Learning with dinosaurs

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Learning with dinosaurs: a study on motivation, cognitive reasoning, and making observations
Hannu Salmia, Helena Thuneberg and Mari-Pauliina Vainikainen

ABSTRACT
Dinosaurs have been a very popular science topic since signs of their presence on earth were first discovered. They have represented so-called ‘edutainment’ for some people. Learning from informal sources and in an out-of-school environment can be effective and motivating. In this study, 12-year-old pupils (N = 366) visited a dinosaur science centre exhibition in Finland. Pupils were tested with standardised tests of motivation as defined by self-determination theory, cognitive skills, and interest via pre-, post-, and delayed post-tests during a six-month period. Findings show that pupils learned from the science centre visit and enjoyed the experience. The factors explaining their post-test knowledge in addition to their previous knowledge were (1) general cognitive competence, (2) liking studying biology at the science centre, (3) participation in a dinosaur demonstration, and (4) gender. As there was no difference between boys and girls in general cognitive competences, the knowledge results of boys and girls equally related to their cognitive competence. Autonomy also influenced situational motivation both directly and indirectly, which in turn had a strong effect on liking studying in the exhibition. It also influenced the post-test knowledge indirectly. In the lowest school achievement group, participation in the dinosaur demonstration increased knowledge in the post-test.

Learning with dinosaurs: a study of motivation, cognitive reasoning, and making observations
The classical symbol of a natural history or science museum is an authentic size, original and genuine fossil skeletons of dinosaurs in a running or hunting position (Hudson, 1977, 1988; Lambert, 1993). One of the very first whole skeletons was found in New Jersey, US, in 1858 and 10 years later it was presented to the audiences in the Natural History Museum of Philadelphia (Lucas, 2008). Twenty years later, in 1878, 2 coal mine workers made a serendipitous discovery: not only 1 but altogether 38 whole skeletons were found. These were reconstructed carefully by scientists, and presented to wide audiences in Brussels in 1883. These Iguanodon are still exhibited in The Royal Natural History Museum, Brussels (Casier, 1978).

These exhibitions were extremely popular. People travelled from all over to see them and, even more importantly, a growing number of journalists from the increasing number of newspapers and magazines reported this discovery all over Europe and worldwide (Thomson, 2005).
Thus dinosaurs have been a very popular topic since their discovery and have contributed much to scientific research. Among the first artists and painters of dinosaurs in history were Benjamin Waterhouse Hawkins and Charles R. Knight, who envisaged certain appearances for the dinosaurs. Their vision still exists in the long tradition of popular culture (Lucas, 2008). Sir Arthur Conan Doyle published the book ‘The lost world’ in 1912 as a series of articles in the Strand Magazine on a continuing basis. It was the first version of describing the meeting of human beings and dinosaurs! This topic has since become an inspiration for several entertainments (e.g. Lucas, 2008). The peak of the dinosaur boom was reached in the mid-1990s when the film Jurassic park started a long-lasting ‘Dino-mania’. In addition to millions of movie visitors, associated products were sold to both children and adults. This trend has become an everyday phenomena in books, films, videos, comics, computer games, clothes, and even children’s rock-bands.

As one result, the more than 100-year tradition of museum dinosaur exhibitions has gained new interest. Since the 1980s, modern exhibitions present dinosaurs very often as ‘look-alike models’ or moving and roaring robots rather than just skeletons (Tunnicliffe, 2000). Today, in addition to traditional museums, there are several specialised, commercial companies producing these exhibits and demonstrations in cooperation with scientific advisory boards. One clear indicator of dinosaurs’ ever-lasting popularity is the fact that the most popular exhibitions of the natural history museums and science centres have been characteristically Dino-exhibitions. A recent development stems from new audio-visual technologies like the 3-D films, and ‘4-D Arena’ happenings resembling the modern rock-tours seen by more than 8 million people in more than 200 big cities in the world (Dinosaurlive, 2016). In addition, computer games related to dinosaurs are a characteristic business in this area. The recent film success has been ‘The Good Dinosaur’ from 2015.

Despite the popularity of the topic and the availability of exhibitions and materials, surprisingly little is known about what people learn about dinosaurs in such informal learning occasions. This study aims at filling this gap by providing evidence on the learning outcomes of 12-years-old pupils during a science centre exhibition about dinosaurs. Special attention is paid to the role of motivation and interest in explaining the differences in learning outcomes of boys and girls, and of pupils with different school achievement backgrounds. The results of this study can be utilised in developing not only science exhibitions about dinosaurs but also other types of open learning environments that can better meet the needs of different kinds of learners.

**Biology – science education, formal and informal**

Biology as science – according to the classical definitions by Mayr (2001, 2004) – can be divided into two areas: *functional biology* and *evolutionary biology*. Functional biology explains the pre-conditions of the life with the help of chemistry and physics. It describes and studies the natural functions of all living organisms. Evolutionary – or historical – biology explains the processes that shape all life over long time periods or eras.

In nearly all countries, practically all biological curriculum contents for pupils from 6 to 12 years deal only with functional biology, such as studying different species of animals and plants and their living conditions. In addition, topics like environmental education, nature outdoor activities, and later the basic biology of human beings are included.

In practice, teaching this huge body of facts and knowledge, the teacher has to choose pedagogical methods and didactic approaches very carefully according to each topic and educational focus. Using out-of-school learning environments for teaching biology has a long tradition because biology as scientific research takes place in nature (Bogner & Wiseman, 2004). Using informal learning sources can benefit the pedagogy of biology education (Bogner, 1998; Sturm & Bogner, 2010). An essential goal is to use informal learning settings in biology to advance more interest and respect for environmental values (Braund & Reiss, 2004, 2006; Falk, 1982; Goldschmidt & Bogner, 2015).

Learning from informal sources and in an out-of-school environment is effective and motivating (Fenichel & Schweingruber, 2010; Osborne & Dillon, 2008; Salmi, Thuneberg, & Vainikainen, 2016).
A starting point for this development was the UNESCO report *Learning to be – the Faure report* in 1968 (Faure et al., 1972). Two other classical books describing this concept are *Deschooling society* by Illich (1971) and *The unschooled mind* by Gardner (1991). Informal education has often been regarded as the opposite of formal education. Since the 1990s, however, informal education has become a widely accepted and integrated part of school systems (Fenichel & Schweingruber, 2010; Salmi, 1993, 2011). However, out-of-school education is considered to be a pedagogical link between formal education and informal learning because it often uses informal education sources for formal education (Rennie, 2014). Science centre education has turned out to have strong motivational effects in this regard (Braund & Reiss, 2006; Salmi, 2011; Salmi et al., 2016; Stocklmayer, 2003; Tan Wee Hin & Subramaniam, 2003).

**Dinosaurs in school education and curriculum**

The study of dinosaurs is not included in the curriculum for 6- to 12-year-old pupils in Finland. However, all five commonly used biology textbooks in Finnish lower-secondary schooling do cover the topic. In Finland text books are not regulated by the government or administrators, thus giving teachers the opportunity to meet the overall goals of the general curriculum by a wide choice of means.

The number of pages and chapters in these commonly used textbooks indicate that the topic can be covered in two to five lessons (lasting 45 minutes each). The parts and pages of the books dealing with dinosaurs are placed between the chapter describing the beginning of life on earth and the animals and creatures existing today. However, the explanations for the evolution of life are very unclear and superficial compared, for example, to some popular science readings (Lambert, 1993; Lucas, 2008). The concept of evolution is mentioned only in one of these textbooks – in its teacher guide book.

The textbooks just mention that the dinosaurs lived long ago, died off, and then mammals took their place. This raises the danger of several misconceptions and naive notions (Driver, Guesne, & Tiberghien, 1985). The most common problem involves the misunderstanding of geological time and eras: When surveying the 10–12-year-old pupils’ understanding of the idea of the ‘ice period era,’ the children understood no realistic time periods related to the life and extinction of the dinosaur (Trend, 1998).

The value of the dinosaurs as part of school biology study relies on the fact that it is nearly the only way to get evolutionary biology (Mayr, 2004) somehow to be a part of biology education in the (lower) secondary school. The time perspective is so essential that the study of dinosaurs cannot start without teaching history as well, thus beginning around the age of eleven and above. Although the topic of dinosaurs easily arouses the interest and motivation of younger children, teaching should take into account that superficial studying easily forms misconceptions which are fairly stable and difficult to correct (Driver et al., 1985; Klausmeier, 1992; Powell, Aram, Aram, & Chase, 2007; Sinatra, Brem, & Evans, 2008).

The dinosaurs as an attractive and fascinating topic offer a fruitful opportunity for learning. Several studies based on the discussion between children and their parents indicate that the children often can have even more detailed facts and knowledge about this topic than their parents do. This unique ‘expert position’ of the child in relation to her parent is totally different than nearly all other discussions and interactions in the science exhibitions, as well as nearly all other studies (Palmquist & Crowley, 2007; Tunnicliffe, 2000).

Dinosaurs have been in the focus of the adult audiences not only as entertainment, but also from the scientific point of view. They were actually an influential tool of public understanding of science already in the 1800s with the very first dinosaur exhibitions. Darwin’s *The origin of the species* was published in 1859, and it caused a huge controversy in the religion-based view of the world and history, even among educated academics, not to mention ordinary people. Large-scale European surveys (viz., Special Eurobarometer 419, 2014) support the idea that dinosaurs are more than just
entertaining and superficial studies. These Europe-wide surveys, administered every three years, indicate that there has been continuous interest and increase in the knowledge related to evolution and dinosaurs among the adult European population.

**Cognitive reasoning and thinking skills**

The main elements of common cognitive ability are the capacity to learn and the capacity to embrace and remember the knowledge once learned (Raven, Raven, & Court, 2000). The particular ways in which people reason and apply their minds to solving problems are called *thinking skills*, which are considered essential to effective learning and reasoning (Adey, Csapó, Demetriou, Hautamäki, & Shayer, 2007; Demetriou, Spanoudis, & Mouyi, 2011). The thinking skills are related to the essential goals of science education: epistemic knowledge, metacognitive awareness (Michalsky, Merevach, & Haibi, 2009). Developing thinking skills helps pupils to get more out of learning, and they can also be taught and evaluated as more general outcomes of education. Successful examples are the *Learning to learn* approaches in several European countries (Csapó, 2007; Demetriou et al., 2011; Hautamäki & Kupiainen, 2014; Hoskins & Fredriksson, 2008).

**Motivation**

In this study, the theoretical basis of regarding motivation is rooted in *self-determination theory* (SDT) (Deci & Ryan, 1985). The theory connects satisfaction for basic psychological needs, autonomy, competence, and relatedness to motivation: the more the needs are fulfilled, the more autonomous motivation self-regulation becomes (Deci & Ryan, 2002).

The SDT theory suggests that motivation – instead of the dichotomous extrinsic versus intrinsic distinction – forms a continuum from total absence of motivation to gradual steps in a more autonomous direction (Thuneberg, 2007). Next to (a) *amotivation*, total absence of motivation, in the continuum is (b) *external* motivation which means that a pupil is motivated by concrete incentives or to avoid punishments. Then comes (c) *introjected* motivation, in which incentives and punishments are symbolic and its effect is on anxiety. In the next motivation style, (d) *identified*, pupils accept external goals because they accept that those are good for learning. Last on the continuum is an autonomous form of motivation, (e) *intrinsic* motivation: the task or behaviour is experienced as interesting as such and pupils engage with it because they like it. It involves curiosity, exploration, and play, all which enhance cognitive development. Typical for this motivation is a critical and open-minded attitude towards learning, seeing the connection between isolated facts and the topic area as a whole, the connection between theory and practice, and curiosity, interest, and problem-based learning (Görllitz, 1987).

**Interest, situation motivation, and attractiveness of learning context**

*Situation motivation* clearly creates physiological and mental alertness as it often grows from experiencing a novel situation that is interesting in part due to the new, attractive, and stimulating environment (Braund & Reiss, 2004; Zoldasova & Prokop, 2006). Evidence from educational research indicates that novelty is one of the principal factors in encouraging learning (Berlyne, 1966). Such novelty can arise within or outside the learning context; that is, the learning of a new subject or from a new setting (Falk, 1982; Falk & Dierking, 2002; Vainikainen, Salmi, & Thuneberg, 2015).

Interest has been shown to develop from triggered situational interest to the evolvement of maintained situational and individual interest (Louhimies, Juuti, & Lavonen, 2016). This, in turn, can finally lead to a well-developed individual interest (Hidi & Renninger, 2006). In a novel learning situation, pupils with more developed individual interests have more and better possibilities for experiencing related situational interest (Renninger & Hidi, 2011). However, the sources of *situation motivation* are crucial when dealing with pupils who in general are not easily motivated in school.
activities (Ainley, Hidi, & Berndorff, 2002). With interest and situation motivation, gender differences are partially topic-specific (Eccles, 2011). One study found that boys can be more vulnerable to the effects of task characteristics (Ainley, Hillman, & Hidi, 2002). In a study in the science centre context, the novelty of the situation produced stronger effects on girls learning outcomes indirectly via their situation motivation (Salmi et al., 2016).

**Situation motivation** in an attractive environment is one key element explaining visitor behaviour and learning in the exhibition context. Such motivation is seen as the first step into deeper learning described as having holding power (Screven, 1992). The most significant conditions for eliciting it are temporary and external factors as well as social relations and entertainment. It thus involves elements of intrinsic motivation through curiosity, as well, but it is basically a feature of extrinsic motivation. Typical features for situation motivation are that such motivation is short-lasting, learning is easily disturbed, and attention orientated to irrelevant subjects (Atkinson, 1964; Deci & Ryan, 1985; McClelland, 1951; Salmi, 2003; Vainikainen et al., 2015).

**Description of the exhibition**

The dinosaurs’ exhibition was presented at Heureka, the Finnish science centre. It was already the fifth temporary dinosaur exhibition during the 25 years history of this science centre. A difference from earlier exhibitions was that the ‘living’ Dino-robots were located in an outside setting, in the park and yard of the centre. The exhibition was very much based on seeing, feeling, and being close to the robots. The dinosaur exhibits did not offer practically any other text-based facts related to dinosaurs than the name labels. However, all the pupils received a leaflet containing background knowledge related to exhibit topics. The guide of the science centre gave a short introduction before entering the exhibition. Making observations (see Oppenheimer, 1972; Salmi, 1993) is the main pedagogy to learn in the exhibition. As a supplement of the exhibition, the science centre also had in its programme a thirty-minute demonstration presentation on the topic ‘Dinosaur Clock.’ This lively demonstration and lecture given by the guide focused on the behaviour, appearance, evolution, extinction of dinosaurs – explaining facts and correcting misconceptions. The audience could attend this presentation, which demonstrated, for example, the size and other main physical characters of the dinosaurs. The presentation involved dialogue between the spectators and the guide.

**Research questions**

In this study we looked at the learning resulting from visiting the dinosaur exhibition in the science centre and how stable the effects are. We were interested in how changing the studying context from school to out-of-school context affects learning and motivation. In addition, the focus was how providing a detailed, planned dinosaur demonstration influenced the learning process and whether it varies according to gender and past school achievement. In the analysis we wanted to carefully study the role of a relatively stable motivation and situation motivation in connection to learning and contextual variables.

Our research questions were:

Q1: Do dinosaurs and evolution exhibitions influence learning outcomes?
Q2: Does experienced interest vary between studying biology at school and at science centre?
Q3: What is the role of motivation on the learning outcomes and how does it differ by gender and prior school achievement?
Methods

Participants

The participants (N = 366) were 12–13-year-old pupils from seven different schools and seventeen classes in Finland in Helsinki metropolitan area’s urban and sub-urban schools selected by representative sample. Of the participants 54% were boys and 46% were girls.

Instruments

The overall design of the study with applied instruments and the measurement time-points are shown in Table 1.

General cognitive competences

Pupils’ general cognitive competences were measured by the visual reasoning test Raven Standard Progressive Matrices which addresses the capacity to learn and the capacity to embrace and remember the knowledge once learned (Raven et al., 2000, 2003). In each item, pupils were asked to identify the missing element which completes a pattern. The test consisted of five sets of twelve items which were to be completed within a predefined time limit. The items were coded dichotomously as correct or incorrect (including the items not completed). The final test score was calculated as a sum of correctly solved items within the time limit. The reliability of the test was good. The reliability for the test score was α = .85 (60 items).

Knowledge test (pre-, post-, and delayed post-test)

Pupils’ prior topic-specific knowledge and learning outcomes were measured by a test designed for the present study. Originally developed through a pilot study, the knowledge test consisted of 27 items related to the content areas of the dinosaur exhibition. An example of a typical item: ‘The biggest ever dinosaur was about the same size as an elephant.’ The answering options to the statements in the test were 1 = true, 2 = untrue, 3 = I do not know (see also Salmi et al., 2016). Thus they had the option to say that they do not know the answer, but in the present study only the number of correct answers were analysed. The post-knowledge tests were conducted two weeks after the science exhibition visit and the delayed post-tests after six months.

The reliability for the pre-test score was α = .78 and for the post-test α = .80, (27 items).

Deci–Ryan Motivation

The Deci–Ryan Motivation (SRQ-A : Self-Regulation Quality – Academic) test has 32 standardised items. An example of a typical item: ‘Why do I try to answer hard questions in class? – Because I want the other students to think I’m smart’ (1 = not at all true, 2 = not quite true, 3 = somewhat true, 4 = totally true).

The questions and the statements form summative variables that locate themselves in the self-determination continuum in the following order: External, Introjected, Identified, and Intrinsic.

Table 1. The instruments and time-points of measurements.

<table>
<thead>
<tr>
<th>Zero week Pre-tests</th>
<th>Four weeks after</th>
<th>Six weeks after Post-tests</th>
<th>Six months after Delayed post-tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge test 1</td>
<td>SCIENCE EXHIBITION VISIT</td>
<td>Knowledge test 2</td>
<td>Knowledge test 3</td>
</tr>
<tr>
<td>Motivation (Deci–Ryan test)</td>
<td></td>
<td>Situation motivation</td>
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<tr>
<td>Liking of biology at school</td>
<td></td>
<td>Liking of biology at science centre</td>
<td></td>
</tr>
<tr>
<td>Visual reasoning (Raven test)</td>
<td>Dinosaurs demonstration</td>
<td>Background variables: school achievement, gender</td>
<td></td>
</tr>
</tbody>
</table>
The reliabilities of the scales were: for External $\alpha = .79$ (8 items), Introjected $\alpha = .84$ (9 items), Identified $\alpha = .80$ (7 items), and Intrinsic $\alpha = .87$ (7 items).

Based on the formula by the Deci–Ryan research group the overall index, the Relative Autonomy Index (RAI), was created: $2 \times$ intrinsic + identified-introjected - $2 \times$ external (Ryan & Connell, 1989). The RAI describes the overall autonomy level experienced by the pupil. In this study, the RAI is used as the indicator of autonomous motivation.

The Deci–Ryan test was administrated as a pre-test because, theoretically, after a one-day intervention, there should not be major changes in the overall motivation which is related to the whole personality. The objective of the test was mapping the pupils’ common motivation related to school, education, and learning.

**Situation motivation test**

Situation motivation indicating attractiveness of the dinosaur exhibition was measured with a questionnaire consisting of 13 Likert scale items (scale 1–5, totally agree–totally disagree). The questionnaire was administered as a post-test only. The reliability for the scale was $\alpha = .87$ (16 items). An example of a typical item: ‘Dinosaur exhibition was fun.’

**Interest in school biology and science centre biology**

The Semantic Differential method (Osgood, 1964) was used for measuring pupils’ liking and interest in learning biology in school settings (pre-test) and in the science centre (post-test). The 14-item scale consisted of three factors. The pupils had to evaluate three pairs of adjectives on a five-point scale (e.g. studying biology in school is/in the science centre was ‘Interesting $\leftrightarrow$ Boring’). The reliability of the interest scale was $\alpha = .92$ (14 items) for the pre-test and $\alpha = .93$ (14 items) for the post-test (NB: We speak about pre- and post-test, but this is not a repeated measure. Although the questions are the same, the respondents have to take the context of school into account in the pre-test and science centre in the post-test).

**Participation in dinosaurs and evolution demonstration**

Of the 366 participants 68% ($n = 249$) participated in dinosaur demonstration during the science centre visit. This non-visit versus visit effect on learning (i.e. knowledge tests), on situation motivation, and on interest on studying biology at the science centre, was analysed.

**School achievement**

School achievement and gender were used as background factors in the analyses. The school achievement variable was the summary of the four grades (Biology/Geography, Mathematics, and Mother tongue) based on information from the teachers. The pupils were classified into three categories according to their school achievement level:

- A+ = Above Average School Achievement (A+; 25%, top quartile of the pupils in each class),
- A = Average School Achievement (A; 50% of the pupils in each class),
- A− = Below Average School Achievement (A−; bottom quartile, 25% of pupils in each class).

Boys were under-represented in the highest achieving group, $\chi^2$ (df2) = 6.309, $p < .05$.

**Analysis methods**

The group differences and interaction effects were analysed by using SPSS 22, GLM Univariate tests. The effect sizes were based on partial eta squared. It can also be interpreted: $\eta^2 > .01$ small, $\eta^2 > .06$ medium, $\eta^2 > .14$ large. The changes between the time-points were analysed by using GLM Repeated measures tests and Wilks-lambda test. Answers to the research questions were drawn additionally from structural equation modelling (SEM) (IBM AMOS 22), by models based on theory,
and by selection of reasonable variables based on correlations. The goodness of fit evaluation of the models was based on a Chi square test ($p > .05$) and several indices: Normal Fit Index (NFI) and Comparative Fit Index (CFI) good fit > .90, or better > .95, Root Mean Square Error of Approximation (RMSEA) reasonable fit < .08, good fit < .05 (see Byrne, 2010). In addition to the maximum likelihood method, bootstrapping with no missing data was applied in order to study the measurement invariance of the knowledge and semantic differential interest and motivation scales, gender and school achievement groups as moderators. Bootstrapping also made possible finding out the significance of the indirect effects.

**Missing values**

Of the data there were on average 4.8% missing values for each sum variable (min. 1.1%, max. 11.5%). The method was to pairwise exclude cases analysis by analysis in the MANOVAs and ANOVAs or in correlation analysis. Because the program used for SEM, Amos22, does not allow any missing values when bootstrapping, cases with missing values were omitted.

**Results**

First, descriptive statistics were calculated for the whole data-set and differences tested by GLM Univariate between girls and boys, school achievement groups, and participation in the dinosaur demonstration. The means, standard deviations, and significant differences are presented in Table 2.

**Gender differences**

The gender effects are presented in Table 2. The results show that:

(a) Boys had higher scores than girls in the knowledge pre-test, post-test, and delayed post-test. (b) Girls, in turn, scored higher in relative autonomy (RAI). The RAI-index of girls was positive, whereas boys’ RAI was negative. (c) Boys and girls had equal scores in biology at school, but girls had higher scores in biology at the science centre. (d) Girls had higher scores in situation motivation than boys. (e) In accordance with theory, no gender effect on Raven was found.

**Differences between school achievement groups**

(a) School achievement had a significant effect on the knowledge tests in pre- and post- time-points (see Table 2). In the pre-test, the lowest achieving A− group had lower scores than the average achieving group A. In the post-test, the main effects were not analysed because of the interaction effect of school achievement * dinosaurs demonstration (see below differences between dinosaur demonstration participation). (b) In Raven all three groups differed from each other highly significantly

<table>
<thead>
<tr>
<th>Table 2. Descriptive statistics for the whole data and significant differences based on GLM Univariate tests.</th>
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<tr>
<td><strong>N</strong></td>
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<tr>
<td>RAVEN</td>
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<td>RAI</td>
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<td>Biol at school</td>
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<td>Biol at science centre</td>
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<td>Situation motivation</td>
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<tr>
<td>Know_1</td>
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<td>Know_2</td>
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<td>Know_3</td>
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</tbody>
</table>

Note! Due to a significant interaction effect school achievement * participation in dinosaurs demonstration the effects in split groups are explained in the body text.

Pairwise group differences in school achievement: Raven, all from each other, $p < .001$, Biology at school, A+ vs. A−, Knowledge_1 A vs. A−, $p < .05$.
and with a large effect size, with the lowest achieving group having the lowest Raven scores, highest group having the highest Raven scores. (c) There was a difference in studying Biology at school: the highest achieving group had the most positive view difference being significant between the lowest achieving and the highest achieving groups. In biology at the science centre no significant differences were found. (d) Regarding relative autonomy experience (RAI) no differences were found, nor in Situation motivation.

**Differences between dinosaur demonstration participation versus non-participation**

Participation in dinosaur demonstration versus non-participation yielded two significant differences: the group which participated in the demonstration had higher knowledge scores both in the post-test and delayed post-test. In the delayed post-test the pupils who participated in dinosaur demonstration had higher knowledge scores than the others. However, the situation of the knowledge post-test had to be analysed in split groups, because there was a significant interaction effect of school achievement * dinosaur demonstration on that variable, \( F(\text{df} = 2) = 5.08, p < .01, \eta^2 = .033 \).

In order to illustrate that interaction effect, the data-set was split by participation in dinosaur demonstration/no-participation. Then the knowledge test results were compared by one-way ANOVA and Tukey pairwise post-hoc tests. The lowest achievement group differed from the average \((p < .05)\) and highest achieving group \((p < .05)\) in the knowledge post-test, of those who did not get the dinosaurs demonstration, \( F(2,104) = 4.57, p < .01 \). But that part of the lowest achievement group which got the dinosaurs demonstration had knowledge scores as high as the other achievement groups, A and A+ (see the Figure 1; on the left). In the other knowledge tests there were no significant differences between the groups.

**Change in knowledge**

The GLM repeated measures analysis measuring learning, i.e. change between the pre- and post-knowledge tests, resulted in significant difference. Wilk’s lambda = .970, \( F = 10.55, \text{error df} = 337, p < .01, \eta^2 = .03 \) between the pre-test \((M = 15.93, \text{SD} = 3.33)\) and the post-test \((M = 16.45, \text{SD} = 3.48)\). Difference between pre-test and delayed test was non-significant. The difference between the post-test and delayed post-test was non-significant, as well.

When gender * time interaction was added in the model, the result was that the change did not vary by gender, \( p = .763 \). Similarly no school achievement * time effect was found, \( p = .727 \). So the gender and achievement groups did learn similarly, even though we already witnessed differences in scores in the time-points between the boys and girls, and between the school achievement groups.

**Figure 1.** The interaction effect of participation in dinosaur demonstration and school achievement on knowledge post-test (on the left) and on delayed post-test (on the right, non-significant).
However, when the grouping factor *participation in dinosaurs demonstration* *time* was added, there was a significant interaction effect on knowledge change – *Wilk’s lambda* = .986, *F* = 4.673, *error df* = 336, *p* < .05, *η²* = .014. This means that the change was different within the groups. Analysis of the means in the split groups revealed that in the *participation* group the change was significant, *p* < .001. The change in the *non-participation* group was non-significant.

**SEM path analysis**

Path modelling was conducted to find out if the observed data would confirm the theoretically based connections in relation to the research questions. This final model is presented in Figure 2. The model fit the data very well (χ² = 31.621, *df* = 31, *p* = .435; NFI = .958 and CFI = .999, RMSEA = .008).

**Direct and indirect effects of the final model**

The standardised regression weights and explained variance are shown in the final model depicting the significant effects (Figure 2) after the effects of *RAI*, *Raven*, School achievement, and gender had been controlled (*RAI* – *gender*, *p* < .01, *Raven* – *School achievement*, *p* < .001). (NB: Gender is coded: boys as ‘0,’ and girls as ‘1.’)

**Effects on biology study interest**

*RAI* had a direct and medium size effect on studying *biology at school*, being the only significant effect on that variable. *RAI* had a small direct effect on studying *biology at the science centre*, but also a significant indirect effect via *situation motivation* and *biology at school* (*p* < .01).

There was a small direct effect of *biology at school* on *biology at the science centre*, but a somewhat bigger indirect effect (*p* < .01) mediated by *situation motivation*. *Situation motivation* had a large effect and *school achievement* a small one on *biology at the science centre*. However, *school achievement* had a small direct effect on *biology at the science centre*.

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**Figure 2.** The final path model. (* = *p* < .05, ** = *p* < .01, *** = *p* < .001).
achievement had in addition a small negative indirect effect on it (p < .01) via situation motivation and so did participation in the dinosaur demonstration (p < .01). (See page 14 for interpretation of the effect sizes.)

The total explanation of variables on studying biology at school was 11% and 55% on studying Biology at the science centre.

Effects on knowledge
Of the knowledge pre-test (knowledge_T1) totally 9% was explained, mostly by gender with a negative regression weight, then studying biology at school and Raven. Of the knowledge post-test (knowledge_T2) the variables explained totally 45%. The highest explainer with a large regression weight was knowledge pre-test, then biology at the science centre, and then gender with negative effect, then Raven and participation in dinosaur demonstration. Biology at the science centre had also a significant indirect effect on post-test (p < .01), and so did gender (p < .01), situation motivation (p < .001), RAI (p < .01), Raven (p < .05), and biology at school (p < .01).

The knowledge post-test had the highest, medium size effect on the knowledge delayed post-test (Knowledge_T3). The knowledge pre-test, participation in dinosaur demonstration, and gender also had an effect on the delayed post-test; gender, a negative one and a negative indirect one via knowledge pre- and post-test (p < .01). Knowledge pre-test (p < .001), biology at school (p < .01), and situation motivation (p < .01) had an indirect effect also on knowledge delayed post-test via post-test.

RAI had no direct effects, and only minor, although significant, indirect effects on knowledge tests.

Effects on situation motivation
The variables explained 21% of variance in situation motivation, the biggest effect being that of studying biology at school. School achievement had a negative effect and so did participation in the dinosaur demonstration. The effect of gender was positive. RAI had a small direct effect on situation motivation, but also a significant indirect effect (p < .001) via biology at school.

Measurement invariance
Next, measurement invariance was tested in order to see whether the models would be invariant across (a) gender and (b) school achievement groups.

The models of girls and boys, from which the grouping gender variable was omitted, did not differ significantly (the difference between the unconstrained and fully constrained model was $\chi^2 = 13.626$, df = 18, $p = .753$). No single paths were significantly different between the groups.

The models of moderation variable school achievement, however, were different ($\chi^2 = 66.143$, df = 40, $p < .01$). There were several paths which differed between the achievement groups at a 95% confidence level: (a) in the lowest achieving group RAI had a positive effect on liking biology studying in the science centre, which was non-significant in the other groups; (b) in the highest achieving group RAI had a significant effect on situation motivation and gender, a negative effect on the knowledge pre-test, but such a relationship was not found in the other two achievement groups; c Raven had an effect on pre-test, in turn, in the average achievement group, but not in the other groups. The only significant path at 99% confidence level was the dinosaur demonstration on the knowledge post-test. The effect was significantly different between the A− and A groups: $z = -2.965$, $p < .01$, $\beta_1 = .31$, $p < .001$ and $\beta_2 = .00$, n.s. The effect was also significant between the A− and A+ groups: $z = -2.237$, $p < .05$, $\beta_1 = .31$, $p < .001$ and $\beta_2 = .09$, n.s. These effects corresponded to the interaction effect results obtained by GLM Univariate and one-way Anova in split groups. This can be seen illustrated in Figure 1, on the left. The differences were no more statistically significant in the delayed post-test, Figure 1, on the right.
Discussion and conclusion: they did learn and interest matters

The dilemma faced by science exhibitions is whether they are capable of managing and enhancing the momentary, strong situational interest and motivation into a long-lasting intrinsic motivation. This is also one of the biggest challenges for open learning environments, such as science centres (Salmi, 1993, 2003). As Hidi and Ainley (2009) put it: ‘Whereas the potential for interest resides in the person, the content and the environment may determine the direction of interest and contribute to its development.’ Therefore, studying the effects of interest in learning outcomes in the context of the present study is important (Vainikainen et al., 2015).

‘Edutainment’ became a widely used term in the beginning of the 2000s. The word itself was formed by putting together the common words of ‘education’ and ‘entertainment’. It was soon receiving two connotations – depending on the speaker: 1. Meaningful learning with joy, motivation, and free-will. 2. Meaningless time wasting with no connections to any educational aspects. Many informal learning institutions and even amusement parks started to use this term (Salmi, 2011).

Based on our results the first meaning of edutainment, that is, meaningful learning with joy, motivation, and free-will, showed to be more applicable and true than critiques made of dinosaur exhibits as a waste of time. The interest development of school-age children is supported by the tasks and the organisation of the learning environment (Renninger & Hidi, 2011). Although the effect was not large, it was proven, once again, that the pupils learned from the science centre visit while simultaneously enjoying the experience (Salmi et al., 2016). The factors, which explained the knowledge post-test, in addition to the previous knowledge, were the general cognitive competence shown by Raven, liking studying biology at the science centre, participation in the dinosaur demonstration, and gender. Because there was no difference between boys and girls in Raven, confirming the theoretical prerequisites, the knowledge results of boys and girls did equally relate to their cognitive competence.

It was interesting that boys scored higher than girls in all knowledge test time-points. Based on the SEM model, the effect of gender was highest on the pre-test compared to post-test and delayed post-test. In the pre-test, being a boy in the highest achieving (A+) group showed to have a significant advantage. Even though the knowledge test results proved to be quite stable between the pre- and post-test and somewhat stable between the post- and delayed post-test results, being a boy still had an added value in both. It means that regardless of the knowledge starting level, one could predict that boys would perform better than girls in the post-tests. However, the boys and the girls did learn equally well in the science centre. In a previous, corresponding study in the context of science exhibitions (contents of physics, chemistry, biology, psychology) boys similarly scored higher in the pre-test. However, girls caught up and did equally as well as boys in post-tests, a finding which has been repeated several times in the research literature (Dillon et al., 2006; Tunnicliffe, 1998, 2000).

Confirming previous results (Salmi et al., 2016) girls, in turn, felt more autonomous than boys. The RAI-index of girls was positive, which means that girls felt relatively autonomous, whereas boys, based on the negative RAI, did not. It indicates that boys experienced being externally controlled and relied probably more on adults than themselves. While there was no difference between girls and boys in liking biology study at school, girls preferred over boys studying it at the science centre. Another indication of that was that girls scored higher in situation motivation and were, thus, more attracted to the exhibition. This result is in line with previous results and reflect the novelty aspect as a motivator (Alexander, Johnsson, Leibham, & Kelley, 2008; Falk, 1982; Falk & Dierking, 2002; Salmi, 2003; Tunnicliffe & Reiss, 2010).

Autonomy experience then affected both liking studying biology at school and in a smaller portion, liking it at science centre. The latter direct effect was more complicated, because it showed to be mixed up with school achievement and to be true in the lowest achieving group. The conclusion is that the more pupils experienced autonomy, the more they overall liked studying biology. Autonomy also influenced situation motivation both directly (being true in the case of school achievement only in the highest achieving group) and indirectly, which in turn had a strong effect on liking studying at
the science centre and that also influenced the knowledge post-test indirectly. The positive role of autonomy on situation motivation confirms previous results (Jilil, Abu Sbeih, Boujetiff, & Barakat, 2009; Salmi, Vainikainen, & Thuneberg, 2015; Salmi et al., 2016).

In this study the effect of liking biology study at the science centre (and indirectly situation motivation and relative autonomy experience) had a higher influence on the knowledge post-test than the organised dinosaur demonstration. The demonstration still had a small main effect on the delayed post-test which, however, the liking of the biology studying at science centre did not have. Interestingly, the lowest school achievement group’s participation in the dinosaur demonstration increased their knowledge in the post-test, so that there was no significant difference in post-test between that group and the other school achievement groups. However, those low-achieving pupils, who did not get the demonstration, differed from the others by having lower scores in the test.

The conclusion is that some groups might be more in need of an intervention like the dinosaur demonstration, and that a relatively small added educational component in the science centre visit can be essential. On the other hand, one should take special notice of the results concerning girls: they responded to the informal learning setting by increasing situation motivation, which then seems to convert into liking studying in the centre and, thus, a positive influence on gaining learning outcomes. This is an essential result, because girls are more vulnerable concerning their feelings towards science (Hong, 2010; Hong, Lin, Wang, Chen, & Yang, 2013; Jidesjö, 2008, 2012) than boys, and gender stereotypes become stronger with age (Martin, Mullis, & Foy, 2008).

The earlier results of the research literature were supported by the encouraging findings of this study. However, certain scepticism remains. According to the reports related especially to family learning (Crowley & Jacobs, 2002), it can be argued that children’s capacity to learn can be both under- and overestimated – simultaneously. It is clear that the exhibition learning is not an ‘educational panacea’. Science centre pedagogy works effectively only if it is well-structured and carefully planned both for context and content.

Influencing attitudes is difficult when they have been formed more intuitively and emotionally than more consciously over a longer period of time (Kahneman, 2003). Thus, the results of complicated connections of gender, attitudes towards the biology learning, school achievement level, and knowledge are essential. Although the effects are not large, however, they can be intervened and influenced.

Note

1. In one dependent (repeated) measures model with one grouping factor model does not deviate from the recommended generalised eta-squared (Bakeman, 2005). However, in UNIANOVA final models more than one grouping variables were used on the Knowledge pre-test and delayed post-test. This has to be noted in the interpretation of the effects sizes. For simplicity reasons, we do not mention ‘partial’ in relation with effect size presentations.

Disclosure statement

No potential conflict of interest was reported by the author.

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