Factors related to observed attitude change toward learning chemistry among university students

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Abstract: To gain insight into factors associated with changes in attitude toward learning chemistry, six students who displayed major attitude changes were identified through a pre- and post-course attitude questionnaire administered to sixty-six first-year university chemistry students. Those with largest attitude changes, both positive and negative, were selected to highlight the contrast between students. The six students were interviewed; descriptions of their one-semester chemistry course experiences were analyzed to identify factors associated with their change in attitude. A positive attitude change was associated with evidence of motivated behaviour, while a negative change was linked to less motivated behaviour. Students addressed similar factors in the educational setting, but students with positive attitude changes exhibited fewer negative views of educational factors, while students with negative attitude changes showed an opposite pattern. Since the same factors, students' perceived level of teacher empathy for their efforts at chemistry learning, affected both groups, this indicates a possibility for changes in educational setting beneficial to all students. [*Chem. Educ. Res. Pract.*, 2005, **6** (1), 1-18]

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Introduction

If university teachers are asked, what is the most important student characteristic associated with successful studies, they usually mention traits such as *attitude*, *motivation*, and *genuine interest*. Similarly, questions about the importance of *attitude* (Dalgety et al., 2003), and of *motivation* (Covington, 2000) have been investigated by many educational researchers.

University students' *attitude towards learning chemistry* is the focus of this study. To gain insight in what could influence changes in attitude, six first-year university students, attending an introductory chemistry course and displaying large changes in attitude toward learning chemistry were identified through questionnaires about attitudes before and after the course. These students were further interviewed about their chemistry course, in order to determine factors associated with their positive or negative *change in attitude* and its relation to *motivation* and *contextual factors*. The study intended to address the following two research questions:

What factors are related to students' shift in attitude toward learning in a university chemistry context?

What is the relative significance of the factors thus identified?

Two additional, related, important aspects that this study touched upon were: (a) the relationship between *epistemological beliefs*, motivation, and learning; (b) the effect of the *educational setting* on students' attitudes. These are treated in Appendixes 1 and 2 respectively.

Perry's theory of intellectual and ethical development of college students

A considerable part of theoretical thinking on the development of student attitudes originates from William Perry's book, *Forms of Intellectual and Ethical Development During the College Years: A Scheme*. For an extensive overview of Perry's work and subsequent research, see Hofer and Pintrich (1997).

Perry developed a theory of intellectual and ethical development among college students. He portrayed a developmental process and not static personality traits, and described nine *stages*, or *positions*, usually condensed into four sequential *categories* (Fitch et al., 1984; Moore, 1994). *Dualism* (Perry positions 1-2) is characterized by a dualistic right or wrong view of the world—authorities supposedly know the truth, which the learner could acquire. The role of the student is to learn the right answers. *Multiplicity* (Perry positions 3-4) represents a modification of dualism, with the possible inclusion of 'not yet known', in addition to right or wrong. The role of a learner is to find knowledge and also to think for oneself. *Contextual relativism* (Perry positions 5-6) represents a major shift in perspective from a world with many exceptions to right or wrong, to the opposite view, that everything is relative and context-bound, with few right or wrong answers. The learner is an active maker of meaning within a context. *Commitment within relativism* (Perry positions 7-9) mainly concerns elaboration of identity and does not refer to cognitive change. Very few undergraduate students reach the Perry positions 7-9 (Moore, 1994).

Perry's work was later modified (Fitch, 1984; Finster, 1991), and applied to science education (Mackenzie et al., 2003). Finster adopted the Perry scheme in the context of chemical education and presented examples of how a student's attitude position could affect how the roles of instructor, evaluation, and laboratory activities are viewed. This paper follows this tradition, analyzing student attitudes towards learning in terms of views of knowledge, assessment, laboratory activities, and perceptions of the roles of instructor and student. It thus has a broader view regarding both the attitude object and attitudes than is common in most science education research.

Experimental design

Sample and method

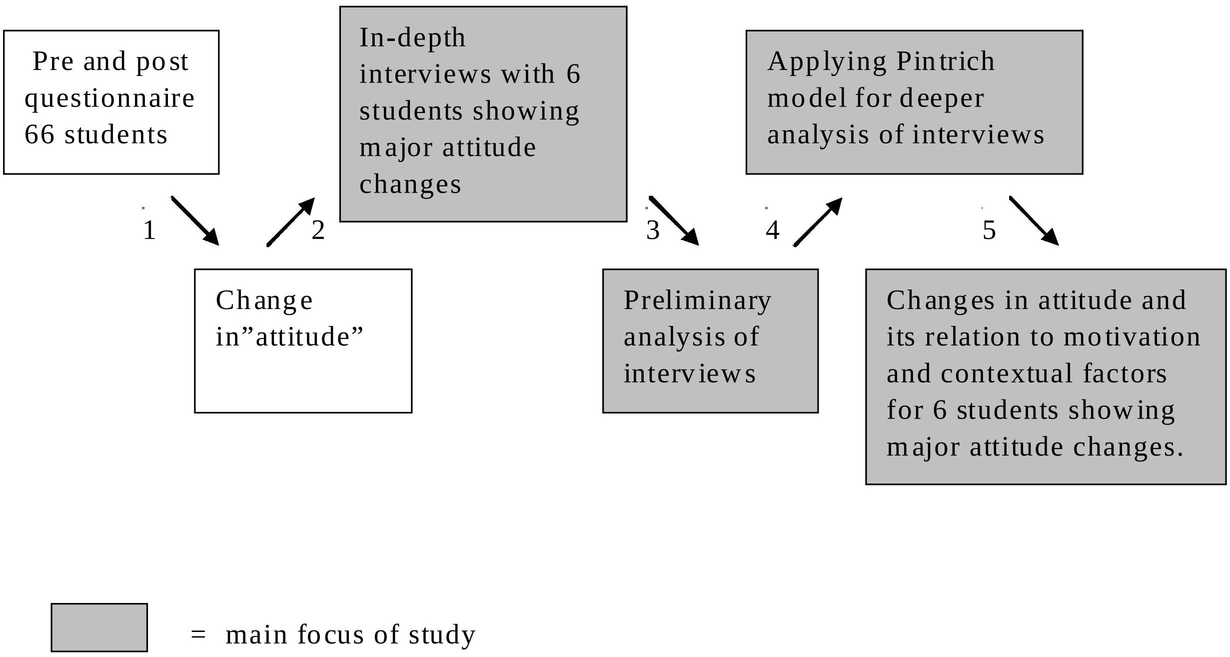
This investigation was completed during a 20-week, full-time introductory university chemistry course. Seventy-two students attended the course, and data were collected from sixty-six of them. Students were majoring in chemistry, biology, chemical engineering, biological engineering, and teacher training. The main areas of chemistry (general, inorganic, organic, physical and biochemistry) were covered in the course. Components of the schedule were *whole-group lectures*, and also *tutorials*, *seminars*, and *laboratory activities*, all the latter in smaller groups with 12-15 students. During the course students changed lecturers and lesson/laboratory instructors for each area of chemistry. Almost all, including the six students (three men, three women) interviewed in-depth, were first-year students.

To gain insight in what could influence changes in attitude toward learning chemistry; six students displaying such changes were identified through a pre- and post-attitude questionnaire administered to the sixty-six students. To understand attitude change, which generally is a long-term process, it is informative to investigate those students in whom marked attitude change has occurred.

The students selected for the interviews were those displaying the largest pre/post changes in attitudes toward learning, as assessed by the questionnaire (see below) and whom this researcher was able to contact. Three students initially selected for interviews could not be reached after the end of the course. Course results and the study program were not criteria for selection but a brief description is presented below. The six interviewed students showed a mixed picture of course results as measured by examination scores and completed laboratory reports. The three students with positive attitude shifts showed results above average and also above the three students showing negative attitude shift. The three students with negative shifts also showed about average results in the course.

All the teaching and all parts of this investigation were carried out in Swedish. The examples from the questionnaire and the interview quotations were all translated from Swedish. An overview of the experimental design is presented in Figure 1.

Figure 1. Overview of the experimental design.



Questionnaire for measuring attitude towards learning

During the second day of the course, a questionnaire was distributed and 20 weeks later, at the end of the course, the same questionnaire was distributed again. The attitude questionnaire is based on work by Perry (1970) and subsequent applications made in chemistry (Finster, 1991; Mackenzie et al., 2003), and constitutes a further development of other extant questionnaires (Henderleiter et al., 1999; Berg et al., 2003). Another chemistry attitudes and experiences questionnaire has been developed by Dalgety et al. (Coll et al., 2002, Dalgety et al., 2003), but was not used in this work.

The questionnaire was designed to assess the attitudes of students towards chemistry learning. It addressed students' view of knowledge, the role of the teacher, students' perception of their own role, of assessment and of laboratory activities. The instrument consists of thirty-four statements representing two viewpoints of the attitude object (Reid, 2003). To avoid the possibility of ambiguity, both views of each item were described with a statement. As an example, the statement *"Learning all the material covered in lectures should be enough to pass the course* "could prompt the response disagree from two students holding very different views. "*I strongly disagree since you should know much more*" and "*I strongly disagree since it is enough to know part of what has been covered in lectures*." With the two-sided format, this possibility for ambiguity was avoided. The response categories were, Strongly Agree, Agree, Undecided, Agree, Strongly Agree. Each statement pair in the current attitude instrument characterizes fully reasonable views, with no viewpoint obviously preferred over the other. To paraphrase Perry (1970), each statement pair ideally characterizes "*two different positions from which a person views his world*," See Table 1 for illustrative items.

Table 1. Some illustrative items from the attitude questionnaire.

		SA A N A SA	
1	Learning the material covered in the lectures should be enough to pass a course.	□□□□□	Learning the material covered in the lectures is not enough to pass a course.
3	I think that lecturers should avoid including course material that is difficult for the students.	□□□□□	I think that lecturers should include difficult course material to provide a challenge for the students.
19	I believe that I best learn the theory illustrated in the lab by planning and completing the experiment myself.	□□□□□	I believe that I best learn the theory illustrated in the lab if there are explicit instructions showing how the experiment should be designed and completed.
30	It is important to include working with real samples e.g. ores or food during laboratory work even if it takes more time and is more complicated.	□□□□□	To perform laboratory experiments with real samples is too time consuming and complicated to be worth the effort.

Analysis of responses from the attitude questionnaire, Step 1 in Figure 1, was conducted using PCA, *principal component analysis* (Eriksson et al., 2001). PCA is a multivariate technique in which several related variables (in this case questionnaire items) are transformed into a smaller set of uncorrelated variables, principal components. PCA resembles *factor analysis* (FA), but is not the same as FA. The main difference is that PCA explains *variability* and has a unique solution, whereas FA explains *correlation* and estimates are not unique (Jackson, 1991).

The first principal component describes as much as possible variability within the data. If the questionnaire is properly designed, the first principal component largely covers what was intended to measure by the items. Another way to describe this is that the first principal component measures the underlying basic attitude that manifests itself in the answers to questionnaire items. In this study, the first principal component describes attitude towards learning, since the statements are designed to assess views of knowledge, perception of the role of the instructor and student, assessment and laboratory activities. In our research group, data from approximately 1000 students in >10 groups collected over four years are available for analysis. Within groups a stable first principal component can be found with loadings from items showing a common pattern. PCA was used in the analysis since it is possible to position each student within the model described by the principal component. This possibility was important in selecting students for interviews, since individual student attitude shifts, within that principal component**,** can be calculated. Construct validity for the instrument is suggested by the fact that more than fifty interviews have been conducted where the interviewer did not know the students' position beforehand (the interviewer only knew that students represented a relatively high or low attitude position) but after the interview the interviewer could conclude that the student held a higher position, HiPos, or lower position, LoPos, always being consistent with the position indicated by the instrument (Berg et al., 2003). It has also been shown that learning outcome (defined as frequency and level of students' spontaneous use of chemical knowledge) from pre-lab activity and cognitive focus during laboratory work are affected by the student's position in the first principal component (Winberg et al., 2004), also suggesting that the instrument assesses central aspects important for learning.

Attitude questionnaires were collected from the sixty-six students of the sample, at both the beginning and end of course and a PCA model was fitted. These students' attitude shift in the first principal component was calculated; see Figure 2.

The interviews

As described above, six students, showing major pre- vs. post-course shifts in attitudes toward learning chemistry (three with positive and three with negative shifts) were interviewed (Step 2 in Figure 1). Their attitude shifts, compared to the whole group, are shown in Figure 2.

Interviews were chosen as a means to obtain detailed, rich information (Perry, 1970; Hofer et al., 1997; Hofer, 2001). This researcher conducted all the interviews 4-6 weeks after end of the course. The 1-2 hour interviews were quite open, since it was not known or decided beforehand what factors could be related to the attitude shift. The interviewer did not know the direction of shift of each student, only that the student's attitude had changed considerably. (A colleague performed the translation of coded identities into names.) The interviews consisted of three main questions:

1 What is your background (previous education, secondary education, working experiences, plans for the future, etc.)?

2 Could you describe your experiences during this semester of chemistry studies?

3 What further thoughts do you have about what has been said in Parts 1 and 2 of this interview?

Each student was free to select topics to talk about during the interview. Nevertheless, the interviewer tried to explore the student's study methods, and his/her experiences of the teaching and laboratory work. In addition, the intention was to highlight important aspects of student attitudes towards learning. If the student, for example, mentioned that "*the reason I found the course interesting was lectures by X,*" the answer was followed up with the question, "*could you try to think what made the course interesting?*" and, eventually, if needed, "*was it something the lecturer did, how he did it, or what?*"

Analysis of interviews was completed in four stages. During the first stage, interview passages containing information judged as relevant were marked, Step 3 in Figure 1. These passages were given short descriptions such as "*experienced lack of time,*" "*appreciated working with friends,*" "*well prepared before laboratory work*," and "*engaged teacher*". Markings and descriptions were completed with a computer program, QMA (qualitative media analyzer) (Skou, 2001). This preliminary analysis produced approximately 30 descriptors, and became a starting point for the second stage of analysis, aimed at obtaining more systematic simple categories. The descriptors were found to fit well into Pintrich's model (1994), Step 4 in Figure 1 - the majority of descriptors falling into the categories *contextual factors* and *motivated behaviour*, and several into internal factors (Table 2).

Table 2. Model for student motivation, after Pintrich (1994) (slightly modified).

Contextual Factors Factors influencing student motivation	**Internal Factors** Beliefs and emotions assumed to mediate between context and behaviour	**Motivated Behaviour** Observable behaviours that can be used as indicators of motivation
1) **Nature of Tasks** - Content/Product	1) **Expectancy Components** - Control beliefs - Attributions - Learned helplessness - Self-efficacy	1) **Choice Behaviour** - Working on course instead of leisure activity - Electing to take another course in discipline - Selecting discipline for a major or going on to graduate school or a career in area
2) **Reward/Goal structures** - Individualistic - Cooperative/Competitive	2) **Value Components** - Intrinsic/Extrinsic goals - Task value - Personal interest	2) **Level of activity and Involvement** - Trying very hard - Studying effectively, use of learning strategies - Thinking deeply, critically about material - Asking questions, taking risks in expressing ideas - High level of performance/achievement
3) **Instructional Methods**	3) **Affective Components** - Test anxiety - Self-worth - Other emotions (pride, shame)	3) **Persistence Behaviour/Regulation of Effort** - Maintaining effort in face of difficulty - Maintaining effort on ’boring‘ tasks - Maintaining effort even when fatigued
4) **Instructor Behaviour**		

During the third stage of analysis, all marked passages were re-marked, using categories from *motivated behaviour* and *contextual factors*. The categories were tagged with positive or negative descriptions. If, for example, a student stated, “*Instead of studying (what the student had planned to do) I went jogging*,” the passage was marked *choice behaviour negative*. If, on the other hand, the student stated that rather than going to the cinema with friends, she/he prepared for the next day’s laboratory exercise, the passage was marked as *choice behaviour positive*. The third stage provided an overview of the data; the total passages in different categories were summarized. A more qualitative analysis was then conducted in the fourth stage where the interview data were summarized under subcategories within *motivated behaviour* and *contextual factors*, Step 5 in Figure 1.

Results

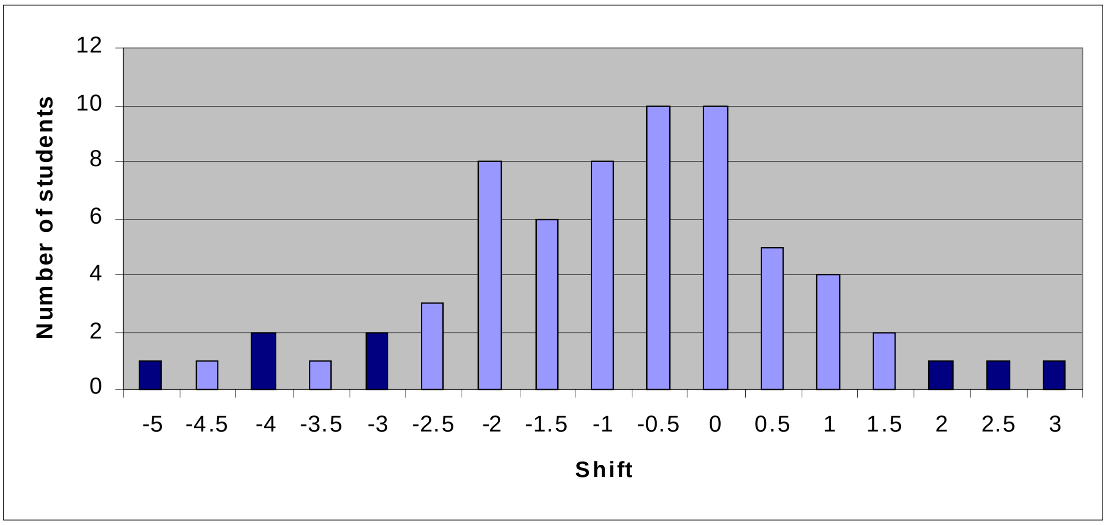
The attitude shift data for all sixty-six students are presented in Figure 2, together with identification of the six students with major attitude changes who were chosen for further investigation. Table 3 and 4 summarize the total passages in different motivational and contextual categories. This quantitative measure provides a partial answer to the first research question, *what factors are related to students shift in attitude towards learning in a university chemistry context?* But it could also provide information related to the second research question, *what is the relative significance of the identified factors*?

A more in-depth analysis of the interviews is presented in the next section, containing short summaries of each motivational and contextual subcategory. This analysis provides a qualitative perspective to the research questions posed, since nuances and emphases offered by students could be captured.

Attitude shift for the whole group and the six interviewed students

Pre- and post-course questionnaires were collected for sixty-six students, forty-three females and twenty-three males (Figure 2). This represents 92% of students who completed the entire course. The students showed a statistically significant shift toward the negative direction in principal component 1 (two sided paired *t*-test = 4.17, $p < 0.01$). This group shift in the negative direction is interesting in itself, but was not a focus of the present study.

Figure 2. Attitude shifts for student group (n = 66). The six interviewed students with major attitude changes are found in the darkened bars.



Numbers of passages in motivational and contextual categories

For all six interviewed students positive examples of motivated behaviour were found, but students with positive shifts show higher frequencies in all three categories—*choice*, *activity*, and *persistence* (Table 3). More passages that revealed less motivated behaviour were found among students with negative attitude shifts. For students with positive shifts, no examples of *negative choices* were found. The main difference between the two groups was that students with negative shifts showed forty-three examples of lacking motivation, while students with positive shifts showed seven such examples.

Table 3. Total number of passages within motivational categories

Motivation category	*Students with positive shift*		*Students with negative shift*	
	Motivation positive	Motivation negative	Motivation positive	Motivation negative
Choice	12	0	3	9
Activity	23	2	20	23
Persistence	7	5	3	11

Relations between attitude shifts and contextual factors are interesting to analyze, since contextual factors could be expected to cause a change in attitude. Positive opinions of context are found in both groups of students (Table 4). The only major difference is that students with a positive attitude shift have twice as many passages concerning *instructional methods*. Students with negative shifts expressed negative views of *context* more frequently. This group has more than five times as many coded passages in all four *contextual* categories than did students with positive shifts.

Table 4. Total number of passages within contextual categories.

Contextual category	*Students with positive shift*		*Students with negative shift*	
	Context positive	Context negative	Context positive	Context negative
Tasks	12	3	8	20
Reward/Goal	10	1	6	12
Instructional methods	26	5	13	29
Instructor behaviour	12	2	14	12

Student motivational behaviour

As summarized above, a positive attitude shift is associated with more motivated behaviour, while a negative shift is linked to less-motivated behaviour. More details are presented below from interviews of the six students showing major attitude changes that illustrate this overall picture. Data from the interviews are first presented in a condensed format in Table 5 where central themes expressed by students showing positive and negative attitude shifts are contrasted. More details are then presented under the three categories given by Pintrich (1994), (1) *Choice behaviour,* (2) *Level of activity, and Involvement*, and (3) *Persistence behaviour/Regulation of effort*.

Table 5. Student reflections on motivational behaviour.

Motivated behaviour	*Students with positive shift: central themes*	*Students with negative shift: central themes*
1) Choice Behaviour	Attended all offered teaching and chose to study further chemistry	Did not attend all offered teaching and chose to study no further chemistry
2) Level of Activity and Involvement	Worked full time or more on course. Used conscious study strategies. Course involvement remained high.	Worked full time or less on course. Study strategies were teacher dependent. Course involvement declined over time.
3) Persistence Behaviour/Regulation of Effort	Persistent when encountering demanding tasks and studied hard even after failures.	Less persistent when encountering demanding tasks. Had good intentions that sometimes remained unfulfilled.

Choice behaviour

Most of the six students made several positive choices *before* entering the university—e.g. studying subjects in upper secondary school to fulfil university admission requirements and taking extra secondary-school courses. The fact that they started studying chemistry at the university is an example of a positive choice. Two of the three students showing positive shifts have applied for more chemistry courses than is required in their undergraduate programmes; in the group showing negative attitude shifts, none. One of these students has elected to leave the program.

All instructional activities, apart from laboratory exercises, safety briefings and exams, are voluntary. The three students with positive shifts participated in all or most instructional activities. In the student group with negative shifts more examples of not attending offered chemistry activities are found. In the group showing negative shifts some students talked about choosing leisure activities before intended studies: "*I went skiing instead of studying during Christmas.*" "*Usually I could not concentrate as long as I had planned, but went jogging instead*."

Level of activity and involvement

One possible measure of student involvement is the total time devoted to studies. All three students showing positive shifts claimed that they studied 40 h/week or more, including lectures and classes, but only one student made that claim in the group showing negative shifts. Examples of elaborated and conscious study strategies can be found in both groups, but it is clear that the three students with positive shifts used more conscious study strategies, such as staying in phase with lectures. They were also more aware of why they did this: "*This is the method (studying continuously and staying in phase with the course) I have developed during my years of study*." By contrast, one student with a negative attitude shift commenting on self-discipline/regulation and the role of the teacher argued, "*If you don't have to study you don't study*." Two of three students with negative shifts explained that their involvement in the course had gradually declined over time, while this was not found at all among students showing positive shifts.

Persistence behaviour / regulation of effort

The observed pattern of student persistence and regulation of effort is complex. However it is clear that all three students showing negative attitude shifts tended to lack persistence when encountering new tasks or course demands. For example, one student found that the task of planning/preparing for laboratory activities took too much time. However, the picture for students showing negative shifts was unclear. Some instances of great effort can be found, i.e. working nine hours to really understand a laboratory activity. What is typical is that even though these students may have good intentions and understand the relevance of tasks, their persistence is low when encountering 'fuzzy tasks' (ill structured or ill formulated tasks) or "*teachers just giving formulae*."

The three students showing positive shifts displayed more persistence when encountering demanding tasks. For example, they showed a willingness to continue studying even after failing an exam, "*I will learn this even better*." One student showing a positive attitude shift explained his point by saying, "*I'm not brilliant, but I'm rather stubborn and focused*."

Student contextual factors

Students' reasoning about contextual factors is presented under the four Pintrich (1994) categories: (1) *Perception of instructor behaviour,* (2) *Perception of tasks,* (3) *Perception of reward and goal structures,* and (4) *Perception of instructional methods.* Data from the interviews are first presented in a condensed format in Table 6 where central themes expressed by students showing positive and negative attitude shifts are contrasted. More details are then presented for each contextual factor.

Table 6.Students' reflections on contextual issues

Contextual Factors	*Students with positive shift: central views*	*Students with negative shift: central views*
1) Nature of Tasks	Appreciation or acceptance of task. Task requiring self regulated learning viewed as acceptable or suitable. Applications of chemistry (e.g. to biology) not mentioned as important.	More complex and critical views of tasks. Tasks requiring self regulated learning viewed as too demanding or time consuming. Applications of chemistry (e.g. to biology) mentioned as important and interesting
2) Reward and Goal structures	Possibilities to work collaboratively seen as positive. Good examination results viewed as encouraging.	
3) Instructional Methods	Generally positive view of instructional methods. Experienced lack of time during the course was less prominent.	Less positive view of instructional methods. Experienced lack of time during the course was prominent.
4) Instructor Behaviour	Coherent descriptions of 'good teachers' and 'bad teachers'. Alternative explanations, eagerness to answer questions, being available and showing an understanding that certain topics are hard to understand were appreciated traits. 'Bad teachers' were described as the opposite.	

Perception of tasks

All three students with positive attitude shifts gave mainly positive views of tasks. Two specifically mentioned tutorials with broader and more open-ended questions as very useful for deeper processing of knowledge. As one student stated, "*I got on further in my knowledge (during tutorials)*." The anticipation, or at least acceptance, of demanding tasks, e.g. planning open laboratory activities and tutorials, was found for two of three students with positive shifts. The students with negative attitude shifts did not mention such tasks as something positive. One student clearly stated that she wanted to understand, but opposes course demands for self-regulated learning (i.e. preparing individual flow charts for laboratory activities). One student with a negative shift clearly stated that he wants more tasks clearly connected to biology, and was very positive about the few connections that were made to biology. Among students with positive shifts, this need for applications in biology was not expressed. One student even commented with astonishment/self-surprise that she appreciated tasks without connection to biology. Both of these students pursued a major in biology.

To summarize, students with positive attitude shifts appreciated or at least accepted most course tasks presented to them. Students with negative shifts expressed more complex and critical views. These critical views were most apparent for tasks that required self-regulated and more demanding learning.

Perception of reward and goal structures

Two students with negative attitude shifts and one with a positive shift described the possibilities of working together during laboratory activities and exercises as very positive; no student mentioned it as something negative. It is obvious that good examination results (sometimes described as better than expected) are very important for self-confidence. This was highlighted by five of six interviewed students. A student with positive shift, who had been very nervous before the first examination, commented: “I was one of the better ones in the exam and my self confidence grew”. Only one student with a negative shift didn’t describe growing self-confidence after passing exams—this student had not passed exams.

Perception of instructional methods

At a surface level, a continuum was observed in student perception of instructional methods, with three students showing positive shifts on one side and three showing negative shifts on the other. The student with the most positive shift concluded, “*You (teachers and the department of chemistry) have done what I as a student could expect*” in a passage where he reported that he attended and appreciated lectures, laboratory work, and exercises during the course. At the other end of the continuum, a student with negative shift characterized her impression of laboratory work as, “*I just wanted it to end*” and contrasted the demanding studies she experienced with other less-demanding studies. This student also stressed she experienced lack of time. Regarding ’lack of time‘, only one student with positive attitude shift mentioned this, while all three students with negative shifts, in some instances, claimed to have experienced lack of time.

The possibility of asking questions and receiving answers was described as positive by all three students showing positive shift, while only one student with negative shift gave the same description. The lack of personal contact described by one student with negative shift could be viewed as an opposite experience, since the opportunity of asking questions is one type of personal contact.

Perception of instructor behaviour

The interviewed students devoted considerable attention to their teachers and their behaviour. They often spontaneously contrasted ‘good teachers’ with ‘bad teachers’. An example of this was a student who appreciated teachers who were able to give alternative explanations when she did not understand. She gave an example of the opposite: “*he didn’t listen to what we wanted to (be clarified) but instead just said the same thing once more*.” This way of describing instructor behaviour was used both by students showing negative and positive shifts (two of three in both groups). The descriptions of ‘good teachers’ were very similar within both groups. The students described ‘good teachers’ as: creating an atmosphere where it is accepted to ask questions; giving alternative explanations when students don’t understand; being ‘structured’, being available, and realizing that certain areas of chemistry are hard for students to understand. The student descriptions of ‘bad teachers’ also share many traits in common, such as: seeming to become angry when students ask questions; answering by saying “*this is the way it is*”, and seeming to “*want to be somewhere else*.”

Summary of information found for the two research questions

First research question: What factors are related to students' shift in attitude toward learning in a university chemistry context?

Evidence from interviews coinciding with Pintrichs' model. The first step in analyzing the interview material resulted in approximately thirty categories, which included everything judged as relevant. During the next stage of analysis these categories were found to fit a model of motivation described by Pintrich (1994) (see Table 2). In Pintrichs' model, contextual factors in conjunction with students' internal factors (motivational beliefs and emotions) affect motivation, which can be seen in motivated behaviour. This model is, as Pintrich emphasizes, a simplification, since this relationship is also reciprocal.

Information about internal factors generally absent. During analysis of the interviews using Pintrich's categories, some passages fell into internal categories (e.g. self efficacy and task value), but these internal factors are not readily accessible—they are, as described, internal. An attempt was made, nevertheless, to describe information gained in this category. For two students, one with positive and one with negative shift, internal information was obtained, while the remaining interviews contained almost no information regarding internal factors. One way to understand this could be that students employing metacognition were able to give information on these internal factors during interviews, while those lacking metacognitive skills could not. This would be in accord with previous findings that the majority of college students fail to show metacognitive skills (Hofer et al., 1997).

Contextual and motivational categories show clear relations to attitude change. The relation found between attitude shift and student motivation is that a positive attitude shift is associated with motivated behaviour while a negative shift is linked to less motivated behaviour. This is found for all three motivational categories, choice behaviour, level of activity and involvement, and persistence.

The primary relationship found between attitude shift and contextual factors is that students with negative shifts give many more instances expressing negative views of context and also employ greater emphasis. This is found for all four categories, *nature of tasks*, *reward and goal structures*, *instructional methods*, and *instructor behaviour*. Students with positive attitude shift show essentially the opposite pattern with more instances and emphasis related to positive views of contextual factors.

The descriptions of the semester showed a mixed picture. The finding of a mixed picture containing both negative and positive views expressed by students is perhaps not surprising, since interviewed students described one full semester of chemistry studies. During this semester they had encountered all main areas of chemistry and numerous different teachers. Although both groups displayed this mixed picture of experiences, what is most notable is that negative views of context and examples of less motivated behaviour are more frequent among those students with negative attitude shifts.

The second research question: What is the relative significance of those identified factors?

The interviewed students' views of context are valuable since contextual factors could, at least partly, be an underlying cause of attitude change (Osborne et al., 2003). Evidence of motivated behaviour, on the other hand, could be viewed as confirming a positive attitude change.

The difference is in the balance of experiences. The pattern of roughly as many positive views of context for both groups and many more negative views expressed by students with negative shifts (Table 4) indicates that the main difference is the balance between positive and negative experiences. For students with negative attitude shifts the balance tilted in a less favourable direction. This is especially pronounced for tasks and instructional methods where negative views were more than twice as frequent as were positive views. In contrast, the group with positive attitude shifts show at least three times more positive views of context compared to total negative views within all four categories.

Good and bad teachers, consensus among students. Students with both positive and negative attitude shifts share essentially similar views of instructor behaviour. They speak frequently about their teachers with considerable emphasis suggesting that this is important to them. Good instructor behaviour is described by both groups as: eager to answer questions; being available and having an understanding that certain things are hard for students to understand.

It is instructive to reflect upon what was *not* said about teachers. An example is that teachers' knowledge in chemistry was never mentioned, even though students spoke considerably about their teachers. Within the category of *reward and goal structures,* students also agree that the opportunity to work collaboratively was appreciated and good examination results were viewed as encouraging.

Tasks and instructional methods, disagreement among students. Regarding the nature of tasks and instructional methods, some discrepancies are worth noting. For tasks requiring more self-regulated learning, such as planning open experiments and tutorials, students with positive attitude shifts reveal greater acceptance, while students with negative attitude shifts are more reluctant to express positive views, even if they expressed an understanding of the relevance of such tasks. Experienced time constraint is another factor where views of the two groups differ. Students shifting negatively in attitudes generally reported more time constraints in their chemistry classes than did positive-shift students.

Same factors but difference in experience. Regarding the relative significance of identified factors, it can be concluded that both groups spoke about similar factors, but the balance between positive and negative views differs considerably between groups. Students showing positive attitude shift exhibited few negative views of context, tilting the balance favourably, while students with negative attitude shifts show the opposite pattern.

Discussion

Show students respect in their chemistry learning

The overall goal of this study was to obtain insights regarding what factors within a university chemistry setting can favourably affect student attitudes and motivation. Much of what was found could be summarized as an instructor admonition "*show the students respect*". That instructor respect can be conveyed as a genuine interest in student learning, offering clear goals and instructions, expressing acknowledgement that certain tasks can be difficult for students, and being available for students. The teachers' respect and empathy for students' learning (or the opposite) was a thought that all interviewed students expressed;

some examples/suggestions are offered in Table 5 regarding how this respect and empathy could be conveyed in more concrete terms. The examples given should not be viewed as patent solutions or as the only important aspects of learning, but as factors, which, according to this study, could favourably affect student motivation and learning.

Table 5.Summary of suggested educational implications.

Stimulate situations/atmosphere like these	*Avoid situations/atmosphere like these*
Teachers being available (mentally and physically) to students, creating an atmosphere where it is acceptable to ask questions and it is accepted that everything may not be understood immediately.	Teachers just ’teaching’ with no genuine interest conveyed in student learning. Viewing student questions and problems as unwanted interruptions in their teaching.
Teachers being accessible especially when students approach demanding tasks.	Students not allowed contact with teachers especially during demanding tasks.
Opportunities for students to work collaboratively and exchange ideas.	Individualistic, competitive atmosphere producing only a few ’winners’.
Where appropriate and possible, connect chemistry to other subjects and situations.	Chemistry viewed as an isolated subject with no applications to areas outside chemistry.
Convey clear instructions and goals especially when students are expected to accomplish intellectually demanding or new tasks—e.g. planning experiments or tutorial questions with no clear, single answer.	Assigning students ill formulated or badly planned experiments or tasks. This should not rule out ’ill formulated‘ tasks if they are intentionally set and students are aware that reality is seldom simple and that they must learn to deal with such situations.
Allocate enough time for students to accomplish a task and communicate clear goals for what is expected.	Create real or perceived lack of time so that students feel that “*it’s useless for me to try*”.

The examples given above are congruent with much previous research (Dalgety et al., 2003; Osborne et al., 2003 and references therein) and, hopefully, also in accord with personal experiences of university teachers. Remember, that these examples are based on what, according to the interviews, stood out for students.

Learning conditions suitable for all students

It is worth noting that students in their descriptions of teachers contrast the pros and cons; the most striking feature is similar descriptions (of good and bad teachers) from both students with negative *and* positive shifts. This indicates a consensus among the six students of the characteristics a good teacher. Support for the commonly expressed view that “*anything I do as a teacher will be good for some and bad for others*” is not found in this study. Instead, students give quite coherent descriptions of what they have appreciated and valued, but also what has not been experienced as especially positive. A trait described positively by some students is *not* described negatively by others or vice versa. The only example pointing in this direction is acceptance of more demanding tasks (e.g. planning your own experiments), which was found among students with positive attitude shifts, whereas students with negative attitude shifts often mentioned this kind of tasks as too demanding. In the interviews there are indications that major student objections toward these demanding tasks is attributable to time constraints and unclear goals, and not necessarily to the demanding tasks themselves. This illustrates the importance of clear aims and goals in conjunction with appropriate time allocated for tasks.

Two areas at the periphery of this study are the importance of students' *internal factors,* such as self-efficacy and goals, and the *attitude change of the entire group* of students over the course. With respect to internal factors, the data collected was not considered rich enough for analysis, something that could perhaps be overcome by an interview format aiming at those internal factors. The observed negative attitude shift of the entire group of students in this study (Figure 2) is not particularly encouraging, since goals of university education are to "*provide the students with a capability of independent and critical judgment, an ability independently to solve problems and an ability to follow the development of knowledge, all within the field covered by the education*" (Swedish higher education act, 1992). One constructive way to approach this important but disappointing finding could be through action research, based on this and other studies (Dalgety et al., 2003) clearly focusing on student attitude development as a complement to other efforts to create environments suitable for good learning.

Final reflections

After listening to students and trying to evaluate the relationship among attitude towards learning, motivation, learning context and, ultimately, learning outcomes, this researcher is struck by the differences/discrepancies in students' stories about what affected them during their semester of chemistry study and efforts by the chemistry department to increase the quality of teaching. The departmental focus has been on selecting the best available literature and level of content, favourable schedule, choosing appropriate laboratory activities and tutorials, while students primarily focus on teacher attitude, atmosphere, and other 'soft' values.

It is tempting, in conclusion, to speculate that university teachers should consider those aspects of student learning as of equal importance to course features already considered.

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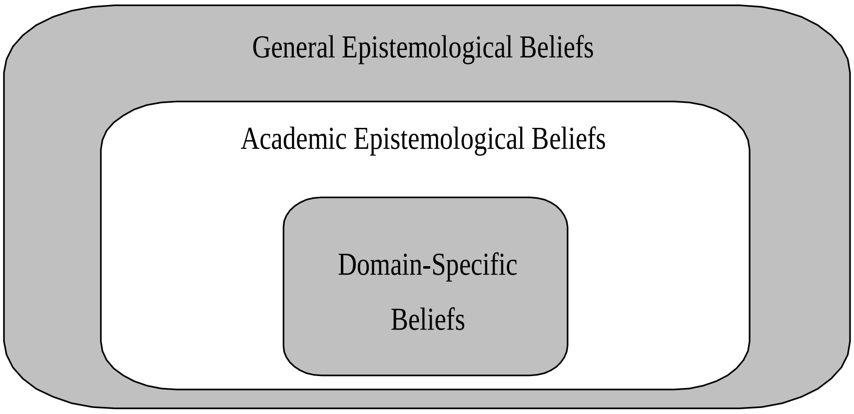
Appendix 1: Epistemological beliefs, motivation, and learning

The present study focuses on attitude towards learning, *where knowledge is central*, and is thus closely related to research into personal epistemological beliefs. *Epistemology* concerns the nature and justification of human knowledge, while *epistemological beliefs* denote “the theories and beliefs they hold about knowing, and the manner in which such epistemological premises are a part of and an influence on the cognitive processes of thinking and reasoning” (Hofer et al., 1997).

An example: The way a student approaches and views laboratory activity is affected by the student’s epistemological belief. A view, that knowledge is a set of accumulated facts and the student a receptor of knowledge, may create a view of laboratory activity as an illustration of facts and learning of procedures. A view that knowledge is an integrated set of constructs and the student constructs knowledge may, on the other hand, stimulate a view of laboratory activity as a situation where knowledge is generated and the student is learning not only procedures, but also scientific methods.

Beuhl and Alexander (2001) present a model illustrating the multilayered nature of epistemological beliefs, with domain-specific beliefs as part of a full epistemological belief system (Figure 3). The focus of the present study is on the domain-specific beliefs as reflected in views of knowledge, perception of roles of instructor and student, assessment and laboratory activity.

Figure 3. Model of an epistemological belief system (Buehl et al., 2001).



What causes changes in epistemological position?

In the field of research on epistemological beliefs there is consensus about a trend toward developmental progression, particularly for those who experience a college education (Hofer et al., 1997). However, there is less agreement on what causes this change; this has been suggested for further research by several writers (Hofer et al., 1997; Paulsen et al., 1998; Buehl et al., 2001; Hofer, 2001; Schraw, 2001; Osborne et al., 2003). For example, Hofer argues: “Regardless of the model, there has been a presumption of all those working in this area that educational experiences play a role in fostering development or belief change. But what types of experiences are most conducive? What instructional strategies can best be employed? Although the literature is replete with advice, less research exists that clarifies the relation between methods and types of instruction and personal epistemology.” (Hofer, 2001, p. 372).

The present study addresses this question of “*what experiences and what instructional strategies fosters development and belief change*?” raised by Hofer. The instructor respect described in the discussion and the suggested educational implications found in Table 5 are a partial answer for this question, in university chemistry setting.

Relations between epistemological beliefs, motivation and learning

The relationships among epistemological beliefs, motivation, and learning are important, especially in real educational settings, and it has been shown that epistemological beliefs affect motivation as well as the quality of learning (Hofer et al., 1997; Paulsen et al., 1998; Hofer, 2001). The importance of epistemological beliefs for student learning and motivation has been described in a working model by Hofer (2001), where epistemological beliefs affect student motivation and strategy selection, which then, separately and in conjunction, affect learning.

In the present study, a more positive attitude towards learning has been accompanied by more motivated behaviour. This could be seen as confirmation of the model described by Hofer, even if attitude, as viewed in this study, is broader than epistemological belief since it includes views of knowledge, instructor and student roles, laboratory activities, and assessment.

Appendix 2: Educational setting and students' attitudes

The effect of educational setting upon student attitudes is of major interest to teachers and researchers. This interest could be captured by this fundamental question. *Is there a (positive) effect of efforts to create classroom environments suitable for good learning?*

Attempts to answer this question have been made by studying many students in diverse educational settings and applying statistical analyses to characterize relationships (e.g. Ramsden et al., 1981). In their study Ramsden and Entwistle found a profound effect of the educational setting upon the orientation and study approaches of students. Another approach has been to investigate, with a smaller sample of students, how students adapt to different educational settings (Hofer, 2004). This study showed that first-year college students view knowledge in science as more certain and unchanging than they do in psychology. Both studies indicate the importance of educational setting and subject in developing students' attitudes towards learning.

In the present study a third approach was used, studying the students with major attitude changes in *one* educational setting. It was found that essentially the same factors in the educational setting had affected students with negative *and* positive attitude shifts. Even though the same factors had affected students the balance in experiences was very different. Students showing positive attitude shift exhibited few negative views of factors in the educational setting, tilting the balance favourably, while students with negative attitude shifts show the opposite pattern. More detailed information about factors in the educational setting and their effect is presented in the results and discussion sections of the article.