Climate Change, Collaboration and Pre-Service Teachers' Emergent Professional Identity

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Abstract
The study group included 74 graduate, pre-service science teachers who were following the Professional Graduate Diploma of Education Secondary (PGDES) in all science subjects, biology with science, chemistry with science and physics with science.

The strong tradition of integrated science in Scotland is reflected (Inspectorate of Schools (Scotland) 1994) in the structure of PGDES programmes (The Scottish Office Education and Industry Department 1998). Scottish School science departments are organised in a variety of ways and a strong collaborative element is often present in providing a common programme of study in science during the early years of secondary schooling. Collaborative coursework on climate change was selected due to its contemporary interest; consultation on the detail of a "Curriculum for Excellence" (The Curriculum Review Group 2004) and the absence of reported depth of experience in this content area in Scottish school science. Issues associated with climate change conform to all ten qualities of socio-scientific issues (Ratcliffe M. and Grace M. 2003.) p. 2-3. The purpose was to simulate the collaborative working environment (Watters J.J. and Ginns I.S. 2000); to establish a 'community of practice' as suggested by the (Lave J. and Wenger E. 1991)model of situated learning; involved aspects of problem based learning (Savin-Baden M. and Howell C.M. 2004) as well as authentic assessment (Wiggins G.P. 1993); and to initiate the formation of identities as science teachers rather than "subject specialists". The task was based on a constructivist framework.

We sought to explore aspects relating to attitudes and knowledge in the context of climate change, to collaboration and the use of ICT.

Students were allocated to mixed subject groups and expected to produce reading materials for 12-14 year olds and an associated teachers' guide on a given aspect of climate change over a seven week period. The product and collaborative aspects of the task were assessed using a combination of tutor and peer assessment, including two group debriefing sessions. Students' knowledge and confidence about global warming and information relating to their experiences of collaboration were assessed using a simple pre- and post-task questionnaire developed for this task.

We found that the students experienced a number of benefits and frustrations of group work task. Overall, they found the process beneficial and collectively produced a high quality resource which is available as a basis for their own teaching. The resource could be adapted for use by other teachers. The students have become more knowledgeable about aspects of climate change. They may also have considered the challenges in teaching complicated socio-scientific issues in relation to their own professional attitudes and values. A generally positive attitudinal movement took place during the period and some variation was observed between students from different subject areas.

Introduction and Context

Science and Initial Teacher Education in Scotland

The (Inspectorate of Schools (Scotland) 1994) referring to secondary schools, observed "An integrated science course during the first two years of secondary stages remains the norm in most Scottish schools." Science is also an established part of the Environmental Studies curriculum in Scottish primary schools. A Curriculum for Excellence (CfE) (Learning and Teaching Scotland 2008) is the current educational reform that is shaping the future curriculum across all subjects for the 3-15 age range. We recognised the potential of student teachers to be active participants in national curriculum developments and to our own obligations as indicated by (Watters James J.; Ginns Ian S. 2000) who looked at a collaborative, problem based learning within a pre-service programme and asserted (p278) "Preservice teacher educators will play a major role in the reform agenda by providing meaningful experiences for undergraduate students through which they can develop appropriate dispositions and understandings of the process and role of science."

Secondary teachers in Scotland are considered to be 'subject specialists' and as such all students conform to entrance requirements (Scottish Executive 2005) that indicate the extent of study in the subject area that the student wishes to teach as well as determining the level of study in English language and Communication. Each University is entitled to set standards beyond the stated minima. The required level and extent of undergraduate study in each teaching subject is defined. The Memorandum explains (Para 5.2) to explain "Teaching qualifications (secondary education) can be awarded in the following . . . Biology with Science. . . Chemistry with Science. . . Physics with Science. . ." Suitably qualified students are entitled to follow two teaching subjects.

The Professional Graduate Diploma of Education (Secondary) (PGDES) is the standard one year initial teacher education pathway in Scotland (Souter N. 2006). The programme had been internally reviewed and externally accredited by the General Teaching Council for Scotland (GTCS) in 2004. It conforms to the guidelines (The Scottish Office Education and Industry Department 1998) (Para 3.7) that indicate the following conditions: "Students undertaking a PGCE (Secondary) course leading to a TQ in physics, chemistry or biology must undertake at least 60 hours of study in general science to prepare them to teach general science from S1 to S4."

The general science provision in our University is described within the module descriptors for Curriculum and Pedagogy of each of the three science subjects. The programme receives strong, positive student evaluations and incorporates a variety of practical labs, workshops and lectures from faculty, visiting academic staff and field practitioners. It includes pedagogical issues relating to integrated science teaching as well as covering a spectrum of interdisciplinary science issues such as safety, learning theory relating to science, and practical problem solving. The programme is enhanced by a sponsored visit to the Glasgow Science Centre and is enriched by the Scottish Universities' Science Residential school, a two day event to which all graduating science students are invited in the final semester of their professional training

Participants

The study group were 74 students enrolled in the one-year preservice PGDES in 2007. Quotas for funded places are established annually by the Scottish Funding Council in response to the Scottish Government's projections on teacher supply that are in turn derived from annual statistical analysis. Teaching subjects are broadly categorised into areas of priority and each University determines the balance of student numbers. The registered student numbers and gender following each subject as a first teaching subject is indicated in table 1

Table 1 Student numbers by first teaching subject and gender

	Female	Male
Biology	23	2
Chemistry	22	5
Physics	7	15

The biology class included 2 female students who were following chemistry, and one who was following PE, as a second teaching subject. Overseas female students came from Canada (2) and Nigeria (1). The chemistry class included 3 female students who were following biology as a second teaching subject and one who was following a part time pathway. Two overseas students, both women, came from the United States and from Tunisia. The physics class included two women from overseas (India) and 1 female student who was following chemistry as second teaching subject, as well a qualified teacher from Africa.

Research Questions

(Payne Brian K.; Monk-Turner Elizabeth; Smith Donald 2006) (p. 441) described advantages of group work; "Among others, those benefits that have been identified in the literature include the following: (1) students learn teamwork skills, (2) students improve their critical thinking skills, and (3) students gain more insight about a particular topic."

We sought to further explore:

- Are the student teachers' attitudes to and knowledge about global warming affected by the collaborative task?
- What are the costs and benefits of the collaborative approach to the task?
- How effective was the use of ICT in helping the student teachers to organise the task / collaborate?

Group organisation and task design

The students were placed into 20 interdisciplinary task groups that were presented to them as "school science departments" each with 3, 4 or 5 members from mixed subject backgrounds and reflect the balance of subjects present within Scottish school science departments. We agreed with (Felder Richard M.; Brent Rebecca J. 2001) (p. 71) "we're sorry if they're unhappy about having to work in teams but the truth is that our job is not to make them happy— it is to prepare them to be professionals" . Imaginary identities were given to each 'school' to help establish group identities. One aspect of climate change was assigned to each one. We introduced the students to cross-disciplinary working in order to emulate collaboration which can be found in secondary school science departments. We encouraged students to use electronic means of collaborating such as the programme intranet and wikis. The tasks were designed in such a way that they would engage with messy, real world problems to meet the challenges of the task and introducing pupils to the uncertain nature of science and its complex interaction with decision making.

Students received briefing and detailed task specification at a lecture that was supported by a briefing note, located in the course intranet. The task involved 20 content areas associated with Climate Change (CC) e.g. "Monitoring CC", "Taking Action on CC" and "CC and Synchrony" and these were assigned by ballot. The complete list of topics is available as appendix 1 to this paper.

Climate change was selected as a suitable topic since it was an area of current public, political and scientific interest and did not have a strong tradition of being taught in as a major topic strand in sequences of science lessons in Scotland. The task was presented as being Problem Based; would involve Collaborative Learning; and was set in the context of a Curriculum for Excellence (CfE)(The Curriculum Review Group 2004). They viewed "An Inconvenient Truth" (Guggenheim D. 2006) and were supplied with a list of possible starting resources that included 20 Web-based Resources; The Science behind Global Warming (10), Taking Action on Global Warming (4), and Global warning: Scepticism (6) and a short bibliography with 6 titles.

The task involved each 'Department' preparing a pupil reader, targeted at S1 and S2 secondary (ages 12-14) to a prescribed format. They were also required to provide a teachers' guide for the science based programme to a given template. The outcome was that all students were to receive a complete electronic copy of the collaboratively produced resource.

We believed the learning experience to be valid and was consistent with (Loughran John; Mulhall Pamela; Berry Amanda 2008) (p.1302) who offered a somewhat more sophisticated way of addressing the ways "in which both the issues of particular science content . . . as well as specific ways of teaching that content . . . can be captured and portrayed for others in order to offer insights into the nature of pedagogical content knowledge."

The task was undertaken during a 6 week period; 3 weeks at University, two weeks spent on block school placement, and one week designated for independent study.

Task submission and peer assessment details were supplied with advice that each group would assess their own and two other submissions. The self assessment and peer assessment proforma permitted grading as suggested by (Felder Richard M.; Brent Rebecca J. 2001) (p. 71) "students confidentially rate their teammates and themselves on various aspects of team citizenship and use the results to assign overall ratings. . . to each team

member" (p. 72). We did not follow the approaches suggested (Payne Brian K.; Monk-Turner Elizabeth; Smith Donald 2006) (p. 444) for dealing with non participating students to reform dysfunctional groups since we believed that a valid simulation of collaboration within the work environment demanded that the groups were fixed. This was also an expedient given the short timescale available for the task.

Some guidance on vehicles to promote collaboration was provided e.g. a suggestion that they might consider using the programme intranet and a wiki site such as "google.docs.com".

Key Literature

A series of literature searches were accessed via the Athens gateway. Searches were carried out in the Social Sciences databases within Cambridge Scientific Abstracts (CSA) on all publication types relating to various combinations of the following keywords: "collaborative learning", "problem based learning", "authentic learning", "science", "preservice", "student", "student learning", "teacher education" and lexical derivations of all these terms

Issues related to each of the following impacted on the task design: Pedagogical Content Knowledge, Problem-Based Learning, Co-operative learning, Collaborative and Cooperative learning, Collaborative writing, Sustainable Development Education, Communication approaches

Pedagogical Content Knowledge (PCK)

We were reminded about PCK by (Loughran John; Mulhall Pamela; Berry Amanda 2008) (p. 1301) as a theoretical construct, originally introduced by Shulman (1986, 1987), as a way of describing the 'particular form of content knowledge that embodies the aspects of content most germane to its teachability' and that comprises 'the ways of representing and formulating the subject that make it comprehensible to others' (Shulman, 1986, p. 9)." Loughran et al (Ibid. p. 1303) described issues in learning to teach and noted the problematic relationship which ". . . arises from the intertwined nature of PCK and subject-matter knowledge." Further discussion was useful in shaping our study. referred to PCK and Shulman's description as being tentative (p. 1272); "However, regardless of interpretation, PCK has become an accepted academic construct. The foundation of PCK is thought to be the amalgam of a teacher's pedagogy and understanding of content such that it influences their teaching in ways that will best engender students' learning for understanding." Further studies e.g. (Moon Bob 2007), (Ratcliffe Mary 2008)and (Leach J. and Moon R. 1999) confirm the complexity of school, subject and pedagogical knowledge in establishing a personal subject construct.

Woolnough in (Wellington Jerry J. 1998) (p110) compared public knowledge with scientific knowledge and recognised "One aspect of authentic scientific activity utilises such personal, tacit knowledge to solve problems." The subject knowledge demands on student teachers was raised by (McCarthy Susan; and Youens Bernadette 2005) in the context of Initial teacher Education in England and that (p 150) "trainees need to know enough science' to be able to teach all the sciences at Key Stage 3 and one science specialism (biology, chemistry or physics) at Key Stage 4". They established strategies for development; involving peer support; and on improving its effectiveness.

McCarthy and Youens (ibid) p160 also described strategies for subject knowledge development during preservice science teacher education: "Peers . . . were valued for their interactive and tailored support. Whilst using peers in both informal and more structured ways, participants in this study felt that peers were an underused resource. They recognised the considerable subject knowledge expertise within the science PGCE cohort, and felt the potential was not fully realised. In response the student teachers identified the need for a greater facilitation of models of peer support by university tutors." They also recognised "The establishing of collegial relationships is an important element of professional development and the models of peer support described in this paper could provide a model for the student teachers to take forward into their teaching careers." The assumption in Scotland is that, since PGDES students are graduates in a specific discipline, they possess sufficient subject knowledge to cope with the school content or that their intellectual standing is such that they have the capacity to learn new content with sufficient understanding.

Problem Based and Collaborative Learning

This study recognized the observation (Paz Dennen Vanessa 2000) (p 329) "The Problem based learning (PBL), collaborative learning, and online learning tools all are popular topics in education today. Each holds the

possibility of promoting active, authentic learning situations." Paz Dennen defined "Collaborative learning is a process that involves interaction amongst individuals in a learning situation." Paz Dennen usefully acknowledged (p. 329); ". . . a PBL scenario assesses student performance on tasks that go beyond requiring just knowledge, comprehension, and application, and that involve demonstration of analysis, synthesis, and evaluation, all of which are more complex abilities." By way of clarification she explained; (p.320) "Problem-based learning does not inherently involve collaborative learning, and vice versa, although frequently the two are used together. The two are used together well when the learning involves heuristic tasks, conceptual understanding and/or cognitive strategies (Nelson, 1999). This method of teaching not only prepares students for future problems they might face, but also encourages interaction and the building of interdependent knowledge communities (Bielaczyc & Collins, 1999)."

While celebrating collaborative learning (Springer Leonard; Stanne Mary Elizabeth; Donovan Samuel S. 1999) (p.1) "The message is clear: What students learn is greatly influenced by how they learn, and many students learn best through active, collaborative, small group work inside and outside the classroom." and that "the collaborative nature of scientific and technological work should be strongly reinforced by frequent group activity in the classroom. Scientists and engineers work mostly in groups and less often as isolated investigators." Springer (p. 21) emphasised that "small-group learning is effective in undergraduate SMET courses. . . . Students who learn in small groups generally demonstrate greater academic achievement, express more favorable attitudes toward learning, and persist through SMET courses or programs. . . ."

(Matthews Roberta S.; Cooper James L.; Davidson Neil; & Hawkes Peter 1995) (p. 38) acknowledged "the pervasive and fundamental influence of John Dewey and his belief that education should be viewed 'as a social enterprise in which all individuals have an opportunity to contribute and to which all feel a responsibility.'"

(Hmelo-Silver Cindy E. Barrows Howard S. 2008) (p55) provided insights into the characteristics of PBL and referring to (Barrows, 2000) defined it as "an active learning method based on the use of complex, ill-structured problems as a stimulus for collaborative learning. She continues "Such problems may not have a single correct answer but require learners to consider and negotiate between alternatives and to provide a reasoned argument to support the solution they generate. The solution is a conceptual artefact in that it involves constructing an explanation. Students using PBL have opportunities to develop skills in reasoning and self-directed learning as well as to build a solid knowledge base." Analysis of the conditions required for knowledge building in problem-based group learning was described. Hmelo et al asserted (p48) "Knowledge building involves increasing the collective knowledge of a group through social discourse. For knowledge building to occur in the classroom, the teacher needs to create opportunities for constructive discourse in order to support student learning and collective knowledge building. In problem-based learning, students learn through collaborative problem solving and reflecting on their experiences." Hmelo et al accepted (p49) Berieter's 2002 description that knowledge building is "generally viewed as a discursive activity intended to enhance collective understanding". They also explain that participants' responsibility for learning; "what they need to know as they become engaged in the collaborative solution of knowledge problems in such a way that responsibility for the success of the effort is shared by the students and teacher instead of being borne by the teacher alone". Citing (Scardamalia), 2002) Hmelo (p. 49) went on to describe 6 conditions to support collaborative knowledge building citing. "First, people must work on knowledge problems that arise from attempts to understand the world. Second, they must work with the goal of improving the coherence, quality, and utility of ideas. Third, participants must negotiate a fit between their own ideas and those of others and use the differences they find to catalyze knowledge advancement. Fourth, there must be collective responsibility for advancing the community's understanding, and all participants must contribute. Fifth, participants must take a critical stance as they use various information sources. Finally, there must be knowledge-building discourse, which is more than knowledge sharing. In this kind of discourse, participants engage in constructing, refining, and transforming knowledge."

Co-operative learning

Cooperative learning according to (Lin E. 2006) (p. 34) is defined as "an instructional method in which students work in small groups to accomplish a common learning goal under the guidance of a teacher". Its value is (p35) to "develop students' social and communication skills, increase tolerance and acceptance of diversity, and improve academic achievement" and agreed with (Johnson D. W. & Johnson R. T. 1999) (p. 72) "working together to achieve a common goal produces higher achievement and greater productivity than does working alone"

Collaborative and Cooperative learning
(Brown Linda and Lara Vicky 2007) provided useful clarification; "The terms overlap in that both indicate that students will be working in groups. It can get confusing because the term collaborative learning will sometimes be used in higher education circles to designate the same practices that at the elementary and secondary level would be called cooperative learning. ." They went on to look at practical examples of collaborative learning techniques.

Collaborative writing
(Jang Syh-Jong 2007) emphasised the value of literacy approaches; "students' construction of science knowledge through talk and writing activities performed in a collaborative learning group." Jang validated our approach (p68). ". . . the use of writing to bring about an understanding of content knowledge is also regarded as an effective teaching tool (Brostoff, 1979; Langer & Applebee, 1987; Britton, 1989; Yore et al., 2003). Writing engages students in making connections between themselves and their subjects, as well as in understanding the world in which they live (Brostoff, 1979)."

Sustainable Development Education
The scope of the task intended to conform to one definition of sustainable development education (Summers Mike; Childs Ann 2007) (p.309) ". . . while definitions may be illusive, we identify in the literature a growing consensus that sustainable development must be conceptualised at the very least in terms of three dimensions: environmental, economic and social.

Communication approaches
We recognized the potential for the internet to support collaborative learning. (Nachmias Rafi; Mioduser David; Oren Avigail; Ram Judith 2000) (p. 2) established that a variety of communication means were available to support collaboration (e.g., mail, chat, video-conferencing, online collaborative-work support tools). They went on to suggest that (p7) "A key characteristic of knowledge generating communities, (e.g., scientific or professional communities) is the dissemination and mutual review of ideas and intellectual produce." We ensured that the target group possessed IT competence. An online audit of IT confidence was required for all students following PGDES and this revealed no serious deficiencies, either in confidence or their competence across a range of applications.

Methodology

Ethical approval
This project conformed to University and departmental procedures for ethical approval. A proforma was lodged with the department's Research committee. Procedures required a description of the project during completion of an internal Ethical Approval Form. This conformed to the University's ethical policies and Code of Practice and required description of the aims, target audience and means of recruitment and access, the proposed methodology and procedures to be used. Questions relating to physical or psychological, access to information about participants from other parties or any ethical issues completed the process.

Group interviews
Group Interviews were conducted twice, concurrently with timetabled task feedback supplied by the course tutors. This was loosely structured and provided opportunities for open discussion on areas relating to the student experience.

Collaboration Questionnaire
A questionnaire aimed to determine aspects of how each student viewed the process and the personal learning derived from collaboration. A tick box asked the range of communication approaches that were used within their group, indicating the most frequently used approach. Further it sought open responses on what the students viewed as the upside and downside of collaboration, what they learned about collaboration in response to the task, their experiences (if any) of Wikis, and finally provided opportunities for further comments. This was completed during the feedback sessions. Preliminary analysis was carried out using the qualitative research tool NVivo8.

Knowledge of and Attitudes towards Climate Change Questionnaire

Student Learning Questionnaires were designed to identify student learning in response to the task. Questions sought students' knowledge, beliefs and values on global warming. Given that nature of the study as a 'one off' we were unable to pilot the questionnaire and determined that the same one should be used at key points during the programme and both before undertaking the collaborative work as well as afterwards. The intervention asked the student teachers to carry out a collaborative task in the context of climate change and then evaluate the end product i.e. the teaching package. Since we were interested in tracking attitudinal change as a result of this intervention we applied a questionnaire before and after the period during which the task was undertaken. A questionnaire was selected, from the variety of survey instruments available, to explore aspects of the respondents' attitudes towards and experiences related to climate change. A forced-choice 4 point Likert scale was applied to the first 8 questions about their agreement with the following statements:

"I am well informed about global warming"
"I believe that global warming is a real phenomenon."
(The questionnaire terminated here if the response was negative)
"I think that global warming is a straightforward issue."
"I think it is important that humans take action to reduce the causes of global warming."
"I think it is urgent that humans take action to reduce the causes of global warming."
"I think that humans will take action to reduce the causes of global warming."
"I think it is urgent that humans take action to reduce the effects of global warming."
"I think that humans will take action to reduce the effects of global warming."

A further 5 open questions sought to reveal their knowledge of climate change as well as seeking their confidence towards teaching in this area

Peer Assessment

Arrangements were made for displaying the printed materials and a timeframe for assessment established. Data were obtained from self and peer assessments that were submitted on a proforma that is included as appendix 2. Each student was required to self assess 5 aspects relating to the group task (loose criteria were parenthesised in the rating sheet), and award 2 points maximum for; General Appearance (Is the display neat and well laid out?); Content (Does it contain all of the required elements); Clarity (Does the display make sense?) Group Understanding (Does the display have the potential to inform pupils/teachers?); and Collaboration (How well do you feel your team collaborated?). They were then required to peer assess a further two displays in the same way with the exception of the final aspect, Collaboration.

Tutor assessment

Tutor feedback commended the class on the production of a "well researched, presented and above all useable resource upon which a high quality experience can be offered to pupils in order to promote effective learning in science, presented in the context of climate change." The complete resource set was provided to all class members both on-line and as a CD-ROM for them to "use during first term placement (warts and all!)." They were alerted that editing was required.

A number of general points were raised on "presentation" and in addition to commenting on those submissions that had exceeded the specification. These included a strong signal that they must give consideration to their audience and attend to: language levels and the use of technical language; to use the spell checker and the grammar checker; to make use of administrative functions in word processing packages; to carefully proof read text.

Readability

Readability scores are readily available in (Microsoft 2008). Word Readability indicators were applied to each of the draft chapters – the Flesch Reading Ease test applies a formula to the text "on a 100-point scale; the higher the score, the easier it is to understand the document" and the Flesch-Kincaid Grade Level which applies a different formula to rate ". . . text on a U.S. school grade level."

Findings

Group interviews

Each discussion lasted between 15 – 20 minutes. The groups provided 17 and 20 comments respectively. The discussions included comments on social aspects of their experiences e.g. "Tact and Diplomacy was needed when dealing with other groups members who may not be pulling their weight"; or to group size where the variation was expressed as being unfair and that "Groups of 3 are more effective"; views were expressed on the nature of the task with clarity of instructions being one issue, the word count being restrictive and the "topic was too large"; other comments related to "Pupils' prior learning experiences" being unknown; the task was reported as "worthwhile"; while "collaboration less so".

Collaboration Questionnaires

70 students returned the collaboration questionnaire, representing an outstandingly high return rate of 95%. Absences and withdrawals accounted for the shortfall.

The responses indicated the following results:

Methods Used for Collaboration

- all participants had taken part in "face to face" meetings
- All students had communicated using electronic mail
  - 47 had used FirstClass, the course intranet (67%)
  - 47 had used both FirstClass and other email communication (67%)
  - 49 had used other emails (70%) indicating a range of providers despite incomplete responses to this question – Google mail (3), Hotmail (11), unspecified personal accounts (7) and University accounts (5)
- Wikis were used by 34 students (49%). Of these 28 had used Google Docs and only 1 other student had specified Ask as the source for sharing the drafts online
- Text messages were used by 20 students (29%)
- Fax was not used by any participants
- No other communication devices were indicated as having been used.

The most frequently used method of communication

This was recorded by 33 respondents (47% of the class). "Face-to-face meeting" was the most frequent with 21 responses (64% of the responses).The remaining responses showed that the variety of email was most frequently used by 7 individuals (21%). Google docs were reported as being most frequently used in 4 responses, (12%); and texting, by 1, (3 % of responses).

The Upside of Collaboration

The questionnaire generated 173 comments on the perceived advantages of collaboration.

Comments relating to organisational aspects of the task were supplied in 125 responses (72%). They generally recognised work sharing and time saving as significant aspects. Comments recognising the knowledge exchange aspects of the task were provided in responses (50%). "New ideas" were prominent and often qualified in terms of other subject knowledge e.g.; "Different subjects expertise to create a "science" based article"; "Ideas from other subjects – Chemistry and Physics."; "More ideas are generated as there are different scientific knowledge." One student "Appreciated the interdisciplinary value of science topics especially global warming."

The social value of the task was recorded within 50 responses (29%). These generally related to meeting new people from different subjects at an early part of the course in terms of extending their network. Confidence in each other was expressed as well: "Inspire each other"; and "More confident in work due to reassurance from group."

Student responses included 36 references (27%) to the collaborative learning that took place within their groups. The group indicated that they had experienced many positive outcomes in relation to what they saw as being a valid and realistic piece of coursework. It is ". . . beneficial to collaborate . . . "; "the final product is "better" . . .; and it can lead to ". . . spark many more ideas than individuals working alone"; providing a "more rounded result." The "Responsibility of working with others"; and raising self awareness were mentioned "I always knew

I am a good team worker; I am poor at decision-making, working in a team it becomes a team agreement. . ."; "Every person in the group . . . had their own strengths and weaknesses.

The responses included 14 references (11%) in relation to the negotiation that took place within their groups. Some celebrated ". . . team work and others ideas can result in a better overall outcome. . ."; and provided a". . . very good opportunity to work together with new people with difference expertise remote working – i.e. people not in same place – co-ordinating ideas to obtain workable end point – satisfactory to all involved." They had learned that they were ". . . able to come to a consensus. . ." and in order to be able to compromise they needed to ". . . be organised + to work with different personalities in a group situation. . ." They had learned "The importance of listening to others"; and that "Collaboration offers a valuable means of learning from others." One predicted ". . . diplomacy would be required within the school environment." Group dynamics were acknowledged as being factors that influence such collaborative work. "People having different values and expectations of the final produce could also be problematic and would probably lean towards the expectations of the stronger-willed individuals." Some ". . . may even disagree on the desired outcome . . ." since ". . . everyone thinks their view is the most important."

Student responses included 14 comments (8%) in relation to the multidisciplinary task and organisation into mixed subject groupings. The comments recognised the synergistic nature of collaboration. "Different subjects . . . different viewpoints. . ."; ". . . different perspectives. . ."; ". . . different aspects. . ."; ". . . have good ideas to contribute . . ."; ". . . can enhance the learning experience. . ." with the potential to "Gain knowledge from perhaps information an individual does not have."; ". . . which can improve the quality of a document." Cautionary notes, perhaps related to the territorial nature later years in the secondary school noted "That different subjects will want the focus to be on theirs"; and that "departments have different priorities."

Downside of collaboration

The students provided 149 comments relating to their experiences of the downside of collaboration.

The majority of comments, 85, (57%), made some reference to issues related to meeting organisation and management. They also referred to timetabling issues during faculty blocks and that it was "Difficult to collaborate when on 2 week induction block + study week".

More than a quarter, 39, (26%), of the comments related to group members' commitment; "Not everyone necessarily pulls their weight."; "Unfair distribution of workload."; ". . . unequal contribution/ideas/ work". In one case the finger was well and truly pointed at a named student who". . . never turned up to any meetings or answered emails."

Several comments, 29, (20%) indicate the depth of difficulties related to compromise: "Having to change things to agree with the group"; "Meetings can be tedious"; "Being outnumbered"; "Different disciplines (refused to compromise)"; "Hard to change your opinion facing some-one else's"; "Clashes of opinion". Associated with compromise were those 28 (19%) comments related to aspects of leadership such as: "Difficult to monitor progress as it was sometimes a case of 'too many cooks'"; "Lacked coordination"; "Designating tasks and splitting tasks fairly."; "Getting group to work to set deadlines"; "Organisation of group meetings etc can be problematic and hold up progress."

Negative social aspects were noted in 15 comments (10%) and these indicated alarmingly unprofessional characteristics such as "Lack of inclusion of all members"; "One member mocking other's ideas and suggestions"; and "Language barrier if foreign person in group".

Student responses included 8 comments (5%) in relation to commitment. These included references to industry such as ". . . not everybody pulls their weight", ". . . some people will happily sit back . . ." and ". . . work ethos was not the same from the different subjects." One student expressed concern about sustainability; ". . . will this still be true after teaching for a few years?"

Student responses included 7 comments (5%) in relation to leadership. Comments alluded on occasion to democratic styles,". . . it takes one or two to push forward before things get started. . ."; to a more determined

approach ". . .need to be assertive, organised, friendly, considerate, fair in dividing task, approachable . . ."; and ultimately for structured management ". . . needs to be a leader in any group to organise everyone and direct . . ."

Student responses included 6 comments (4%) in relation to workload. These recognised that collaboration was "not always easy but very relevant to school life and to producing the best work . . ." and that "logistics . . . play a major role. . ." and a "lot of research and organising goes into (product)." Group cohesion may have been issues to the student who reported ". . . is great when everyone works well and is hard work when they don't" to the despairing one who declared "It was frustrating and not worth the effort!"

Written responses to "If you used a wiki, do you have any comments?" were supplied by 40 students but 18 (24% of study group) had indicated "N/A" and one reported that they had found it useful on a previous occasion. One student seemed to have missed the point; "What is a wiki?"

The 22 responses were overwhelmingly positive (90 %) and comments included "Awesome"; "Effective"; "Useful"; "Google Docs very useful to get everybody's information together."; ". . . sped up task completion."; and "Good, easy to set up. Good place to store info. Did what it was meant to." Some cautionary notes were expressed relating to functions within the wiki as well as aspects of trust such as; ". . . became overloaded with messages and we were not familiar enough with it to use it properly."; ". . . would mess up format of document."; ". . . ensure everyone on the team knows how to use it."; ". . . difficult to use with regards to diagrams."; ". . . can't completely trust the material as anyone can add to it.

Additional comments were supplied by 10 students. These reiterated comments that had been made elsewhere in the questionnaire and on the downside of collaboration in particular. One student asserted "Overall task seemed to be a bit of a waste of time."

Knowledge of and Attitudes towards Climate Change

The results assume that the Likert scale can be treated as an equal interval scale. A score of 1.0 would indicate complete agreement with the statements about NOS. A score of 4 would indicate complete disagreement. Since a score of 2.0 indicates agreement with the statement, anything more than 2.0 indicates some level of disagreement with the statement.

Changes of opinion

The results are expressed as "Change of opinion" indicating both the direction and extent of the changes.

Table 2 Opinion changes on the climate change questionnaire

	Before	After	Change
Sum all science	877	818.0	59
Average all science	15.7	14.6	**1.1**
Sum Biology	299	272.0	27
Average Biology	15.7	14.3	**1.4**
Sum Chemistry	278	260.0	18
Average Chemistry	14.6	13.7	**0.9**
Sum Physics	300	286.0	14
Average Physics	16.7	15.9	**0.8**

Table 3 indicates the comparative statistics on the self and peer assessments of the materials produced during the task

Table 3 comparative statistics

Descriptive statistics	
Mean	1.00
Standard Error	0.31
Median	1.00
Mode	0.00
Standard Deviation	2.34
Range	12.00
Minimum	-5.00
Maximum	7.00
Confidence Level (95.0%)	0.63

Detailed analysis of the responses to the open response questions is continuing but initial indications are that:

> The range of responses indicate that a variety of understanding existed in the student teachers and that conceptual difficulties exist in understanding of the causes of climate change, the possible outcomes of global warming on identifying effective solutions to global warming.

The results also suggest that the student teachers confidence in planning and teaching aspects related to climate change and global warning increased during the study period.

Self and Peer Assessment of Course work

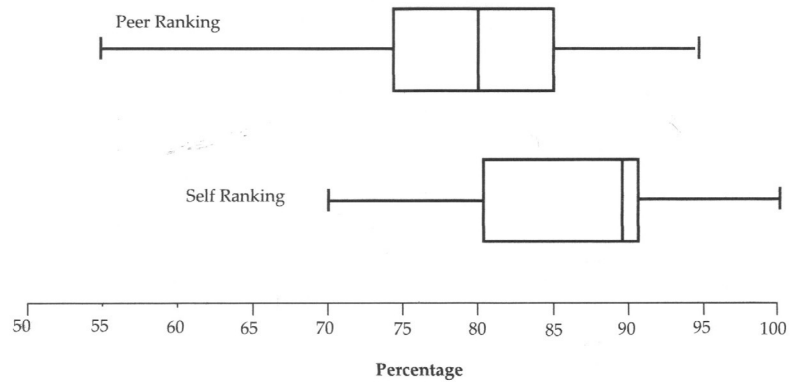
Table 4 indicates the self and peer assessments on the materials produced during the task (converted to % for the purpose of comparison.)

Table 4 self and peer assessments

School	**Self Ranking%**	**Peer ranking %**
School 1	100	93.75
School 2	100	76.75
School 3	100	73.25
School 4	95	65.13
School 5	93.8	79.75
School 6	91.3	85
School 7	90	91.63
School 8	90	85
School 9	90	81.25
School 10	90	79.13
School 11	88	87.5
School 12	86.7	87.5
School 13	86.7	75
School 14	85	68.75
School 15	83.3	71.88
School 16	82.5	78.13
School 17	80	84.38
School 18	76.7	83.38
School 19	70	80
School 20	70	55.38
Mean	87.45	79.13

We noted a small positive correlation between self and peer ranking (0.28)

Figure 1 indicates???



Readability

Table 5 indicates the readability of draft pupil chapters.

Table 5

Group ID	Flesch reading ease	Flesch-Kincaid Grade Level
School 1	35.1	11.9
School 2	47.4	10.5
School 3	60.2	8.4
School 4	55.1	9
School 5	63.7	8
School 6	53	10.3
School 7	56.5	7.3
School 8	67.1	8.5
School 9	46.7	11.2
School 10	50.5	10.5
School 11	46.3	11
School 12	57.3	9.7
School 13	51.9	9.8
School 14	59	9.5
School 15	71.7	6.2
School 16	58	8.7
School 17	45.6	14.2
School 18	71.5	6.6
School 19	63.5	8.1
School 20	65.8	8
Mean	56.3	9.4

Discussion and Areas for Future Study

Group interviews
The group interviews emphasised the positive responses received from the questionnaires and additionally corresponded strongly to those aspects confirmed in the questionnaire analysis outlined below. These findings are useful for triangulation purposes.

The group interview took place immediately after the students had completed the written questionnaires. The advantage of this was that they were aware of the fields within which the research was focused. The students nevertheless raised issues that lay outside the scope of our study and we believed that this was valuable in terms of shaping future study.

Collaboration Questionnaire
The methods used for collaboration by the students and that all participants had taken part in "face to face" meetings and had collaborated in a range of electronic manners supported Matthews view in relation to the maturity of the audience and their capacity to function effectively as task groups. (Brown Linda and Lara Vicky 2007) summarised Matthews : "Collaborative learning practitioners are inclined to assume students are responsible participants who already use social skills in undertaking and completing tasks. Therefore students receive less instruction in group skills and roles and perform less structured reflection on group interaction than in cooperative-learning classrooms."

The student teachers high level ICT competence was evidenced firstly by the unanimous use of email, secondly by the variety and flexible use of email accounts deployed, and thirdly through the high use of wikis. The high use of text messages requires further study. That fax had not been used at all is perhaps indicative of its demise for domestic use.

The ordinality of communication approaches, face-to-face > email > Google docs > texting, might reflect the expedient related to each of the most popular approaches.

Data relating to the frequency of using each communication approach was significantly lower than the remainder of the questionnaire indicating a lack of clarity in our intentions. It is unclear what happened at each encounter. Future study will involve clarifying the questionnaire to optimise the responses rate and the purpose of communication events will be clarified during interviews.

Students reported positively on the upside of collaboration. The organisational aspects of collaboration rated most highly indicates firstly that the students recognised the value of knowledge exchange with the potential to enriching the product and secondly that they welcomed sharing aspects of the work. Product enrichment and social aspects were also noted as being a worthwhile aspect of their collaborative PCK learning. Positive social aspects supported both the worth of the task at an early stage in the programme as well as helping build trust between professionals at a key point during their initial professional development.

Further analysis is required including clarifying subsets, establishing relationships, and clarifying trends and patterns between each of the comments. Similarly we recognise the need to review responses in relation to gender as described by (Souter N. 2006), subject origin, age and other variables.

When commenting on the downside of collaboration the majority of feedback related to organisation and management issues and this has shaped our future study as detailed below.

During further study will brief the students in a group tutorial during which they will spend planning time and it is hoped that this will simultaneously address issues related to group members' commitment as well as highlighting the need to establish ground rules for compromise. We will suggest that they assign one group member as the leader who will have a set of task related responsibilities. It is also hoped that this approach will help avoid those negative social aspects that were outlined in the study. Further analysis is required including clarifying subsets, establishing relationships, and clarifying trends and patterns between each of the comments.

The overwhelmingly positive response to the use of wikis suggests that we should encourage their use in further study. Further analysis is required including clarifying subsets, establishing relationships, and clarifying trends and patterns between each of the comments.

The additional comments reiterated those that had been made elsewhere in the questionnaires and are useful for triangulation purposes. One student asserted "Overall task seemed to be a bit of a waste of time."

Self and Peer Assessment of Course work

Although school 1 was most highly rated on the self and peer scales and school 20 received the lowest rating on each scale, 5 of lower 10 on peer assessed materials had self rated in the top 10. This relationship is supported by the small positive correlation between each.

Future study will include greater rigour in the assessment descriptor. Tutor ratings will be included for verifying the validity of the assessments. We will ask the research question, "Does the quality of collaboration affect the quality of the product" and analyse the quality of interpersonal aspects in relation to the comparative position of peer compared to self assessments.

Deeper understanding is required of both the nature and the extent of the communication approaches deployed in future studies.

Knowledge of and Attitudes towards Climate Change

The results showed a systematic trend in the development of student teachers' ideas about Climate Change within or between teaching subjects. The overall movement suggests increased acceptance of the statements relating to climate change. Variation exist between each of the 3 subjects with chemistry students being most receptive to the statements; biology students second and physics students third. Each group moved forward in overall terms however t greatest positive movement was observed in the biology class and the least in the physics class. The negative movement in responses that was observed in 11 students also appears to be related to the subject and 3 biologists showed an average change of opinion of -1.7; the 4 chemists moved -2; and the 4 physicists moved -2.5.

Further study is required in seeking clarification in relation to each aspect of the knowledge and attitude towards climate change. Analysis by gender, teaching subject and first degree offer exciting opportunities. Analysis of the qualitative data generated by the open questions the potential fro deeper insights.

Readability

The range of readability, as determined by each instrument applied, suggests that the group were generally writing text that was set at a level that was higher than the target audience. This is consistent with other experiences that are reported by visiting tutors relating to many first term students encountering difficulties in reaching the required level for the target audience. Further analysis is required, especially in relating the readability statistics to the peer and self assessment data. Future work will involve a requirement for the student group to set the reading level at an appropriate level for the target audience.

In conclusion

We believe that it would be worthwhile to revisit the students during the probationary year as well as at some point in the future.

We intend to continue this study and focus on aspects of collaboration between student teachers during the early part of their programme, a period during which it is essential that they establish appropriate professional practices while gaining a sense of the audience for whom they will be responsible as newly qualified teachers.

References

Brown Linda and Lara Vicky. (2007). "Professional Development Module on Collaborative Learning." Retrieved 20 July 2008, from http://www.texascollaborative.org/Collaborative_Learning_Module.htm.

Felder Richard M.; Brent Rebecca J. (2001). "Effective Strategies for Cooperative Learning." ournal of Cooperation & Collaboration in College Teaching **10** (2): 69-75.

Guggenheim D. (2006). An Inconvenient Truth.

Hmelo-Silver Cindy E. Barrows Howard S. (2008). "Facilitating Collaborative Knowledge Building." Cognition and Instruction **26**: 48-94.

Inspectorate of Schools (Scotland) (1994). Effective learning and teaching in Scottish secondary schools : the sciences. HM Inspectors of Schools. Edinburgh, the Scottish Office Education Department.

Jang Syh-Jong (2007). "A Study of Students' Construction of Science Knowledge: Talk and Writing in a Collaborative Group." Educational Research **49** (1): 65-81.

Johnson D. W. & Johnson R. T. (1999). "Making cooperative learning work." Theory into Practice **38**(2): 67-73.

Lave J. and Wenger E., Ed. (1991). Situated Learning: Legitimate Peripheral Participation. Cambridge: , Cambridge University Press.

Leach J. and Moon R. (1999). Learners and Pedagogy, . London, Paul Chapman Publishing.

Learning and Teaching Scotland. (2008). "Curriculum for Excellence." Retrieved 7 August 2008, from http://www.ltscotland.org.uk/curriculumforexcellence/index.asp.

Lin E. (2006). "Cooperative learning in the science classroom." The Science Teacher **73**(5): 34-39.

Loughran John; Mulhall Pamela; Berry Amanda (2008). "Exploring Pedagogical Content Knowledge in Science Teacher Education." International Journal of Science Education **30**(10): 1301-1320.

Matthews Roberta S.; Cooper James L.; Davidson Neil; & Hawkes Peter (1995). "Building Bridges between Cooperative and Collaborative Learning " Change **27**(July/August): 34-40.

McCarthy Susan; and Youens Bernadette (2005). "Strategies used by science student teachers for subject knowledge
development: a focus on peer support." Research in Science & Technological Education, **23**(2): 149 - 162.

Microsoft. (2008). "Microsoft Office Online." Retrieved 30 July 2008, from http://support.microsoft.com/kb/290943/.

Moon Bob. (2007). "Curriculum, Domain Knowledge and Pedagogy ", from http://www.tlrp.org/themes/seminar/moon/papers.html.

Nachmias Rafi; Mioduser David; Oren Avigail; Ram Judith (2000). "Web-Supported Emergent-Collaboration in Higher Education Courses." Educational Technology & Society **3**(3).

Payne Brian K.; Monk-Turner Elizabeth; Smith Donald (2006). "Improving Group Work: Voices of Students " Education **126** (3): 441-8.

Paz Dennen Vanessa (2000). "Task Structuring for On-line Problem Based Learning: A Case Study." Educational Technology & Society **3**(3).

Ratcliffe M. and Grace M., Ed. (2003.). Science Education for Citizenship: Teaching Socio-Scientific Issues Maidenhead: , Open University Press.

Ratcliffe Mary (2008). Pedagogical content knowledge for teaching concepts of the nature of science. 9th Nordic Research Symposium on Science Education. Reykjavik Iceland.

Savin-Baden M. and Howell C.M., Ed. (2004). Foundations of problem-based learning. Maidenhead, Society for Research into Higher Education and Open University Press.

Scottish Executive (2005). Memorandum on Entry Requirements to Courses of Initial Teacher Education in Scotland. Scottish Executive Education Department. Edinburgh, Scottish Executive,**:** 20.

Souter N. (2006). Exactly what do I have to do to enter PGDE in biology? Scottish Educational Research Association. Perth, UK.

Springer Leonard; Stanne Mary Elizabeth; Donovan Samuel S. (1999). "Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis." Review of Educational Research **69**(1): 21-51.

Summers Mike; Childs Ann (2007). "Student Science Teachers' Conceptions of Sustainable Development: An Empirical Study of Three Postgraduate Training Cohorts." Research in Science & Technological Education **25**(3): 307-327.

The Curriculum Review Group (2004). A Curriculum for Excellence - Purposes and Principles for the Curriculum 3-18. S. Executive. Edinburgh.

The Scottish Office Education and Industry Department (1998). Guidelines for Initial Teacher Education Courses in Scotland. . The Scottish Office Education and Industry Department. Edinburgh, The Scottish Office Education and Industry Department.

Watters J.J. and Ginns I.S. (2000). "Developing Motivation To Teach Elementary Science: Effect of Collaborative and Authentic Learning Practices in Preservice Education. ." Journal of Science Teacher Education **11**: 301-321.

Watters James J.; Ginns Ian S. (2000). "Developing Motivation to Teach Elementary Science: Effect of Collaborative and Authentic Learning Practices in Preservice Education." Journal of Science Teacher Education **11**(4): 301-321.

Wellington Jerry J. (1998). Practical Work in School Science: Which Way Now?, Routledge.

Wiggins G.P., Ed. (1993). Assessing student performance. San Francisco, Jossey-Bass Publishers.

Appendix 1

Topic List

Monitoring Climate Change – Biological
The hydrogen economy
Taking Action on Climate Change
The Nuclear Alternative
Causes of Climate Change
Evidence for Climate Change
Indicators of Climate Change
Competitive Advantages
Alternative energy sources
Recording Climate Change
Combating Climate Change
Outdoor Learning Possibilities
Monitoring Climate Change - Physical / Instrumentation
Are the Seasons Changing?
School Science Skills and Climate Change
Biodiversity and Climate Change
Greenhouse Gases
Climate Change and Synchrony
What is the Greenhouse Effect?
Monitoring Climate Change – Chemical

Appendix 2

PGDE Secondary General Science Task Session 2007-08 Peer Assessment

During the period 29 October - 1 November all students must visit the Biolab (ground floor Smith building) and review the displays, (do this on Monday, Tuesday or, Wednesday when you are not scheduled for other classes.). For your own and the next two numbered displays you must follow the procedures for peer assessment that require you to complete proformas which include the following information:

Feedback will be provided to the biology, chemistry and physics groups during C&P classes in week beginning 29 October 2007.

You will be asked to complete an evaluation of the task during that session.

Your own Display
Assign the appropriate number of points for **each** category for **each** display.

School name _____

1. General Appearance:

Is the display neat and well laid out? **2 pt. total**

2. Content:

Does it contain all of the required elements **2 pt. total**

3. Clarity:

Does the display make sense? **2 pt. total**

4. Group Understanding **2 pt. total**

Does the display have the potential to inform pupils/teachers?

5. Collaboration

How well do you feel your team collaborated? **2 pt. Total**

Total Points Earned: **/10**

Now rate the next two displays

First Peer Assessed Display
Assign the appropriate number of points for **each** category for **each** display.

School name _____

1. General Appearance:

Is the display neat and well laid out? **2 pt. total**

2. Content:

Does it contain all of the required elements **2 pt. total**

3. Clarity:

Does the display make sense? **2 pt. total**

4. Group Understanding **2 pt. total**

Does the display have the potential to inform pupils/teachers?

Total Points Earned: **/8**

School name _____

1. General Appearance:

Is the display neat and well laid out? **2 pt. total**

2. Content:

Does it contain all of the required elements **2 pt. total**

3. Clarity:

Does the display make sense? **2 pt. total**

4. Group Understanding **2 pt. total**

Does the display have the potential to inform pupils/teachers?

Total Points Earned: **/8**

Now Post this Peer Assessment Sheet in the box supplied.