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Science and play – oil and water?

Background
The new curriculum implemented in Norwegian primary schools 1997 (L 97) is a radical break with earlier curricula. This is especially true where science and science teaching is concerned. L 97 says very clearly that

1. Science is an integral part of the curriculum in the primary school (in earlier curricula science was part of a wider subject - *Environmental studies* - and was often relegated to second rang relative to the other components – history and social science)
2. Physics and chemistry has equal weight with biology (biology was formerly the dominant part of science)
3. Play is one of several teaching methods, in the lower primary the dominant method

The challenge to science educators is therefore:

How can we train student teachers to amalgate science teaching with play-inspired activities?

General comments
To most people, science and play seem to be opposites and using play as a teaching method in science is for many, both teachers and teacher students, counter-intuitive.
Science is associated with goal-oriented activity, rigorous planning, following strict rules and procedures. Play on the other hand is perceived to be a carefree activity, where you can follow any whim that strikes you. In short: Play is pleasure, scientific activity is *work*.

Play researchers and science educators know that a such view is simplistic. On the one hand, scientific research is a complex and many-facetted activity that includes toying with ideas, groping for answers and problem solving. Likewise, play is a common denominator for a variety of activities that has many aspects. One hallmark of much play is an exploratory activity. The children investigate the possibilities inherent in the toys and materials at hand; they explore their environments and set themselves tasks to be solved. In scientific inquiry as well as in much play, a divergent thinking is a strong component of the activity.

Unfortunately, to a large extent, it is the plodding side of the scientific activity that has filtered down to science teaching in schools. Typically, problems are teacher-given, the methods are spelled out and the aims are well defined. The children fail or succeed according to what extent they achieve a set of specific, externally given goals. Although buzzwords like “project-work”, “open-ended investigations”, “problem-solving activity” have been around for some time, the dominant teaching methods in science-related subjects are still to a large extent teacher directed where neither aim nor procedures are self-generated. All to often a spirit of inquiry is sacrificed to teacher-imposed requirements.

Play researchers are fairly certain that introducing an element of play in the teaching of science will have a beneficial effect on children`s comprehension of scientific concepts and laws. (Wolfe, Cummins, Myers 1998). Playful learning promotes curiosity, increases creativity and general cognitive development (Severeide, Pizzini 1984, Henniger 1987).

The greatest benefit lies in motivation. Many of the science tasks given to the children are meaningless and have no personal relevance. Contrast this with this definition of play: “Play are activities that are internally motivated, self-directed, spirited, and characterized by some degree of divergent “as-if” thinking” (Spodek and Saracho, 1988).

Theoretical perspective

All the current educational theories in education have some relevance to science teaching and can be taken to favour a playful approach to teaching science, especially for small children. Constructivism with its stress of the child as a constructor of mental frameworks rather than a passive recorder of facts has overlapping to the theory of Bruner. His learning theory, which stresses the importance of discovery, is well established and has had a lasting influence in the science educator community.

Wolfe, Cummins and Myers (1998*)* argue that what they call *exploratory representational play* (ERP) is a type of play that is conducive to the development of scientific ideas. By ERP they mean a kind of play that is personally meaningful to the participants and contains a significant content of symbolic or representational dimension. This kind of play is most relevant for children in the 8-12 years age group.

Csikszentmihalyi´s concept of “flow” (Csikszentmihalyi, 1979) has special relevance to science (especially physics) play of a more constructional character. When the tasks are self-given and problems arise spontaneously as they do in non-directed play, the probability is greater for there being a harmony between task and ability.

Wassermann (1988) advocates a three-stage *play-debrief-replay* model for teaching science themes. In the first stage, after supplying the necessary environment including equipment and other basic resources, the teacher tries to create an open atmosphere where the pupils are encouraged to hands-on-investigations and making constructions. In the debriefing stage teacher and pupils reflect on their experience, what hypotheses have been brought forward, how should we test this further? What constructions showed themselves to be viable and which ones did not? Why not? After some discussion where the main purpose is to help pupils extract the meaning to and the scientific content of their experiences, the pupils go back to play, hopefully with a tighter focus and employing a more directed approach.

Wasserman clearly recognizes the crucial role of the teacher. This is even more pronounced in Vygotsky´s theory. His “zone of proximal development” refers to those cases in which the pupils are stuck but a little help from teacher or other pupils could solve the problems.

Aim

Good science teaching requires teachers that are conversant with subject matter as well as having a good grounding in teaching methods. How should we train teachers to use playful methods in science teaching?

The problem is three-fold:

1. The student teachers should have a subject knowledge that is practical and hands-on
2. The students teachers should be able to pin-point the science content in the activities, and develop strategies for making these more focused to the pupils
3. The students teachers should have a personal experience of play as a teaching method

1 and 2 are two sides of the same problem. Theoretical knowledge is of limited use when the teachers are faced with practical material in situations that are predictable only to a certain extent. It is far from self-evident how to extract and formulate scientific concepts and laws and suggest more rigorous procedures. In view of Vygotsky´s theory of giving pupils scaffolding this is a crucial point.

Play as a teaching method differs from other methods in many ways. It is not a set procedure where the pupils follow a set of instructions, on the contrary it is to a large extent unpredictable and the teacher has much less control over the development. Many teachers are not comfortable with this situation; will the pupils learn what they are supposed to learn? Self directed, inner motivated activity has an emotional content that is different from that of externally given tasks. One way to make the student teachers appreciate this is to put them in situations where play is an integral part.

The aims of this investigation are therefore:

1. To investigate to what extent student teachers are able to extract, appreciate and verbalize the science implicit in the play activities
2. To investigate how the student teachers functions in a playful approach

Methods

Observations, interview, written and oral reports from student teachers and in-service teachers from 1996 to 2000 constitute the basis of this report.

The student teachers were mostly in the 20-25 years age group with some mature students, 90% female. Most students took a three-year course that caters mainly for the 2-7 years age group; the remainder were older teachers who took a half-year in-service course specializing in the 6-10 years age group. These teachers were older. All students took part in a science course with a total duration of ¼ of a year. The pre-college scientific background varied widely, but was on the whole rather meagre. Very few had a specific interest in science. The total body of student teachers taking part over the 4-year period is approximately 180 students.

Description of a session

25 students partook in two sessions, each of approximately 4 hours duration. The students were divided into groups, the norm being 4 students in each group.

Students were led to understand that some constructions were expected, but were given rather vague instructions:

1. How can you use these materials (this area) to implement a playful activity that has a scientific content?
2. What scientific laws, concepts and procedures can children learn from this activity?

The object of study varied, but most were out-of-door activities. Two examples will be given here:

1. Water-play in connection with a local stream
2. Play with snow and ice

1. A nearby, unpolluted stream of modest dimensions was our arena. Some tools and materials were provided, but students were encouraged to use in situ material.
   The students saw immediate possibilities in building bridges, construction of dams and making simple waterwheels. They used the more quiet parts to construct quays, moorings and boathouses. All of them constructed some boats, the more adventurous created complicated arrangements where the boats were attached to the waterwheels. Many tried to build sluices, these attempts invariably failed.

2. Snow and ice is of course the perfect playground for physical activities - ski, sledges and skates are important implements for children in cold climates. In this case however, the students were told not to use these but were instructed to use snow and ice as construction material.
   All students were given a rough outline of the more technical aspects of snow and ice, and they had a practical session in how to manipulate ice (melting, freezing ice-blocks together, freezing water in different containers).
   The workability of snow is very dependent upon what type of snow is available, old snow has different qualities from fresh snow, wet snow is suitable to some constructions but not others. This in large part explains why the student products differed widely from one year to another. But there were large variations also within different groups in the same year. All groups made snowmen and snow huts, some of these were rather stereotypical, other groups made more elaborate shapes. The best groups made whole villages consisting of different buildings, roads and bridges and enhanced the work with ice-sculptures.

A small minority of the student teachers (8) implemented a watered-down version of the activities in their teaching practice. The corresponding number of teachers in the in-service courses doing the same was 5. In total 88 pupils in the age-group 5-10 participated in these projects, most did snow-ice as well as stream work, the rest did only one of the two. The duration varied from one day to several days.

Results

The collected data has been categorized according to two criteria:

I. To what degree did the students get involved in playful activity?
II. To what extent could they extract the scientific content?

The criteria are rather vague and do not permit a fine grading. A division into 3 categories seems to be permissible:

Ad I

1. Approximately 1/5 of the student group were not emotionally involved in what they were doing. Their products were poor and stereotypical; they saw few or no possibilities for further developments. When asked how they rated play as a learning method for science, the response was typically “poor” or “inferior to other methods”. “Other methods” refers to a more goal-oriented, teacher-led teaching which they considered more effective.

2. Roughly the same number of students can be described as having a more positive attitude. Their products showed more variations and variety. Their comments expressed obvious enjoyment in what they were doing and they rated play activity as a superior method compared to more traditional teaching. When asked why, the answer most frequently given was that that the experience was enjoyable.

3. The rest of the students (3/5 of the total) were much more involved in what they were doing, some were totally immersed in the activities. Their state can only be described by “flow”. They saw the tasks as challenges, and were highly motivated to succeed. The structures they built showed originality, technical problems were often solved in surprising ways and they frequently demonstrated a willingness to experiment with the material in ways not anticipated by the tutor. The most striking difference between this group and the others was, however, that they saw possibilities for expressions of fantasy, creative work and role-play. Many expressed the opinion that they would use a “story line”-approach when teaching children. Some composed a story to fit the circumstances:

- A princess in distress on one side of the river necessitates some means (a boat, a bridge, a catapult…) for the prince on the opposite bank to save her
- An ice-witch casts a spell over a princess living in a snow castle. What to do?

Ad II
When asked: "What will the children learn from these activities?" the students were nearly unanimous in saying that water, snow and ice-play created a favourable and positive environment where social skills such as cooperation, empathy etc. had good opportunities to being developed and reinforced. When asked if this kind of teaching would make the children learn any skills, give them insights in scientific laws, concepts and processes, the answers were much more divergent and hesitant. The answers were subdivided into three groups:

A. Approximately 25% saw no learning effect at all and considered the play-activity as being of little or inferior value in science teaching. They recognised, however, that the children could acquire some technical skills in the construction of waterwheels, boats and snow huts.

B. 30% of the students saw some learning benefits, but were rather vague to what exactly could be learnt. Concepts like "wet", "flow", "wide" and "narrow", "fast" and "slow" were those most often mentioned in relation to the stream work; "freezing" and "melting", "soft" and "hard" were commonly associated with snow and ice. Some mentioned that there were aesthetic values to be found in the snow and ice.

C. The rest (45%) had a richer and more composite response. The concepts were more numerous and more refined, they were conscious of the possibilities of making the children learn about properties of water, snow and ice which were difficult to teach with more traditional methods. They also expressed positive opinions about the depth of learning; e.g. building snow huts, tunnels and bridges with snow gives the children a deeper insight in the properties of snow than can be learnt with other methods, wading in a stream and in building dams gives a direct experience about the forces in a running stream.

It is very significant that this last group is to a large extent overlapping with group 3. Group 3 students built more imaginative and more elaborate structures. They created a more diverse learning environment and thereby encountered more challenges and had a greater learning potential. An example illustrates this: One group built snow huts and used bits of ice as windows. This group was the only one who listed "transparency" as one of the concepts children could learn.

Some of the student teachers and teachers from the in-service courses used these sessions as inspiration to implement their own schemes with the children. The written reports give the overall impression that the children found the experience joyful and fulfilling. The student teachers and teachers had, however, a harder time documenting what science insight the children had acquired. Written pupils work, and quotations from children give us some foundation to say that quite a lot of learning had taken place. It is worth noting that the children, especially the girls, saw immediate use of the constructions as means for role-play.

Discussion
We should be very careful in drawing too firm conclusions. Factors that can influence the outcome comprise:

a. Sex

The men were a small minority in the student teacher study (10%). The results from work with children indicates that boys are much more likely to take to construction play than girls. The girls favour role-play. This might in part explain the negative attitude of a relative large (20%) portion of the student group. It is noteworthy that none of the students grouped themselves as warriors with snowballs attacking and defending fortified castles. This was a frequent activity with the children.

b. Scientific background

Obviously, those with a thorough schooling in science should be more able to grasp the scientific content of the activities. No attempt has been made in this study to analyse the results in this perspective. It is fairly easy to assess the academic background of the students, but the discerning factor

here is not only theoretical knowledge, but what kind of hands-on experience the students have. This varies widely according to socio-economic status, age, marital status etc.

c. External factors

Out-of-door activities have their own problems. Weather conditions obviously influence both the working conditions and the state of mind of the participants. The results were for example invariably more positive when the weather was good. This may partly explain that some groups were categorized in different classes for different tasks.

d. Teacher bias

The student teachers, and specially the teachers in the in-service courses, have a certain influence in composing the day-to-day syllabus. It is conceivable that only those teachers who were favourable to work of the above-mentioned character chose to implement it with the children. An enthusiastic teacher will influence the outcome and this might be partly responsible for the overwhelming positive results reported from the work with children.

e. Malfunctioning of groups

Bad results may be due to inability to the group to function properly and not because of negative attitude to science play per se.

Tentative conclusions:

Only a long-time study will reveal if play-inspired activity is a better method for teaching science than more traditional approaches. This study indicates

1. That the attitude and play competence of the teachers in a science learning context varies widely
2. To create a valuable play-inspired learning environment the teacher must find this kind of activity enjoyable and meaningful. Only those teachers who are capable of experiencing a certain amount of “flow” have a positive attitude towards play as an effective teaching method
3. Possibly the biggest problem is to train teachers to extract the science-content implicit in the activity. Even for teachers with a certain background in science this is not a simple task

My suggestion is to put the student teachers in play-situations similar to the above-mentioned. These sessions must, however, be followed up by a thorough discussion of what concepts, laws and procedures are relevant.

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