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Building and sustaining a learning culture in pre-initial teacher training.

Academic biographies

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Abstract

The teaching and learning of science in many schools follows traditional lines, which has lead to many pupils view science as a "dry" subject area, lacking in creativity and interest. In responding to this situation a number of tutors at University College Plymouth St. Mark & St. John (UCP Marjon) sought funding from the Teacher Development Agency (TDA) in 2007 to set up a chemistry Subject Knowledge Enhancement (SKE) course (now known as the UCP Marjon ChEC course). Their rationale was to explore ways in which graduate students (without degrees in Chemistry) who were considering taking a Postgraduate Certificate in Education to enter teaching as science teachers could be introduced to new and creative ways of teaching Chemistry. SKE courses have been funded by the Teacher Development Agency (TDA) to meet shortages in recruitment of maths and physical science teachers. This paper offers an overview of the UCP Marjon ChEC course, how it was set up and an evaluation of its impact on students.

Key words: Chemistry problems, image, recruitment & retention of physical scientists, enhancement courses.

Background

> "Pupils are being turned off science by unexciting teaching and a lack of practical experiments, according to an inquiry by Ofsted set up to find out why standards in the subject have stalled... Children are being taught too narrowly to pass tests rather than develop a passion for the subject... Christine Gilbert, the chief inspector and head of Ofsted, said: "Science is a fascinating and exciting subject, yet for many pupils, it lacks appeal because of the way that it is taught... "The most stimulating and engaging teaching and the best learning occur when science is brought to life and pupils are given the chance to conduct, record, and evaluate their own investigations. Schools need to raise pupils' aspirations and enjoyment of science and ensure that they nurture the talents of our potential young scientists of the future."... Jim Knight, the schools minister, said... "It is vital that we make science lessons in schools inspiring and exciting so that more young people opt for a career in science. (Curtis, P. In Education Guardian, 17.06.08)

For many teachers the notion that the teaching and learning of science in schools should follow traditional lines persists. Indeed, many pupils view science as a "dry" subject area, lacking in creativity and interest and characterised all too frequently by a narrow and prescriptive set of activities such as: undertaking "recipe" practicals, lengthy spells spent listening to the teacher, and contrived question and answer sessions. In responding to this situation a number of tutors at University College Plymouth St. Mark & St. John (UCP Marjon) sought funding from the Teacher Development Agency (TDA) in 2007 to set up a chemistry Subject Knowledge Enhancement (SKE) course (now known as the *UCP Marjon ChEC* course). Their rationale was to explore ways in which graduate students (without degrees in Chemistry) who were considering taking a Postgraduate Certificate in Education to enter teaching as science teachers could be introduced to new and creative ways of teaching Chemistry. SKE courses have been funded by the Teacher Development Agency (TDA) to meet shortages in recruitment of maths and physical science teachers. This paper offers an overview of the

UCP Marjon ChEC course, how it was set up and attempts at evaluating its impact.

An Alternative Pedagogy

The *UCP Marjon ChEC* course is distinct from other enhancement courses on offer in other Higher Education Institutions (HEIs). Other Chemistry course providers, for example, use their foundation degree courses as a basis for their enhancement course provision, which, in practice, means that their students typically receive a course that is delivered through lectures, laboratory work, tutorials and seminars. This can be conceived of as being a *traditional diet*. Whilst UCP Marjon has no chemistry foundation degree course and so, therefore, cannot build upon Foundation Degree experience this is not seen by tutors as a barrier. In contrast, it is viewed as a benefit in that it frees tutors to meet the students' needs in what they consider to be more meaningful, purposeful and creative ways.

Though *The UCP Marjon ChEC* course does utilise the lecture format, the format is, unlike many other HEIs, deliberately informal. This informality is facilitated by, for example, encouraging students to ask questions during lectures and engage with their tutors in a relaxed and open way. Students also benefit from extensive work in the laboratories, from individual tutorials, and from focused and challenging discussions during seminars. More particularly, *The UCP Marjon ChEC* course provides its students with opportunities to experience, at first hand, more creative modes of delivery. This more creative way of working also allows for the production of artefacts. For example, the writing of poems, songs, letters, plays, and the creation of posters, cartoons and so on that can be used to reveal what is, in reality, a sophisticated but simply presented technical lexicon (see Appendix 1). Currently, there are two Virtual Learning repositories (referred to as E-Galleries), which include artefacts from the 2008 and 2009 *UCP Marjon ChEC* cohorts of students. When combined with formal assessments, these artefacts (referred to as E-Galleries) formed the basis for judgement by tutors of student progress. A further feature of the *UCP Marjon ChEC* course was the explicit teaching of a number of different theoretical approaches, namely the Behaviourist, Constructivist, Brain Based, Multiple Intelligences and Neuro-Linguistic Programming (NLP) approaches. These approaches informed the model used to build the *UCP Marjon ChEC* course.

Linking practice to theory: modifying cognitive structures

> "Learning to teach well is a complex task. Expert teaching performance depends on judgements made in the moment within a situation rather than the application of rules... The most effective teachers are reflective about their practice... To bring student teachers to this level of critical reflection requires more than apprenticeship as a trainee in a school... Higher education (HE) has a significant role to play in educating students to be able to reflect critically and analyse their own practice."
>
> (Tanner and Davies, 2009:373)

In an attempt to understand what makes for good teaching performance and how student teachers could be brought to much higher levels of critical understanding it was decided to explore the relevance that the work of Feuerstein, Rand, and Hoffman (1979) and Feuerstein, Rand, Hoffman, and Miller (1980). The work of Feuerstein and his colleagues was known to the authors who felt that his emphasis on the importance of mediating learning (see below) would offer an appropriate framework for evaluating the *UCP Marjon ChEC.*course. Consideration was also given to the early work of J. P. Guilford on *Dive rgent* and *Convergent* thinking, cited

in Fontana (1995: 127-8), in the area of creativity. Feuerstein's work has, we believe, the potential for practical application to the learning environments created within Higher Education Institutions for all students, and especially those, we would argue, who are moving towards a career in working with young learners. Much of Feuerstein's thinking is in line with that of the authors and with the aims and objectives of the *UCP Marjon ChEC.* course. Indeed, at postgraduate level it is most important that students who are prospective teachers are facilitated in new ways of thinking, acting and developing as individuals (Geens, James, and MacBlain, 2009).

At the core of Feuerstein's work is the view that theories are based on those belief systems and values held by individuals within societies. These belief systems, he argues, are essential in the determining of action, which can be construed as effective but he emphasises that belief systems must view human potential as having almost no limits though artificial barriers remain in place which will work to prevent change. In the case of the *UCP Marjon ChEC* course a primary aim was to identify students' belief systems regarding the ways in which chemistry is, and should be taught in schools, and to challenge these.

Feuerstein asserts that all individuals can become effective learners. By adopting such a belief system, a number of consequences occur, most notably, the concept of "structural cognitive modifiability". This refers to the belief that the brain's cognitive structure can be altered by an enabling process, which permits the learner to "learn how to learn". Learning, therefore, becomes essentially cumulative and affects performance throughout an individual's entire life (Burden 1987; Feuerstein, 1980). Feuerstein (1980:16) views such "structural change" as an individual's manner of "acting on and responding to, sources of information". The three crucial factors in mediating learning, he suggests, are: that the mediator must be aware of, make known and ensure the learner has comprehended what is intended, that the mediator must explain why she/he is going to work at a task, and that the act must be shown to have value over and above the here and now (Burden, 1987). It was these three factors that sat at the core of the *UCP Marjon ChEC* course.

One important feature that was identified in the early stages of the project was the need to create an environment in which the students could reflect on their own philosophies of teaching and learning and how the project team could "mediate" their learning experience. How, for example, might the project team as "mediating agents" select and organise the world of unexpected and unanticipated stimuli that were presented to the students each week? How could they do this from a starting point of poor awareness of the potential to teach chemistry differently, and for children to learn differently? This particular dilemma offers an entry point into the field of creativity and how mediated experience can work to facilitate this and structure the thinking of learners through widening their thinking, in this case the experience of teaching and learning Chemistry. The psychologist David Fontana (1995: 134-5) writing specifically for teachers has commented thus:

> "Just as all teachers are teachers of language, whatever their subject, so all teachers are teachers of creativity. This applies to science teachers as much as to those in the arts field."

Evaluating the project

At the outset it was recognised that any data were, essentially, qualitative in nature and derived from observation and interpretation. This was not viewed

as a hindrance to the overall analysis and evaluation but rather as a means of exploring possible insights and generating new and alternative hypotheses regarding the learning that was taking place. Given the complexity of independent variables affecting the interpretation of verbal responses from the students it was considered that informed interpretation was an appropriate method for analysis (O'Brien, 1998; Cohen, Manion and Morrison, 2007). In choosing this type of research paradigm, it was acknowledged that more traditional scientific research, with its emphasis on quantitative-experimental methods, would not go far enough in confronting those underlying strands of experience with which individuals at the centre of the study would actively operate to construct the intricacies of their own learning and reflect upon the mediated experiences of which they were a dialectical part.

Also appreciated, was the growing belief in some academic quarters, and amongst many practitioners in the fields of education and the psychology of learning, that quantitative-experimental research methods can fail to reflect the quality of experience from which individuals construct their everyday working realities (Parlett and Hamilton, 1972; Eggleston, 1974; Hamilton, et al, 1977; Hamilton, 1981; Reason and Rowan, 1981). For many practitioners, quantitative-experimental research may have little real meaning. Social reality, after all, is not something that operates in isolation, but is constructed around and through the realities of those individuals who participate and share in it. It was also considered important to present this work in a way that is accessible to the reader and that would make judgement possible. Stenhouse (1979), who has been a major influence in the field of educational research, and more particularly, action research, has emphasised the importance of capturing in the presentation of research, that, "*texture of reality"* that facilitates and makes, "*judgement possible"* for the reader.

The structuring of any protocol for the collection of evidence must be underpinned by the concept of informed consent. Time was spent, therefore, explaining to the students the nature of the data that would be required, why they were required, how data would be used, who would have access to the data, and how the data gained through feedback would be anonymous. It was also acknowledged that materials that would be posted on the E-Gallery would be discussed with students as these could be identified through the incorporation of photographs. The Project team were particularly concerned with modelling good ethical practice to these prospective teachers and were guided by Rees *et al* (2007) who concluded that only 30% of studies involving children and young people in school based research had complied to the ethical requirements of seeking informed consent. .

The *UCP Marjon ChEC* project sought to explore ways of recording evidence and turning this into a digital format. This digital evidence included sound files, video, podcasts, bloggs, learning diaries, all of which were stored in E-portfolios. Feedback from students was collected on Friday afternoons as the last activity of the week. This was facilitated by giving students sentence stems to complete, and asking them to write descriptions of events or to give rankings related to particular statements. These sentences/rankings were completed individually, without collaboration. The feedback was hand written, with no names to ensure anonymity. Feedback sheets were placed facedown on the desk in a designated area, so that tutor was unable to identify the respondent from their seating position.

These raw feedback sheets were taken to the chemistry administrator who typed them up and put the subsequent document on Learning Space. Once on Learning Space the feedback could be accessed by all students on that year's course. In addition to the above, student reflection on their own learning process was facilitated through the completion of weekly learning diaries. Students were encouraged to reflect upon how they were learning, rather than what they were learning. No learning diary material has been included in this paper as it was personal to the learner and only shared with the course lecturer during one-to one tutorials.

The technical lexicon

The Technical Lexicon in Table 1 (Appendix 1) was used to look at the application of the technical lexicon common to Chemistry by the students in some of the activities undertaken during the course. In the analysis of these data words have only been counted once as it was considered that doing otherwise would over-estimate the lexicon used by students. The twenty six activities in Table 1 gave over 100 words, but not all of these were technical as twelve individuals were mentioned in these artefacts or feedback. Scientific methodology also accounted for twelve words. Chemical technical terms accounted for 78 words. Only some of the artefacts produced by activities on the course have been "captured". Therefore, the chemical technical lexicon used by the students, in the artefacts produced is actually higher than the 78 words mentioned above.

Feedback from *UCP Marjon ChEC* course (09 cohort)

Tables 2 –19 offer feedback collected from the *UCP Marjon ChEC* 2009 cohort of students. This cohort's feedback was used as it represents a more complete dataset. A more practical reason was the fact that the *UCP Marjon ChEC* course at that time had a designated administrator who could consistently transfer the hand written material to "Word" documents. It should be noted that the 09 cohort were less positive in feedback than the 08 cohort. This was mostly due to two individuals in the 09 cohort who were expecting a "traditional diet" of teaching and learning, and found significant difficulty in adapting to the alternative model of delivery used by the Project team. Table 2 (Appendix 2) shows some of the areas covered by feedback posted on Learning Space.

Findings and analysis

The following section offers perceived insights into the learning that took place over the duration of the course and is set out on a weekly basis. Such a format offers the reader a structure and a timeline, but more particularly, a sense of progression and sustainability of change in cognitive functioning and self-perception.

Week 01. Students' ideas on the process of learning before and after learning theory day.

Subsequent analysis of the first Learning Day suggested that there had been a significant impact on students' perceptions of learning (see Table 3). At the beginning of the day 41% of respondents had indicated that, to their knowledge, they had never previously talked in any meaningful way about actual differences between learning processes and learner styles and actions. In contrast, at the end of the day, this percentage had risen to 88%. Whilst this was recognised as a function of the purpose of the day, it was also apparent that much of the conversations throughout the day had been driven by an intrinsic interest on the part of the students and relatively

high levels of motivation to explore the views and perceptions of their peers. At the beginning of the day not one of the students had indicated that they had ever engaged in any meaningful conversation with others on the subject of theories of learning. At the end of the day 76% had indicated that they had discussed at least one learning theory during the day. In addition, at the beginning of the day only 41% of students had mentioned at least one of the modalities (Visual, Auditory, Kinaesthetic) with one respondent, only, mentioning all three modalities. In contrast, at the end of the day 65% had mentioned three modalities.

Week 03. Feedback from Chemistry walk – designed to make students aware of the chemistry around us in everyday life.

One of the criteria considered by the *UCP Marjon ChEC* course team as accomplished performance was the ability for students to link classroom chemistry to everyday examples so that the relevance of the subject becomes more obvious to pupils in schools (see above).

Table 3 Students (09) A sample of initial views on the process of learning before and after learning theory day. Week 1.

Before:	*I don't know much about learning* *I think it is being able to retain and use information given to you by teachers, books and I.T. etc.* *Also information gained through experiment.*
After	*Learning can be separated into different categories and theories.* *There are 6 stages to learning and 10 multiple intelligence tools to help us learn.* *Most people learn best through a variety of tools and not just 1.* *Presentation and organisation of info impacts on how well people learn it.*
Before:	*What do I know about learning?* • *Result of collective data analysis and gain – variety of methods – seeing listening, doing.* • *Can be short-term memory/long term? – i.e. to make it long term need to keep reaffirming the learning.*
After:	*What do I know about learning now?* • *Lots of different theories as to how people learn – none of which is necessarily wrong or right – can take ideas from all.* • *There are different intelligences e.g. logistical, musical, spatial and people learn in different ways so its good to try to use a combination of methods.* • *In the same way that there are visual, auditory, kinaesthetic learners and you should try and use a combination of these to reach the widest range of people.*
Before:	*It comes by hearing reading and the recapitulation of what is heard and read and seen.* *Being involved with a process helps to learn about the process.*
After:	*Negative emotions hinder learning.* *Some people learn by different ways or a mixture of ways including visual, audio, kinaesthetic, reading and tactile.*

This was considered by the *UCP Marjon ChEC* course team to be of central importance, as it was strongly felt that many of those pupils in schools who do not engage with the subject of chemistry do so because they fail to see its relevance to their lives. In response to this obvious obstacle the *UCP Marjon ChEC* course team considered that it was necessary to include some form of real experience whereby students could, themselves, experience the reality of connecting chemistry with some form of lived reality. One approach was to engage the students in a short walk out of doors. Table 4 provides evidence for the impact of this activity. 59% of the feedback emphasised the relation of chemistry to everyday life. 47% of respondents made comments on using this type of activity in their future teaching.

Week 04. Scientific method - a series of activities to investigate the concepts of scientific method, linked to philosophy of science.

Table 5 summarises data gained from feedback following a series of activities in which students were introduced to the scientific method and its place within the nature of science. Central to this was one approach, entitled, The Black Box Activity. In this activity, a number of small sealed boxes were filled with different materials. For example, one box contained a heavy piece of metal placed at one end of the inside of the box so that the box could be balanced on the edge of a table with the weighted end of the box keeping it in place and the end without a weight hanging over the table edge. Another box had marbles placed in it but only so the marbles were running between a fixed channel inside the box preventing the marbles from moving freely around the box. A further box contained rice, which could move freely around the inside of the box. Six different black boxes were used in total. Students had to examine the boxes (without opening) and decide what was in the box. The Black Box Activity provided an analogy for the scientific process.

Week 05. Feedback on practical skills - titration.

One of the practical skill sets required in final year examinations for pupils studying at school, prior to entry to university, is the titration of solutions. Whilst titrations had been introduced, and used by the students earlier in the course, the titration exercise introduced in Week 5 was different in that it was taught as a problem solving situation. The scenario for this activity was that government Trading Standards officials had been contacted by a member

Table 4: Feedback from Chemistry walk – designed to make students aware of the chemistry around us in everyday life. Week 3

• *Useful – acted as a good demonstration of chemistry and chemical reactions working in everyday life all around us.*
• *Showed just how much chemistry is around us. Everything, everywhere.*
• *It was an interesting way of getting students to consider the chemistry at everyday things we take for granted. It is something I would consider using in the future.*
• *It was interesting to see chemistry in action in the everyday things around us.*

Table 5: Scientific method a series of activities to investigate the concepts of scientific method. This was then linked to philosophy of science. Week 4

• *Black box – really good day. Showed me a completely different way to look at science. Nice to do a visual approach using the poster to show the ways to approach a scientific investigation. Commercial chocolate spread experiment – good to think up our own practical ways of carrying out an investigation.*
• *Philosophy is making me question general science that is taken for granted as factual and now I'm looking at pseudoscience for interest.*
• *Good techniques today showing how to introduce ideas of science and scientific methods using the black box experiment and scientific method posters. I'm really enjoying learning the history of science and found the work on philosophy really interesting.*

Table 6: Feedback on practical skills- titration (Week 5)

• *I feel my titration skills have improved dramatically. I found the titration calculations really easy too; hope this wasn't just a fluke!*

Table 7: Feedback on visit to Plymouth Gin – a batch industrial process. (Week 6)

• *The gin distillery visit was a lovely way to finish the afternoon and much shorter than I expected.. Again, seeing how chemistry is actually used in the 'real world' in a way everyone will be familiar with.*

Of the public who believed that some vinegar they had purchased had been diluted. Students were then set the task of determining whether or not the vinegar had, indeed, been diluted. When students were asked to indicate their own learning following this activity, 70% reported that their titration skills had improved (Table 6). Of those who gave feedback 100% felt that their ability to perform calculations had also improved.

Week 06. Feedback on visit to Plymouth Gin – a batch industrial process.

Table 7 looks at feedback from a visit to Plymouth Gin, an example of an industrial batch process. The visit also looks at how waste products of an industrial process can be sold to other industries. Seventy-three per cent of respondents were positive about the tour using words such as interesting or fascinating.

Week 07. Feedback on the use of Learning Space to publish the feedback from the whole group for others to read.

The use of Learning Space to hold feedback from the group which can be accessed by all members of the *UCP Marjon ChEC course* is shown in Table 8.

Table 8: Feedback on the use of Learning Space to publish the feedback from the whole group for others to read. (Week 7)

Learning Space on BlackBoard VLE
• *I am using feedback. It's good to see others feel the same on some aspects. Also helps me to panic less as there are others who struggle too*
•
• *Find feedback very helpful! (And some amusing!).*
• *Use when I am writing my reflective diary and good to see other people's viewpoints. Sometimes makes me feel better if I am struggling.*

Table 9: Students review increase in subject knowledge & confidence with calculations/practicals (Week 11)

	Very Confident	Confident	Not Confident
Chemical knowledge	9	8	0
Chemical calculation	6	11	0
Before Course: chemical practicals	4	9	4
End of Course: chemical practicals	13	4	0

Ninety-three per cent of students have looked at the feedback from the group: although the frequency, with which the feedback is accessed by students, varies. 53% use words such as: useful, helpful, interesting or good in their responses on publishing feedback. One respondent uses the feedback when writing their reflective diary

Week 10. Students review increase in subject knowledge and confidence with calculations and practicals.

Students completed a small questionnaire to look at: increases in their knowledge of chemistry, confidence with calculations, and practical work (see Table 9). Chemical knowledge was considered to have increased by 100% of students, with 47% feeling a slight increase in knowledge and 53% feeling a substantial increase in subject knowledge. One hundred per cent of students felt confident with chemical calculations they had undertaken so far in the course, with 65% feeling confident and 35% feeling very confident. At the commencement of the course 24% of students indicated that they had not felt confident with chemistry practicals, whilst 52% had felt slightly confident and 24% confident. After 11 weeks on the course these figures had changed to 0% not confident, 24% slightly confident and 76% were confident.

Week 11. Students give feedback on their reflective diaries.

As these *UCP Marjon ChEC* course students were going onto the PGCE course and into a teaching career, which will be at Masters degree level, it was felt important that the course should develop their ability to reflect on their own learning/practice, a necessary element of any Masters Degree course. This was the rationale for the incorporation of the

Table 10: Students give feedback on their reflective diaries. (Week 10)

My diary…
• Helps me organise things in my head and will be useful to refer to when planning lessons
• I think it's a really useful tool just reading it back, is a good memory jogger and it's encouraging seeing the progress I've made.

Table 11: Students give feedback on this course and their creativity (Week 12)

My creativity…
• *My creativity has definitely improved...*
• *Has increased whilst on this course...*

reflective diary into the course structure. The opinions of students on the use of reflective diaries can be usefully considered in terms of positive and negative responses. In essence, 28% made positive comments compared to 17% who made negative comments. Those who were positive about the diaries felt them to be helpful for:

- organising things
- seeing the progress they have made
- reflecting on how they learn
- to see concerns and strengths and how these change
- how what they are doing relates to future teaching

Negative comments were about:

- taking up too many resources
- difficult to do
- being a burden ("*.. a chore, as a reflective person it is something I already overdo*!")

In addition to seeing Reflective Diaries as being as useful learning device 17% of students felt that their actual abilities to reflect had, in themselves, improved while the same percentage saw a need to further improve their ability to reflect (See Table 10).

Week 12a. Students give feedback on this course and their creativity.

A self-audit of students' perceptions of their own levels of creativity was considered relevant. Results of this provided some interesting data suggest some possible foci for future investigation. Thirty-one per cent of respondents felt that they had problems with creativity whilst 13% felt they were creative, and 44% felt that their creativity had been improved by experiences on the course (See Table 11). A sample of responses reflects the change in self-perceptions:

- *Whenever we learn a new topic I try to think how I could make this accessible to kids*.
- *...seems to be providing alternative and effective methodology*.

Week 12b. Students consider the move from description in learning diaries to reflection.

The subject of reflection was addressed, in the feedback, again in week 12 due to the low numbers of students reporting benefits from their reflective diary. The feedback that was requested, asked about the shift from description to reflection. 25% of respondents described this shift as "*difficult*", "*tricky*" or "*hard*". While 56% feel that they have moved to

Table 12: Students consider the move from description in learning diaries to reflection (Week 12)

Moving from description to reflection…
• *I believe I have moved from description to reflection in my diary and am finding it a useful tool for developing my understanding and learning.*
• *Has been a conscious process, i.e. I have to think about reflecting!*
• *Is very difficult but makes you really analyse what you're doing and how you feel. It's a good tool to review, you can see how far you've come, what difficulties you've overcome or still have.*

Table 13: Students ideas about learning (Week 13)

My ideas about learning…
• *Have changed greatly since I started this course.*
• *Have multiplied since the outset of this course; I'm much more open-minded to different approaches and pick up a considerable amount conferring with class-mates.*

Table 14: Students talk about their confidence with chemical concepts (week 24)

My confidence in teaching chemistry...
• *Realise I've got a lot to learn/practise /improve on but happy to give it a go.*
• *Has increased since I started the course due to all the presentations we have done and the mini lesson we performed.*

reflection. (Table 12) Comments were:

- *Takes deeper thought process.*
- *Has been a conscious process, i.e. I have to think about reflecting.*

Feedback on learning was looked at again in week 13 (Table 13) to see how these had changed (or not) from week 1. 67% of students related that their ideas on learning by week 13 had changed, expanded or increased. For those who felt this way some of the comments were:

- *I've started using other strategies not used by me before.*
- *Beforehand I would have only really thought of lecturing and revision as a way of learning. I am now aware of different techniques such as flash cards, mind maps and concept maps.*
- *I never realised learning could be fun and creative at the same time as being informative.*
- *I feel 100% more confident that I could teach chemistry in schools eventually.*

Week 24a. Students talk about their confidence with chemical concepts.

Week 24, of the then 26 week course, students were asked about their confidence in teaching chemistry (Table 14). 62% reported an improvement or increase in their confidence, with a further 23% reporting positives e.g.

- *...is high*
- *Has been given a boost*

The remaining 15% felt their confidence in teaching chemistry was:

- *I realise I've got a lot to learn/practise.*

Week 24b. Students give their ideas about their creativity.

71% of students responded that their creativity has increased or improved compared with 44% in week 12. Other replies were positive e.g.

- *Been given life on the ChEC course.*

Table 15: Students give their ideas about their creativity (week 24)

My creativity...
• *Has improved. I feel I have a library of ways to express or demonstrate topics.*
• *Has been really stimulating and I have loads of ideas.*

Table 16: Impact of course on students' ideas about learning (Week 25)

• *It has opened my eyes to lots of different ways of learning. I now understand much better how I learn best and that people learn in many different ways which I can hopefully take with me into the classroom.*
• *Learning had many angles to it. People learn differently from each other. My way isn't the best way for some others to learn. I will try and vary my teaching to incorporate different learning styles.*

Table 17: Students give feedback on feedback (Week 26)

• *Has been diverse and a useful tool for reflection. It has highlighted how different people value different processes.*
• *Was surprising as what I've read don't reflect what I thought people in the class would write.*
• *Has given me more confidence in feeling like I'm not the only one and more able to get things wrong.*

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- *Has had some focus and purpose. Thank you.*

Week 25. Impact of course on students ideas about learning.

Students' ideas on learning were sampled again on week 25, the penultimate week, to make comparisons with weeks 1 and 13 and determine the impact (Table 16). 41% mention the differences between learners; the same as on day 1 before the learning input. Taken alone this might indicate that there has been no lasting impact on students ideas of learning. However, the feedback also shows that 12% feel they have broadened or had more depth of ideas about learning. Another 12% felt that ideas about learning had changed from when they were at school. A further 12% talked about the complexity or many angles to learning. Other comments included:

- *For the first time on a course I have learnt a lot and it's because I have enjoyed the course and subject and because it has been aimed at my learning style as well as other peoples, unlike other courses I have been on.*

Only one respondent appeared to have made no move in their ideas about learning.

Week 26a. Students give feedback on feedback.

The final week of the course (week 26) was used to sample students' ideas about key facets of the course these included: feedback (Table 17), chemistry (Table 18), impact on their ability to teach (Table 18) and the course as a whole (Table 20). 36% found reading the feedback interesting; while 22% found it useful or helpful or built confidence. Two responses were of interest in that they seemed to indicate that feedback was being used to change behaviour e.g. "more sensitive" and "my input could help". One respondent felt that it had helped the group communicate. (Table 17)

Table 18: Students reflect on Chemistry (Week 26)

Chemistry…
• *This course has made me look at key concepts again and not just covered the subject.*
• *Will be a fun subject to teach to kids.*
• *Has finally made sense to me. After failing at AS level then struggling to understand during uni I feel I've finally taken in chemistry and its because I have enjoyed it and wanted to learn it.*
• *Has changed greatly since I was at school and I have had to re-learn what I thought I already knew – which has been tough!*

Table 19: Students talk about the impact of the course on their ability to teach (Week 26)

My ability to teach…
• *Has improved every week of the course. My confidence has taken a beating at times but through reflection I can see how to improve.*
• *Has improved as I know now how to change learning styles to suit different people.*

Table 20: Students perception of the course (Week 26).

The course…
• *The course has been jam packed – I was extremely nervous at the start about the content...*
• *Has been fantastic for my development in chemistry knowledge... I am now looking forward to the PGCE course with far more confidence than I had in January.*

Week 26b. Students give feedback on Chemistry.

Thirty-five per cent of respondents link chemistry with fun (Table 18). This is considered an important outcome as chemistry is often perceived as difficult and boring. If future teachers can inspire pupils to see chemistry as fun then perhaps subject take up post 16 would increase. Twenty-four per cent use words such as interesting, exciting, fascinating, or marvel. Others talked about feeling more comfortable with the subject or that it now made sense.

Week 26c. Students talk about the impact of the course on their ability to teach Chemistry.

Table 19 shows that 82% use words such as: improved, enhanced, better, benefit or boosted. Several respondents talked of improved confidence. No respondent gave the impression that the course had not been useful.

Week 26d. Students offer their perceptions of the course.

Ninety-four per cent of respondents felt the course was helpful, while 1 respondent found it:

- *...demanding and stimulating.*

The 94% include words such as excellent, beneficial, brilliant, good experience, enjoyable and helpful. Many comment on their increase in confidence. Several state that they could not see doing a PGCE without the course.

- *Has been great and I wouldn't have been comfortable starting a PGCE without doing this course first.*
- *Has been a good experience overall and an excellent spring-board for the PGCE/SCITT.*

Conclusions

As with any new initiative there are conflicting pressures. Adopting new ways of working requires that some form of risk is undertaken. The greater the risk, however, the greater are the potential rewards. In the case of the *UCP Marjon ChEC* it can be argued with a high degree of certainty that the rewards of working in this new and creative way have been great. Student perceptions, knowledge base and attitudes have altered, with the result that actual student behaviour has changed in positive ways. This has significant implications, not only for the way HEIs prepare their future teachers to teach science, but also for the manner in which many pupils in schools are taught. It has been the contention of the authors that one of the problems of teaching chemistry in schools is the large technical lexicon that accompanies the subject. This study has demonstrated how as many as 78 subject-specific words can be produced from 26 activities, and in a way that is fun, that holds the interest of the learners and that challenges the notion that many pupils in schools are baffled by the terms used in the teaching of science. The findings of this project offer strong support for the view that science does not have to be seen by pupils in schools as dry and overly complicated, and for "the few". Like the arts, it can be exciting and relevant.

Appendix 1: The Technical Lexicon

Table 1: Evidence of Developing Technical Lexicon (from e-Galleries and other parts of VLE)

Artefact 08 & 09	Concepts	Technical	Information
Carbon blues song	Global warming	Carbon balance Fuel depletion Emissions Recycling	Musical
Powerpoint	The Haber Process	Industrial Economics Reversible reactions Yield Rate Fertilisers	VA
Song: Oh Haber Haber		Pressure Temperature Catalyst Reaction co-ordinate	Musical
Letter to Granny	Hess's Law	Thermo-chemistry Endothermic Exothermic Energy transfer Work	R
Greasy Chip shop song	Fuels	Fuels Sustainable development Bio-fuel Combustion	Musical
Demo: Eggs	Density Chemical reactions	Mass Volume Reactants & products Gases Forces	KVA

Powerpoint	Atom	Model Electron	VA
Role play	Organic reaction mechanisms	Carbocations Hybridization	K
East enders	Organic reaction mechanisms	Nucleophiles Electrophiles Substitution Addition Elimination	K
Silent Movie	Organic reaction mechanisms	Free Radicals Condensation Polymerisation	K
Chemistry Walk	Materials	Uses Problems with use Classification Metals, Ceramics, Plastics Glass Composites SMART	VAKT
Poster	Scientific Literacy	Persuasion Evidence Authority	VR
Poster 1	Scientific method	Observation Hypothesis Theory Test	VR
Glossary	Scientific method	Law	R Linguistic
Poem	Scientific method	Explanations Newton Hooke Boyle Einstein	R Intrapersonal
Decision making activity	Decision making (using maps)	Cause Effect Skills	Visual
Traffic lights	Earth & environment	Rocks Tectonic plates Cracking	A
PowerPoint	History of chemistry	Bronze age Iron age Plato Euclid Aristotle Democritus Bacon Plank Bohr	R Intrapersonal
Debate	Chemistry & society	Technology Medicine Transport Farming Warfare Media Sanitation Food preservation	A

		Health Employment	
Balloon models	Orbitals	Hybridisation	T Visual
Limestone Enquiry	Extractive Industry	Profit Impact	VAK Interpersonal
Poster 2	Scientific method	Prediction Experiment Creativity Objectivity Conclusions Problem	VR
Cartoon	Development of aspirin	Research Application	VR
Industrial visit	Industry – Plymouth Gin	Batch process Distillation Customs & Excise	VAKRT
Investigation & Report	Investigation	Planning Data Collection Analysis Conclusion Evaluation Significant figures Errors	KRT
DNA study day	DNA	Macromolecules Replication Extraction Base-pairs Hydrogen bonding Rosalind Franklin	VKTR

V= Visual A = Auditory K = Kinaesthetic R = Read write T = Tactile

Appendix 2: Student Voice

Table 2: Feedback from student voice surveys.

	Feedback topics shown in the body of the text.	Week
2	Students (09) Ideas on the process of learning before and after learning theory day.	1
3	Feedback from Chemistry walk – designed to make students aware of the chemistry around us in everyday life.	3
4	Scientific method a series of activities to investigate the concepts of scientific method. This was then linked to philosophy of science.	4
5	Feedback on practical skills- titration.	5
6	Feedback on visit to Plymouth Gin – a batch industrial process.	6
7	Feedback on the use of Learning Space to publish the feedback from the whole group for others to read.	7
8	Students review increase in subject knowledge and confidence with calculations and practicals.	10
9	Students give feedback on their reflective diaries.	11
10	Students give feedback on this course and their creativity.	12
11	Students consider the move from description in learning diaries to reflection.	12
12	Students ideas about learning.	13
13	Students talk about their confidence with chemical concepts.	24
14	Students give their ideas about their creativity.	24
15	Impact of course on students ideas about learning.	25
16	Students give feedback on feedback.	26
17	Students reflect on Chemistry.	26
18	Students talk about the impact of the course on their ability to teach.	26
19	Students perception of the course.	26

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