confidence level) between males and females on any of the measures of the Chemistry Self-Concept Inventory, both before and after the summer school. Both males and females showed a significant increase in academic self-concept (noted already for the whole cohort) and there was an increase (at the 1σ level) for females in the creativity self-concept and academic enjoyment category.

Impact on future intentions

Subjects considered for study at university

Participants were asked to list all the subjects they considered for study at university, in each questionnaire. A small increase in the number of subjects considered was found in responses after the summer school (pre summer school average number of subjects considered = 2.81, post summer school average number of subjects considered = 3.26). There was also a small increase in the number of participants stating chemistry as a subject they were considering in responses given after the summer school. Overall, females stated on average slightly more considered subjects than males, both before and after the summer school. A paired samples t-test was used to compare scores before and after the summer school, and an independent samples t-test was used to compare scores between males and females, and no statistically significant differences were found in either result.

Likelihood of studying chemistry

Students were asked to indicate on a 5-point scale how likely they were to choose to study chemistry or a chemistry related subject at university (1 = not at all likely, 5 = extremely likely). There was no difference found between scores before and after the summer school (pre summer school mean = 4.0, post summer school mean = 4.1). There was also no gender difference found in the scores reflecting the likelihood of studying chemistry.

Qualitative data

Reasons for attending the summer school

Students were asked 'Thinking about how you felt before the summer school, why did you want to attend?' Responses were coded into categories, and 15 categories were established based on the responses received. Table 4 contains the categories created, and the number of responses that were elicited for each.

Table 4. Students' reasons for attending the summer school (categorised)

Category	Frequency
Improve existing skills / knowledge	14
Gain experience of chemistry	11
Enjoyment	9
Learn new skills / knowledge	8
Help future decisions (relating to course)	7
Aid applications	6
Gain experience of university	5
Social / meet new friends	5
Aid success (current study)	4
Gain experience of chemistry in other settings	3
Help future decisions (relating to university)	3
Provide motivation	2
Aid success (future study)	1
Assess own ability	1
Extra / unrelated benefits	1

These categories were then coded again into broader groups, to aid interpretation of results. This resulted in 8 broad category groupings being created. The groups and number of responses are shown in Table 5.

Table 5. Students' reasons for attending the summer school (coded)

Category	Frequency
Improve / gain skills and/or knowledge	20
Gain experience	18
Enjoyment	9
Decision making	8
Aid / improve study	6
Aid / improve applications	6
Social	5
Other	1

The coding and categorising shows that students want to attend summer schools like the one offered by Bristol ChemLabS for a variety of reasons. The most popular reasons for wanting to attend are related to knowledge, skills and experience.

Perceived benefits of attending the summer school

Students were asked 'Thinking about how you felt after the summer school, what benefits, if any, do you think you gained from attending' Responses were coded into categories, and 21 categories were established based on the responses received. Table 6 shows the categories created, and the number of responses that were elicited for each.

Table 6. Students' perceived benefits of the summer school (categorised)

Category	Frequency
Improved practical skills	20
Improved knowledge / theory / understanding	17
Made friends / met new people	11
Increased knowledge of what university chemistry involves	7
Experience of practical work / a laboratory	6
Experience of university life / campus	6
Increased confidence in practical work	5
Learnt about whether will apply for chemistry	4
Independence	3
Social skills	3
Experience of theory work	2
Considering applying to Trinity College Dublin	2
New experiments	1
New equipment	1
Increased confidence (unspecified)	1
More career ideas	1
Considering applying to University of Bristol	1
Increased enjoyment of subject	1
Knowledge of university application process	1
Better understanding of previous school work	1
Head start for undergraduate studies	1

These categories were then coded again into broader groups, to aid interpretation of results. This resulted in 9 broad category groupings being created. The groups and number of responses are shown in Table 7.

Table 7. Students' perceived benefits of the summer school (coded)

Category	Frequency
Improved skills / knowledge	28
Gained experience	13
Met new people	11
Decision making	7
Insight into university chemistry	7
Increased confidence	6
Personal attributes	6
Aid study	2
Aid applications	1
Enjoyment	1

Students' perceived benefits of attending the summer school followed a similar pattern to their reasons for attending; answers were varied, but the main focus was on skills and knowledge – there were more frequent references to these types of reasons than in responses to the 'reasons for attending' question, suggesting it was not just those students expecting to increase their knowledge and skills that felt this was a benefit gained. A wider range of benefits were mentioned than would be expected based on the reasons given for students wanting to attend.

Most valuable benefits of attending the summer school

Students were asked 'What, if any, do you think was the most valuable benefit you gained from attending the summer school?' Responses were coded into categories, and 15 categories were established based on the responses received. Table 8 shows the categories created, and the number of responses that were elicited for each.

Table 8. Students' perceived most valuable benefit of the summer school (categorised)

Category	Frequency
Improve / gain practical skills	15
Experience high-quality lab / equipment	6
Met new people	6
Decision making	3
Aid current studies	3
Develop social skills	3
Experience university and university life	2
Learn about the applications of chemistry	2
Enjoyment	2
All round development / overall experience	2
Learn theory	1
Improve understanding	1
Insight into chemistry degree	1
Increased confidence	1
Independence	1

These categories were then coded again into broader groups, to aid interpretation of results. This resulted in 9 broad category groupings being created. The groups and number of responses are shown in Table 9.

Table 9. Students' perceived most valuable benefit of the summer school (coded)

Category	Frequency
Improve skills / knowledge / understanding	17
Gain experience	8
Decision making	6
Met new people	6
Personal attributes	4
Aid / improve study	3
Enjoyment	2
Overall development	2
Increased confidence	1

The benefits students' cited as the most valuable were similar to those in the previous question, relating to skills, knowledge and experience.

7. Discussion / Implications

Quantitative Data

Self-concept

Before and after measures showed there was no change in chemistry self-concept over time. Overall, students tended to have a high-self-concept before the summer school had started and so there was less opportunity for further improvement. The attending students had all chosen to study A-level chemistry, which suggests they would indeed have had a fairly high self-concept in the subject to make this decision. Another consideration is that students attending the summer school had a thorough insight into tertiary level chemistry, and this may have increased their awareness of what they still don't understand or have knowledge of. We can also consider the scale itself – there may be different facets to self-concept in chemistry that the scale does not measure that could have been affected by summer school attendance. It is important to recognise too that chemistry self-concept did not decrease – students were introduced to new concepts and methods at the summer school, were regularly challenged intellectually, competing against each other in some instances, however their chemistry self-concept did not decrease.

Maths self-concept also did not differ before and after the summer school. As with scores on the chemistry self-concept scale, students' scores before the summer school were already reasonably high. Also, the summer school was not created specifically to improve maths skills, and so there may not have been enough emphasis on maths skills (even though they are obviously important in chemistry) to impact on self concept. Students may also have encountered new mathematical concepts, as well as practicing ones they were aware of, and this may have meant their self-concept did not alter. Again as with the chemistry self-concept measure, there may be different facets to self-concept in chemistry that the scale does not measure.

Creativity self-concept also did not differ before and after the summer school for the whole cohort but it should be noted that there was a significant increase at the 1σ level for females. There were no tasks explicitly involving creativity, as the activities students took part in were structured practicals and lectures, so for this reason the creativity self-concept is likely to be static. The tendency to see an increase in the female cohort is interesting and it is noteworthy that female students contributed more to the summer school in terms of questions as the summer school went on.

Academic self-concept significantly increased among students after attendance at the summer school. Interestingly, this seems to suggest that the summer school has a more general impact on students and their beliefs in their ability in general academia rather than specifically chemistry. This measure of self-concept was included in the Chemistry Self-Concept Inventory to allow for a comparison between changes to chemistry specific self-concepts (chemistry and maths) and more general academic self-concepts. In this case, the scale has served to demonstrate how the Bristol ChemLabS summer school seems to have had an impact on more general self-concepts rather than ones that are chemistry-specific. The individual items of this scale that changed most significantly after the summer school were the statements 'I am good at combining ideas in ways that others have not tried' and 'I'm good at most academic subjects'. Reasons why this increase in academic self-concept occurred stem from the fact that students obtained an insight into life at university, and as a result they were more confident about their ability to get there, and to study at university. They felt successful in some or all parts of the summer school, and this translated into a more general belief in their academic abilities. They also felt as though they had learnt new approaches to study which they could apply in their study in the future, not just in chemistry but in other subjects. Further research into whether this change in academic self-concept persists in the long-term would be useful.

Academic enjoyment was not significantly different before and after the summer school but it was different, and the result was a near-significant one. It should be noted that there was no significant increase for males but there was at the 1σ level for females and that all of the increase was in the female cohort.

Impact on Future Intentions

Although there were no statistical differences in the results relating to subjects considered for future study, there were some interesting findings. Students stated slightly more subjects being considered for university after attending the summer school than before. This is interesting given that some students explicitly stated they were attending the summer school to help them decide whether or not to study chemistry, yet options considered tended to increase after attendance. Potential reasons for this small increase were that the summer school showed students options they had not considered before, and broadened their horizons. Also, they may well have discussed subject choice with other students, academic leaders, postgraduate students and gained ideas for further study from one other and from the lectures.

Second, another small difference found was that there was a small, statistically insignificant increase in students considering studying chemistry. It would be hoped that at least some students would start to consider the subject more after experiencing the summer school, but it is interesting to consider why this increase was not bigger. First, it should be noted that most students were already considering chemistry before the summer school, so there was little scope to increase this further. Also, those students that weren't considering chemistry already yet were attending a chemistry specific summer school may well have been attending for other purposes, such as an interest in studying medicine.

Students were also asked about their likelihood of studying chemistry, and there was no significant difference in answers to this question before and after the summer school. Responses were already very positive (likely to study chemistry) before the summer school so there was not so much room for improvement in the first place, and as before, those who weren't considering it were probably attending for other purposes e.g. medicine, and so were focused on that goal instead.

Qualitative Data

The qualitative data collected from the post-summer school surveys also provided some interesting findings.

Reasons for attending

Students were first asked about their reasons for wanting to attend. Reasons given were varied and specific, suggesting students have formed goals and objectives in signing up for such events rather than just 'wanting to do some chemistry'. The most popular reasons for wanting to attend were related to skills, knowledge and experience. This is understandable, as the summer school offers a unique experience into university life and chemistry at university, and a full programme of practical and theoretical work to help with knowledge and theoretical and practical skills. Responses in these categories suggest students have clear objectives of what they want to get out of the summer school, and an understanding of what will happen, and what will be expected of them. Many also stated that it would be fun, or enjoyable. This reason was not given in isolation but usually in conjunction with other, more academic-related reasons such as skills and knowledge, suggesting that students are not attending just for fun, but that they expect it to be an enjoyable experience. Other reasons cited related to decision making – students gain an insight into universities and chemistry at universities in the summer school, which will give them much more information on which to base their future decisions. In fact, it could be considered surprising that more students did not mention this, but there may well have been students that had already made their decision, and were rather looking to improve skills and knowledge for their future decisions. Students were also interested in help with their current studies – this is related to knowledge and skills. Others were concerned with help with applications – they saw the summer school as something to give them an edge over other applicants, something to talk about in university application interviews etc. This shows an insightful knowledge into the application process, and shows these students are already considering how to follow the career path they are interested in (rather than being solely focused on their current study). Another interesting finding is that the reasons given were mostly concerned with current (e.g. examinations such as A levels) and future (degree, career) concerns, rather than a specific focus on one or the other. This suggests that students are adept at simultaneously considering their current situation (e.g. how can I pass my exams?) as well as their future (e.g. how can I get to do chemistry at university?) which could be considered a sophisticated, skilled approach to their work and future.

Benefits of attending

As with reasons for attending, the most popular cited benefits are related to gaining or improving skills and/or knowledge. There were more references to these categories than in students' answers to the 'reasons for attending' question, suggesting that there were some students who felt they increased their skills or knowledge despite it not being one of their initial reasons for attending the summer school. Gaining experience was another common benefit cited, since the students' were experiencing university level chemistry, as well as two different university environments. Despite social aspects not being a commonly cited reason for attending, around a third of students felt this was a benefit of attending, being able to meet like-minded people and make new friends. Although this is clearly not a key factor in students wanting to come to the summer school, it seems to be a valuable benefit to many. Also worthy of consideration is that a number of students felt the summer school had increased their confidence in chemistry. This is interesting firstly because this was not an explicit objective stated by any of the students in their reasons for attending, so may well have been quite an unexpected benefit. It is also interesting as earlier results from the Chemistry Self Concept Scale suggested little change in students' beliefs about their ability in chemistry. This indicates that the summer school may have some impact on facets of chemistry self-concept that are not measured by the Chemistry Self Concept Scale.

Most valuable benefit of attending: Answers to this question tended to relate to a gain in knowledge, skills or experience as in prior questions. It is important to note that students' reasons for attending and the benefits they felt they gained are very similar, which suggests that the summer school may have met or exceeded expectations for many of the students.

8. Summary

The findings from this research show a positive response from students attending the summer school in their opinions on the event and their experiences. Students have specific and varied expectations of what the summer school will provide, and their questionnaire responses show they have generally gained the benefits they had hoped for. The students already had a high interest in the subject of chemistry prior to the summer school, and so their intentions to study the subject did not appear greatly altered, but for many it seems the event was seen as an opportunity to improve their skills and knowledge in a subject that they had already been thinking or planning to study further. Perhaps surprisingly, there was no measurable difference in students' self concept in chemistry (as measured by the Chemistry Self Concept Inventory) after the summer school, but this may have been be due to reasons such as high scores prior to the summer school, or the aspects of chemistry self-concept that the scale is actually measuring. What did change over the course of the summer school was students' academic self-concept, suggesting the event may have had some impact on students' beliefs about their general academic abilities.

9. Limitations

Although the sample size was large enough to allow for some statistical analysis, a larger group would have provided greater reliability of results. In future research it would also be useful to repeat the study, to increase the overall sample size, to enable comparisons between summer schools by year, and observe any trends that occur over time.

This study used a pre-post test design, but did not use a control group for comparison due to time constraints and the difficulty in establishing a matched group considering the students attending were of varying backgrounds and abilities. However, if more time was available a control group could potentially be established if the demographic profile of summer school attendees was available to the researcher in good time before the summer school. The use of control group would provide further insight into the potential effects of participation in the chemistry summer school.

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