DEVELOPMENT OF OBSERVATION SKILLS IN SCIENCE EDUCATION FOR ENHANCED UNDERSTANDING

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Observation is a skill necessary for the development of knowledge in science and is used, e.g., in studies to notice patterns and connections between abiotic and biotic factors, or in laboratory experiments where detailed observations are necessary to achieve understanding. Observation does not only include viewing details but also hearing, smelling and tasting to get all available information from the senses. How students perceive the information depends on their previous personal experiences. It is therefore essential for students to practice the ability to observe and to understand the contextual importance for learning. Here we present a study where 55 pre-service preschool teacher students attended a science course for 10 weeks with a variety of exercises. Late in the course they visited a Natural History Museum, a greenhouse with plants adapted to Mediterranean climate conditions and an art museum. Evaluation of written reflections after the visits were done by using the quality marker 4R's of Doll's (Relations, Recursion, Richness and Rigor) for the Natural History Museum and the greenhouse and Roland Barthes concepts studium and punctum for the art museum. Our results showed that the students described their experiences from the visits in a personal way with high quality. The variation of activities was important for the students' ability to observe and to understand how to design pedagogic activities for children in preschool.

Keywords: observation, pedagogic activities in museums, pre-service preschool education,

INTRODUCTION

Perception may be "the ability to see, hear, or become aware of something through the sense" while *observation* is described as "the action or process of closely observing or monitoring something or someone" were *observe* is to "notice or perceive (something) and register it as being significant" (Oxford University Press, 2018). Thus, observation is a more complex action where it is necessary to interpret the input by perception and to put it into a context by cognitive processes.

Small children develop knowledge of their surroundings by observations, experiments and repeated training. For example, the understanding of shadows may be a result of the child's repeated inquires by itself which finally gives the experience that the own shadow with the aid of light is a projection of an image of the child itself.

Observation is also a skill necessary for the development of knowledge in science and is used, e.g., in studies to notice patterns and connections between abiotic and biotic factors, to understand nature and the interaction of animals and plants in a wide context, in laboratory

experiments where detailed observations are necessary to achieve understanding, or to detect technology in our surroundings. Observation does not only include viewing details by the naked eye but also by hearing, smelling and tasting in order to get all the information from the senses. It also depend on experience and understanding of the situation (Pugh & Girod, 2007, Kohlhauf, Rutke, & Neuhaus, 2011). Therefore, training of observations of details in different situations is necessary in order to understand complex situations. Observation competences of children are primarily dependent on their previous knowledge based on experience and not so much on their language skills (Kohlhauf, Rutke, & Neuhaus, 2011). The observation skills can be divided into three levels, incidental, unsystematic and systematic observations with three dimensions describing, scientific reasoning and interpreting (Kohlhauf, Rutke, & Neuhaus, 2011). In order to promote knowledge in science the teacher should create conditions and situations to enhance the achievement of understanding starting from the student's own experiences (Pugh & Girod, 2007). These activities should be diverse and promote students to inquire and explore. They include training of the observation skills of the students in order to detect details and to create understanding by connecting the observations with their previous experiences. Learning is also enhanced in a sociocultural environment where children communicate their understanding to each other, thus demonstrating different perspectives. To verbalize the process of learning and to make knowledge visible are other important issues enhanced by working in groups (Johnston, 2009).

In the goals for development and learning in Swedish Curriculum for the Preschool science education is pronounced:

The preschool should strive to ensure that each child

– develop their interest and understanding of the different cycles in nature, and how people, nature and society influence each other,

– develop their understanding of science and relationships in nature, as well as knowledge of plants, animals, and also simple chemical processes and physical phenomena,

– develop their ability to distinguish, explore, document, put questions about and talk about science (Skolverket, 2011, p. 10).

This means that the education of pre-service preschool teachers has to involve training of skills to help them to make observations and recognize the process of using it in order to understand complex situations in science. Here we present a study on the development of the scientific content knowledge and the pedagogic content knowledge of pre-service preschool teachers during a science course.

OBJECTIVES

As shown above it is not sufficient for the teacher to carry out demonstrations in order to create understanding of scientific relations. The demonstrations will be perceived differently by the students, primarily depending on the large variation of their previous experiences. Here we focus on two questions. How do the students perceive the information from

observations differently? Is it possible to train students to increase their ability to observe and enhance their understanding of the contextual dependence?

COURSE DESCRIPTION

During a 7 weeks course in science (biology, chemistry and physics), 55 pre-service preschool teacher students was given a variation of exercises including experiments and excursions as well as creating pedagogic activities for children. All exercises where carried out in groups of 5−6 students. During the course students wrote four scientific reports where they described the exercise, the goal, their observations, questions and reflections of their own learning processes. These reports where commented by students or teachers in order to further develop the student's understanding of the exercises and their connections to the development of the students'. After six weeks the students visited the Natural History museum in Stockholm to study dioramas with plants and animals typical for Sweden and the Edvard Anderson Conservatory, a greenhouse in Bergius Botanic Garden in Stockholm, to investigate vegetation in four different regions of the world (Mediterranean, South Africa, California and Australia) and tried to find out how plants are adapted to these different areas with Mediterranean climate. They wrote reflections from the visits of the Natural History museum and the greenhouse about their own personal experiences and made a pedagogic plan of how to use the museum and the greenhouse in pedagogic activities for children in preschool, including aim with the visit, what to do during the visit, how to document it, and how to follow up (evaluate) the visit. Two days later the students went on an excursion in the city of Stockholm trying to find out the special features of different places selected by the teachers and to create personal relations to these places. This exercise created experiences of different spaces. They also visited the Museum of Modern Art in Stockholm in order to train the ability to observe, analyse, make reflections, and make documentations of the exhibition "Life itself" and art work by Alexander Calder, Niki de Saint Phalle or Jean Tinguely. In order to promote this and increase the quality of their reflections the students got a short instruction how to analyse the art work based on the concepts *studium* and *punctum* by Roland Barthes (Wikipedia, 2017).

After seven weeks the students had a written exam in which with three different tasks included in Table 5 below. They should give examples of the scientific content and phenomena in preschool environment (question 1), the importance of scientific discovery (question 2) and how to describe nature and its cycles (question 3). All three questions have to be approved for the final mark "passed" and for the "high mark", at least two questions had each to be assessed "high mark" and one question with "passed".

METHODS

The quality of written exams and reflections from the visit in the Natural History Museum and Edvard Anderson Conservatory was made using the quality markers 4R's of Doll's, *Relations*, *Recursions, Richness* and *Rigor* (Doll, 1993). Doll's 4R's where compared with the evaluation of the reflection of the artwork using Roland Barthes *studium* and *punctum* (Table 1).

Table 1. Tools for analysing texts.

Texts	**Assessment**
Visit at the Natural history museum and green house	Quality markers Doll's 4 R's
Visit at the Museum of Modern art	Roland Barthes' concepts s*tudium* and *punctum*

Barthes described *punctum* and *studium* as two ways to experience images. *Punctum* as an unconscious personal feeling that something in the image pierces the viewer creating a wound or a scar and *studium*, opposite *punctum*, the meaning and explanation the image describes. (Barthes, 1981). The quality markers had three different levels in each category used in the analysis (Table 2) and the *studium* four different levels of quality (Table 3) (Mutvei, Lönn, & Mattsson, 2017, Mattsson, Lönn, & Mutvei, 2017).

Table 2. Assessment rubric for the assessment of the 4 R's of the examination task (Mutvei, Lönn, & Mattsson, 2017)

Relations	1. Describes relations between persons or objects and context.
	2. Emphasizes the importance of interactions.
	3. Describes the process.
Recursion	1. Refers to previous experience
	2. Refers to learning out of previous experience.
	3. Consistently use of recursion.
Richness	1. Rich vocabulary and varied language use.
	2. Writing in own words, indicating acquired knowledge.
	3. Use of several approaches (perspectives, dimensions).
Rigor	1. Unexpected change of subject within the context
	2. Unexpected change of subject outside the context
	3. Courage to leave the framework totally and enter new contexts.

Table 3. Rubric for the assessment of art work reflections (Mattsson, Lönn, & Mutvei, 2017)**.**

Punctum	1	Refers to a touching detail establishing a direct personal relationship.
Studium	4	Refers to personal experiences not shown in the related art work.
Studium	3	Refers to strong emotions related to the art work
Studium	2	Explains the personal choice of art work (recognition)
Studium	1	Description of the art work

Associations between marks of the different questions in the final exam and the quality marker of 4R's and *studium* were analysed and visualized using classification trees (package rpart) and generalized linear models using the mark (high mark/not) response assuming a binomial error using the R statistical program (R Core Team, 2017).

RESULTS

Analysis of *studium* and *punctum* showed a high level of quality on the reflections about the artwork. More than half of students referred to strong emotions in relation to the art work (Table 4). Among these, half of the students referred to important personal experiences outside the context of the art objects. Almost all students explained their personal choice of art work. Only 9 students referred to a touching detail establishing a direct personal relationship. The result of the written examination showed that 32 students passed, 14 had higher mark (Table 5) and 9 failed or did not attend (not shown).

Table 4. Number of students at each quality level of the 4 R's in texts from Museum and green house and each level of *studium* and *punctum* in texts from Museum of modern art.

Types of R's	Number of students	Level	Number of students
Recursion	19	Studium 4	16
Relation	44	Studium 3	15
Richness	33	Studium 2	18
Rigor	6	Studium 1	4
		Punctum	9

Out of the 14 students with high mark on final exam, 9 of them (64%) reflected with high scores in *studium* whereas 18 out of 32 students (56%) showing high levels of reflection passed on the examination. Many students expressed the importance to work in groups for enhanced learning.

Table 5. Number of students' marks on final examination.

Question		"pass"	"high mark"
Question 1	Give three examples of a scientific phenomenon you can observe in the forest.	44	7
Question 2	Describe a scientific discovery that influenced our culture and the word.	26	20
Question 3	Choose one question in physics and one in biology. Examples: From the exercise on ice, describe how frictions varies. Give an example of how plants and animals are connected in a cycle.	26	22
Final mark of the exam		32	14

Examples of answers from students

Here some examples of students' answers and the results of the assessment using *studium* and the quality marker 4R's of Doll's are presented.

Studium, level 4, in art work, referring to personal experiences not shown in the related art work.

The art ”Kunstformen der Natur” is by a German biologist, Ernst Haeckel showing the symmetry of natural things (https://en.wikipedia.org/wiki/Kunstformen_der_Natur).

“The illustrations are so beautiful that I'm happy to look at them. […] They give me the same feeling as when I watch the forest or the sunset in the bush of Zambia – a sense of wonder about life and a gratitude for living. In such a moment, complicated questions about life do not matter to me. […] Perhaps it is not necessary to answer questions like “what is the meaning of life”? It may be enough to have a sense of wonder that you even live among all this beautiful and fascinating. When I've had trouble in life, that's the feeling that helped me. At such an instant, complicated questions about life do not matter to me.”

Another example is describing art by Joseph Beuys representing seven rusted metal barrels in different size.

“When I looked at this artwork, I get the feeling of hard work. I'm thinking of milk churn, how milk farmers worked hard to carry milk churns with only their own power. I have relatives who have a farmhouse. I have memories of my childhood when I saw how they carried the milk churns uphill several times a day. […] I know how heavy these barrels were because I did not even manage to lift one up the hill. Even though I know there are other methods today, I only get a sad feeling about the hard work done for each liter of milk and yet it's so cheap to buy in the stores. I know how much pain in the back my relative has today so this piece of artwork mediates the feeling of pain and made me experience memories from my earlier life.”

Recursions 2, in written reflection from the visit in the Natural History Museum and greenhouse referring to learning out of previous experience.

“I have been several times before to the museum when I was a child and what I like mainly are the big areas that allow children to actually move even though they are in a museum. I also like that the museum use senses to create curiosity to the children and especially the touch.”

Relations, level 3, in written reflections from the visit in the Natural History Museum and greenhouse which describes the process.

“When I left the museum, I felt I had brought something from my visit. Knowledge. Knowledge that I did not have before the visit. When working in a group, one learns from each other and that I felt was fun. That I learned and maybe even learned to someone else.”

Richness, level 3, in written reflection from the visit in the Natural History Museum and greenhouse, which uses several approaches (perspectives, dimensions).

“By the reaction of my classmates from the regions, they have done a very convincing job of creating a little Greece just north of Stockholm. Right now, there are many children forced to leave their homes in the Mediterranean region, and perhaps get very strong memories from home. This may be far-fetched, but it may be worth thinking that smell can make us travel in memories through time and space. Maybe someone gets sad without explaining why”.

No students showed *Rigor* in their texts leaving the framework totally and enter new contexts.

Statistical analysis

Statistical analysis showed that students with high quality in their reflections from the Natural History Museum and green house had a high probability to get high mark in question 1 of the final exam. The analysis showed that students having high scores of *studium* had a high probability to get high mark of question 2 of the final exam (Figure 1).

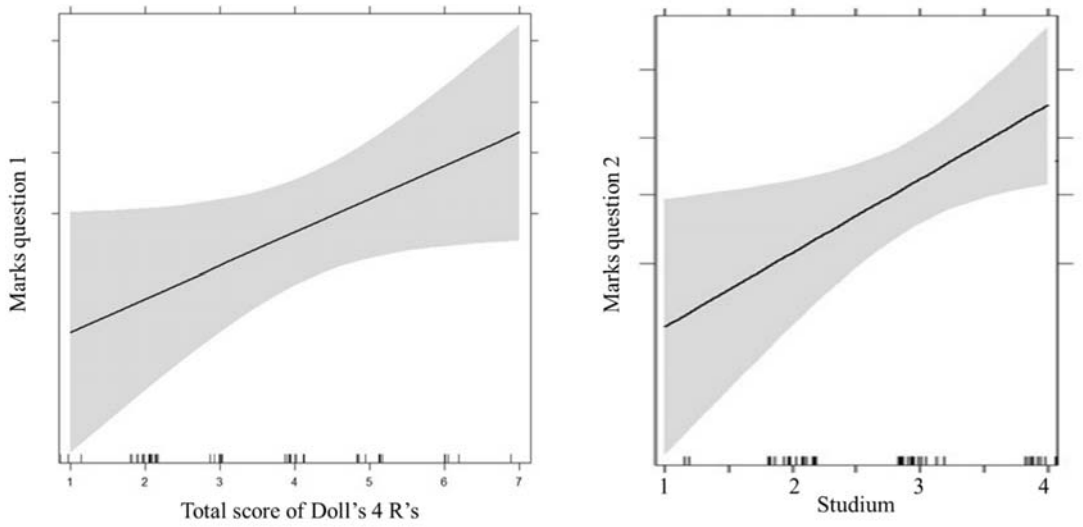

Figure 1. The effect of the total score of 4R's on the marks of question 1 (left) and *studium* on question 2 (right). The mark (high mark/not) was used as response in two generalized linear models with Total score of 4R's or *studium* score as explanatory variables and the significances of the effects are from ANOVA analyses of the models. Question 1; Total score of 4R's from the texts of the Natural history museum and the green house (p=0.041*) and question 2; s*tudium* scores from the texts of the Modern art museum (p=0.011*).

Using classification trees, it is possible to see the connection between different competences and marks on the question in the final exam. The analysis of question 1 in classification tree showed the distribution of students that passed or had high marks. The largest group of students that did not express *Recursion* in the text passed (G). However, students expressing *Recursion* (>0.5) and *Relations* (>0.5) in the texts of the reflections from the Natural History Museum and green house and *studium* (> 2.5) in the texts of the Modern art museum had probability to get high marks (V) on question 1 (Figure 2) (60% in the group had V of the group representing 12% of all students).

When a classification tree was done using marks on question 3 as response, also *Recursion* (>0.5) was important. In addition, *Richness* (>1,5) was indicating higher marks (V). In this group consisting of 38% of all students, 2/3 of them had high marks (V) (fig3).

These analysis show that different competences are often necessary in order to be able to perform well on exams with questions of different kind.

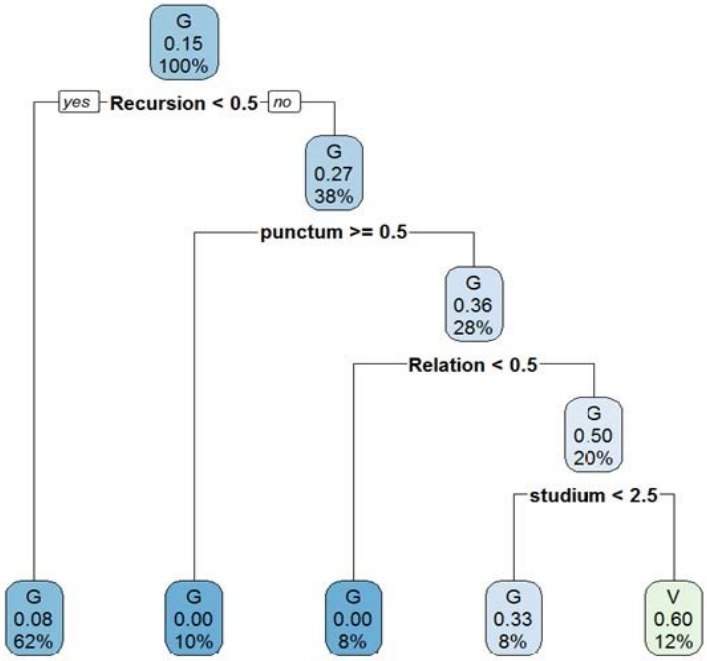

Figure 2. A classification tree (rpart in the R programme) sorting students on marks at question 1 of the final exam sorted by *studium*, *punctum*, *Recursion* and *Relation*s. The representation of marks for the largest group of the students is indicated in the box (G=passed, V= higher mark). The percentage indicate the proportion of the students in each group and the decimal number the proportion of the group that has the high mark (V) in the box (15 % of group had high marks). The left branches show the result if the criterium at each node is fulfilled and the right branches if it is not (exemplified with yes/no at first node).

This show how different competences are needed in answering even fairly open questions compared to the open task to reflect on art work that the student chooses by themselves. This is in agreement with our previous results showing that students show better understanding when answering open questions (Mattsson & Mutvei, 2015).

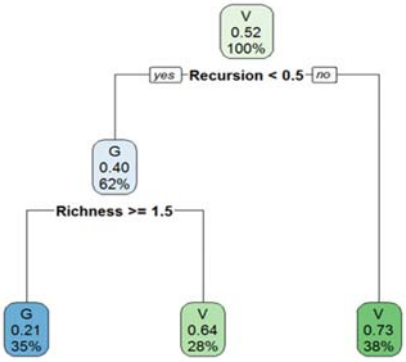

Figure 3. A classification tree (rpart in the R programme) sorting students on marks at question 3 of the final exam sorted by *Recursion* and *Richness*. The representation of marks for the largest group of the students is indicated in the box (G=passed, V= higher mark). The percentage indicate the proportion of the students in each group and the decimal number the proportion of the group that has the high mark (V) in the box (52 % of group had high marks). The left branches show the result if the criterium at each node is fulfilled and the right branches if it is not (exemplified with yes/no at first node).

DISCUSSION

The ability to see pattern by the analysis of observations of different kind is important for learning. This is supported by our results and connection between different factors and ability to answer open questions. Training of observation of nature and art combined with making reflections improves the ability to see patterns. Therefore, it is important to create many possibilities to practice observation, to analyse and to make reflections during the education of pre-service preschool teachers. Not only for their own understanding of science but also in order to understand how teachers need to create learning situations where children can get new experiences. These will improve children's competence to observe factors affecting nature, make observation when working with scientific method and to deepen understanding. In addition, teachers have to design pedagogic activities to give children possibility early to develop qualifications for learning. Furthermore, working with open questions and observations in different contexts will enhance the development of knowledge of the student in their own personal way.

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