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How to form creative learners in science

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Abstract

Creative learning involves meaningful learning, ownership of learning, control of learning processes and innovation when new understanding is realised. In order to produce learning situations where creative learning is achieved, teachers have to create trustful atmospheres where students are allowed to think and discuss without critical evaluation of the teacher. It is also important to create practical exercises in which theoretical models are processed and connected to observations. During many years we have tried to develop courses in science with the goal to promote students to become independent learners and explorers out of their own prerequisites. Different methods and designs of teaching have been investigated and the variation of the student's creative learning was observed. To continue this development, we here are investigating a chemistry course. Chemistry involves considerable amounts of abstract thinking. Further, as many students had bad experiences from school this was a challenge. 17 preservice teacher students were trained by one teacher to become independent and creative in their own learning of chemistry. The course of 10 full days over three weeks included practical activities mixed with discussions in groups followed by discussion with the teacher in order to connect theory with practical exercises. The students wrote short reflections after each week answering the questions: What do you take with you from your own learning processes and/or in meeting other's learning processes? What surprised and/or amazed you most? The three reflections where analysed by qualitative methods scoring demonstrations of professional development, process thinking and learning processes. Our results showed that students negative to chemistry changed their opinion and enjoyed thinking of phenomena in everyday life with chemical perspectives. All students expressed the importance of practical exercise and group discussions in their own learning. The reflections contained detailed chemical explanations, concepts used properly and were describing their learning processes. They also used their experiences when they discussed how to design teaching situations. Thus, the design of the course promoted creative thinking and deepened their understanding of chemistry.

Keywords: Creative learning, preservice teacher students, chemistry education, reflections

1. Introduction

It is important for teachers to establish an environment for creative learning that allow students to think and discuss without critical evaluation. This can be done by changing from teacher-centred to student-centred teaching and learning where students are responsible for their own learning [1]. Creative learning emerges when learning is meaningful, self-motivated and innovative [2]. Teaching should be inquiry based and connect observations to theoretical models for students to create their own knowledge [2]. By asking questions and solving problems during inquiry, students can make connections between theories and practise [2]. Another important aspect of creative learning is that students are engaged, collaborate with others and enjoy exploring further [1] [3].

We have tried to develop courses in science in order to achieve students becoming independent learners. A variation of methods and designs of teaching have been investigated and the student's creative learning was analysed [4] [5] [6] [7]. To further develop creative teaching, we have been investigating a chemistry course. Chemistry involves considerable amounts of abstract thinking. Further, as many students had bad experiences of chemistry from school this was a challenge.

2. Course description

17 preservice teacher students for year 4–6 were trained by one teacher to become independent and creative in their own learning of chemistry. The course of 10 full days took place over three weeks. During these weeks, students were working on different experiments to get an understanding of molecules and mechanisms in nature. Students were studying and working with questions in a Science textbook in English as well as a textbook on chemistry education in Swedish during the

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campus free days. The emphasis was included practical activities mixed with discussions in groups followed by discussion with the teacher in order to connect theory with practical exercises. The teaching started with a short introduction to the subject and the concepts that had to be investigated in the first experiments. Students made observations and discussed the outcome of the experiments in small groups sitting in small islands in the course lab while the teacher supervised and listened to the discussions. Finally, the teacher discussed with all students allowing them to describe what they have understood followed by a summary of the theory behind the concepts by the teacher. The course also included a guided visit to the Vasa Museum in Stockholm showing the chemistry around a wrecked ship from 17th century saved sixty years ago. The students wrote short reflections after each week answering the questions: What do you take with you from your own learning processes and/or in meeting other's learning processes? What surprised and/or amazed you most? These questions have been developed since 2011 by us as being successful for written reflections about learning processes. The students were assessed through a written exam.

3. Methods.

The three reflections were analysed by qualitative methods scoring demonstrations of professional development, process thinking and learning processes. The analysis was focused on six categories: A. changed attitude towards chemistry, B. connection to everyday life, C. importance of practical exercises for learning, D. importance of group discussions for learning, E. chemical descriptions using concepts and F. connection to future profession as teacher.

4. Results

4.1 Analysis of student reflections

The first week many students expressed their negative experience of chemistry at school and that they were more interested now and found it meaningful (Fig. 1, A reflection 1). At the end of the course students described how they will teach as professional teachers (Fig. 1, F reflection 3). Also, a few students reflected on chemistry as school subject and learning in more general terms at the end of the course.

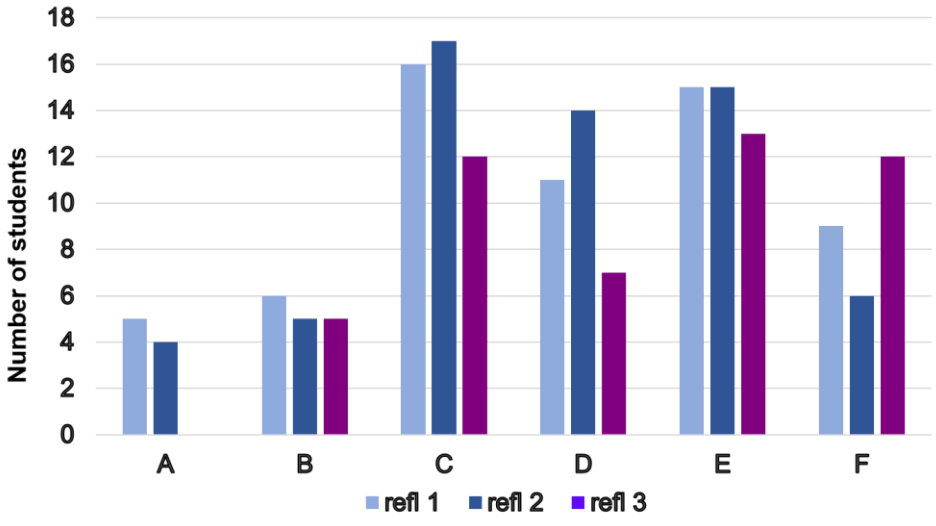

Fig. 1 The graph shows the number of students using categories A – F in each reflection (refl. 1 – 3.)

A	changed attitude towards chemistry
B	connection to everyday life
C	importance of practical exercises for learning
D	importance of group discussions for learning
E	chemical descriptions using concepts
F	connection to future profession as teacher

A	B	C	D	E	F
29%	59%	100%	94%	100%	65%

Table 1. Total number of students referring to the categories A – F in the three written reflections (n=17).

Table 1 show that all students described experiences from the exercises in the lab using chemical concepts and explanations. The students found that practical work is very important for their learning. Most students also refer to the importance of group discussion for their understanding of models and theories in chemistry. This agrees with the definition of creative learners that group discussions and practical activity enhance creative learning [1], [2]. Already after one week many students already used concepts correctly when describing a phenomenon that surprised them. The analysis also showed that two thirds of the students were confident enough in chemistry to teach the subject in their future profession. Already after the first week the atmosphere in the lab was very joyful and open and the teacher and students had good and trustful relations. Students were describing how they by formulating different hypothesis and explanation to each other are helping others to understand the abstract models.

4.2 Example of the different categories from the reflection

A. ”What surprised me the most is my understanding of the subject of chemistry. During my schooling, both I and others have had a very difficult relation to chemistry. Partly because we did not find the subject interesting, that the educator did not introduce the subject in an interesting and proper manner and that the subject's various terms made us feel negative to make an effort during the chemistry lessons.”

B. “Learning from the place (the Vasa Museum), on the spot, gives a lot. You get links to other things related to reality. What you learn is not just school knowledge”.
“I saw the logic, which made me realize that I know a lot of chemistry without having reflected on the fact that it is actually chemistry. I have mixed mustard vinaigrette countless times without reflecting on that it is a mixture that is made possible by just the mustard when it acts as emulsifier and disperse the fat into small, small droplets which then creates the emulsion.”

C. “I bring with me the importance of experimenting and thinking for myself, in order to be able to approach an understanding of different phenomena in the chemistry world. With the opportunity to do, observe, think and discuss, one can "carry" the knowledge. When performing different types of experiments that give similar results, you can see patterns and get to learn to observe carefully.”

D. “It has been interesting to work in groups. This is something that has benefited me positively because I do not have much knowledge about the subject of chemistry in general. By having socialized with others I have learned about new knowledge and thoughts and other things that I did not think about. I have more or less succeeded in contributing new ideas and thoughts while my group managed to raise me and make me more comfortable to actually dare to say what I think and feel.”

E. “An example of this is when we today talked about emulsion and how emulsifiers work, and then fed back to digestion and bile which in the body works just like emulsifying agent. In this way, understanding becomes deeper in both the biology and chemistry topic.”

F. “Everything we do in the class is not just about studying for an exam. I see a pattern in the whole, I assume the teacher's assignment at the university is to show a working method for us which we will later do the same with our students at school. We should be able to convey that it is important to cooperate with their classmates in order to gain a deeper understanding of the topic. It is not the result

that is most important at the examination, but the knowledge about what you have learned and what you can teach later."

6. Summary

Our results showed that students negative to chemistry in the beginning of the course changed their opinion and enjoyed thinking of phenomena in everyday life with chemical perspectives. All students also expressed the importance of practical exercise and group discussions in their own learning. The reflections contained detailed chemical explanations, using concepts in a proper way, describing their learning processes during the course. They also used their experiences from the course when they discussed how they will design teaching situations in chemistry as future teachers. A teaching primarily based on curiosity both on the subject but also in widening the perspectives in corporation with the students in order to promote their personal relation and understanding of the subject content. Thus, the design of the course promoted creative thinking and deepened their understanding of chemistry.

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