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Tessa R. Govers | 3116719

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Supervisors: J. van Keulen | Educational Development & Training, Centre for Teaching and Learning Utrecht University, Faculty of Social and Behavioural Sciences, Utrecht University

E.P.H.M. de Bakker | Freudenthal Institute for Science and Mathematics Education, Faculty of Science, Utrecht University

Involvement as a Measure of the Educational Potential of Museums

Tessa R Govers*

Freudenthal Institute for Science and Mathematics Education, Faculty of Science, Utrecht University, Utrecht, the Netherlands

Determining learning in the informal educational setting of science centres is difficult, but has been examined in most studies by focussing on results. This study aimed to gain more insight in learning in science museums, by presenting a research method to measure the educational potential of museums, focussing on learning process. Involvement is used as process variable, because it indicates learning. The main research question was how involvement can be used as process variable in order to operationalize measuring the educational potential of museums. The Leuven Involvement Scale (LIS) was used to measure involvement, complemented by tools to measure context factors that might contribute to learning in an informal museum environment. These were object affordances, cognitive affordances and social interaction. Studying three educational programmes, 550 observations were made of 124 primary school students to examine the methodology. The LIS proved to be a valid and reliable instrument to measure involvement as process variable and object affordances and cognitive affordances were found to contribute to the learning process. The educational potential of museums is therefore operationalized in a method that measures involvement with the LIS and examines object affordances and cognitive affordances as well. Because involvement indicates that learning is taking place, science centres can use the presented method to evaluate their educational programmes, in order to optimise them for learning.

Keywords: *Science learning in museums; Leuven Involvement Scale; Informal education; Learning process; Museum objects*

* Email: T.R.Govers@uu.nl

Introduction

Learning science is part of every child's education in the Netherlands. All primary schools are expected to teach science, in order to meet all of the government's 'core objectives' for primary education (Ministerie van Onderwijs, Cultuur en Wetenschap [OCW], 2006). Even though an entire section of core objectives is nature- and technique-related, there are concerns that science is not given enough attention in primary school. Because learning science is regarded as important, primary schools are urged by the government to teach more science and technology (Bakker, 2012).

Learning science in an informal environment might contribute to the formal curriculum. The informal learning context of a science museum[1] can contribute by meeting science-related learning objectives (Van Keulen, 2011). Recently, a committee formed to give advice on how to increase attention given to science and technology in primary schools, even recommended schools to cooperate (more) with science centres (Verkenningscommissie wetenschap en technologie primair onderwijs, 2013). This can especially be done by attending educational programmes in science centres. These programmes are science-related lessons within science centres, designed for visiting school classes and taught by members of the museum staff: museum educators. Schools could benefit from these educational programmes if learning is taking place. If this is the case, it could possibly result in more school visits, of which the museums benefit in turn.

But the question is, how do we know if children actually *learn* science from educational programmes in a science centre? In the last decades various studies on informal learning have been conducted, such as studies that focus on bridging the gap between formal and informal learning or on learning outcomes (Bamberger, & Tal, 2008). Formal education cannot offer the informal educational experiences. Bamberger and Tal (2008) found that students connect science learned at school to museum experiences, which caused an increase in learning. A school visit to a science centre can therefore be very valuable, if the museum's educational programme provides the opportunity for a good experience. This can be done by letting the visiting students be actively engaged with real objects (e.g. a real fossil instead of a picture of one) in a stimulating setting (Ramey-Gassert, Walberg, & Walberg, 1994). Informal science learning in this setting is more open-ended, has a central social aspect and is more

[1] In this paper, museums are referred to when indicating museums encompassing science. This however is not used only to indicate big institutions with a museum function, but every science centre with an educational role (following the example of Rennie & Johnston, 2004). Though appearance may differ, the learning process in science museums and science centres takes place in comparable informal educational environments. Differentiation between these two is therefore not necessary in this study.

learner-centred than school based learning (Wellington, 1990), which make learning processes outside of school different (Guisasola, Morentin, & Zuza, 2005). So, most studies stress the importance of informal learning and some, like Bamberger and Tal (2008) and Sturm and Bogner (2010), conclude that students are able to learn in the informal learning context of a museum. Bamberger and Tal (2008) interviewed students asking for what they had learned in the museum a day before and Sturm and Bogner (2010) implemented their own educational programme and checked learning results with a test. Both these studies are however limited in to whether or not the authors give insight in learning in an actual informal museum setting, since interviewing can have an impact on the students and testing is an unusual thing to do for museums. Assessing what has been learned is not part of educational programmes. Because the experience, and not the result, is central to informal education, it is ‘unnatural’ to measure these results. These learning results are unknown in typical informal education.

So in answering the question how to measure learning in informal education, the focus should not be on the outcome of the learning, but on the learning experience itself. This is the process taking place. However, not much research has been conducted measuring the learning process in museums (see e.g. Falk, 1983), so little is known about this way of investigating learning in this informal educational environment. The present study is therefore an attempt to comprehend this learning process by presenting and examining a method to investigate it.

By focussing on the process, this study attempts to offer a way of measuring the educational potential of museums. This educational potential is defined here as the possibilities within a museum that facilitate learning to take place. This includes the process and the elements that drive it, as well as the learning outcome, to which the process leads. The interaction between these elements forms the educational potential of the museum. This will be discussed in more detail in further sections of this paper.

A measure of process is involvement. Because an involved child uses more of its potential capabilities, learning is possible (Laevers, 1997). Involvement is an indicator of learning taking place and is therefore seen as a fitting measure, when providing a method to investigate the learning process in the informal educational environment of a museum. This study therefore aimed to gain more insight in learning in science museums, by presenting and exploring a research method using involvement as a measure for museums’ educational potential. The accompanying research question was: how can involvement be used as process variable in order to operationalize measuring the educational potential of museums?

By exploring a process measure in a science museum setting, this study can be both beneficial to museums and schools. The former are offered a tool to evaluate their educational programmes in order to optimise these experiences for learning to take place. The latter could meet the curriculum requirements on science by letting their students learn in the museums.

Learning in Museums

Most studies on education in science centres highlight learning in museums. Particularly learning outcomes of museums' educational programmes are a common research subject. Yet, there is no general method to determine learning in museums, so different studies use different techniques. Results on the levels of learning of the students investigated differed. Bamberger and Tal (2008) studied educational programmes in four different natural history museums, observing school visits and interviewing some students afterwards. Although they found low to medium outcomes on scientific knowledge, there was evidence that the students connected the science concepts of the visit to those learned in school. Cox-Peterson, Marsh, Kisiel and Melber (2003) observed school visits to nine different natural history museums and did not only interview the students, but the teacher and museum educator as well. The study resulted in satisfied students, but science learning outcomes were low.

It would therefore appear that learning outcomes of educational programmes are not of high quality, however, when research focused on a collaboration of formal education and informal museum education, learning outcomes are higher. For example, Guisasola et al. (2005) designed educational materials for a museum programme, preceded by a preparation at school which covered the same subject matters. This approach of the educational programme resulted in high learning outcomes. In a study of Sturm and Bogner (2010) the students were prepared in school before acting with the educational material as well. Only now one part of the students went to a museum for the learning activity, while the other part worked with the same material in school. Results showed a higher learning outcome for the group that attended the museum programme. An example of more intense museum-school cooperation is the MuseumScouts project, described by Wishart and Triggs (2010). Schools in five European countries participated in this project, of which the goal was to connect schools and different kinds of informal educational settings. Of these settings, students appreciated museums the most and they learned from engaging with the museum objects, according to their teachers.

These studies show that the stimulating environment of a museum can be beneficial for the formal educational curriculum (Sturm, & Bogner, 2010; Wishart, & Triggs, 2010).

Examining the Process

The studies discussed above focus on learning in museums, but none do that by focusing on the learning *process*. Because little is known on this, this study does focus on this process, using involvement as process variable.

When children are intensively engaged, in other words involved, they have the possibility to learn. This is because an involved child uses the 'edge' of its capabilities, as stated by Vygotsky (e.g. 1979) in his zone of proximal development. Involvement has been studied in different areas, hence, instruments were developed to study for example involvement in work environments or involvement of patients. In educational settings, different elements have been examined studying involvement, such as parent involvement (Hoover-Dempsey & Sande, 1995; Izzo, Weissberg, Kasprow, & Fendrich, 1999). and involvement of students. Astin (1984) for example, discussed a theory on student involvement. He stresses its influence on student learning, referring to the students' energy and effectiveness. However, Astin's theory is based on higher education students and not on primary school students. Berger and Milem (1999) investigated involvement of students in higher education too. Based on their study, they provide a model of persistence. Involvement of children has been studied with the Leuven Involvement Scale (LIS) of Laevers, Declercq and Jackaman (2011), in different educational settings (see Laevers, 1997; Pascal, Bertram, Mould, & Hall, 1998; Uren, & Stagnitti, 2009).

The LIS[2] is based on the idea that an educational environment contains context, process variables and effects. Involvement is seen as a criterion for the process, as it shows what educational activities bring about in a child (Laevers, et al., 2011). In this educational instrument involved individuals are determined if they show concentration in activities, a persistence of the activity and motivation, which leads to alertness of perception and satisfaction (Laevers, et al., 2011). The LIS is an instrument designed to observe children's involvement in different educational settings, for involvement indicates learning. Because of this method of observation, the LIS seems a fitting instrument to measure process, while it measures during learning and not afterwards. On top of that, observation indicates that there is almost no interference with the normal course of students' activities.

[2] In literature the LIS sometimes referred to as the CIS: the Child Involvement Scale.

The LIS therefore seems to be an adequate instrument to measure involvement in primary school education, both formal and informal. However, the instrument has not yet been used to investigate the informal education in museums. This study therefore examines the validity and reliability of the LIS in this informal educational environment.

Elements Driving the Learning Process

Learning is a big part of a child’s development. It can be defined as information processing, through which mental representations transform (Gazzaniga, Ivry, & Mangun, 2007). According to the work of Piaget (e.g. 1972) and Dewey (e.g. 1963), learning can be seen as constructing new knowledge on layers of prior knowledge and believes, and new knowledge is acquired through experiences. These experiences are not just school based, since a child spends approximately 80% of its time outside of school (Meltzoff, Kuhl, Movellan, & Sejnowski, 2009). Learning in science centres requires action, for as mentioned above, experiences facilitate knowledge construction. These active experiences are thus the learning process. Museums anticipate on child development in the design of their exhibits, by making children handle museum objects. These active experiences indicate an educational potential of museums (Hein, 1998): they are a rich environment for learning.

When examining the process in museum education, learning can be indicated. To fully encompass the educational potential of a museum, however, elements driving the process and thus contributing to learning are examined in this study as well. To determine these elements, this paper looks into developmental aspects of learning combined with what the informal educational environment of a museum offers.

The fact that museums are rich environments for learning is partly due to what this environment affords. An affordance relates to a child’s perception of the world, for this connects an individual with its environment. This can be seen as an interaction, in which the environment offers possibilities and resources for action and the individual possess capabilities for action (Gibson, & Pick, 2000). Affordances relate to active experiences because they are action possibilities, and are therefore examined in this study.

Affordances can be found in environmental elements, but Gibson and Pick (2000) stress that affordances must be perceived. The ability to perceive affordances changes during development, because a child needs to learn to use them. An affordance can thus be seen as a characteristic of an environmental element that needs to be perceived along with the element itself, in order to recognise the possibilities of acting with it. Interaction between perception and action is thus necessary.

Museum objects are an essential element of the museum experience. In particular the engagement children have with these real artefacts, that are usually not found in formal education, reoccurs in studies on museum education (see e.g. Sturm & Bogner, 2010; Wishart, & Triggs, 2010). A museum's collection does not just contain historical artefacts such as ancient tools. A modern museum has different types of objects and apart from the 'real' objects, it contains objects such as models and replicas, digital exhibits, hands-on exhibits, display exhibits. These are different types of objects, but that does not mean that this is the only way to classify museum objects, there is no clear classification. An environment with museum objects, regardless of their type, is full of affordances, facilitating science learning (Henderson, & Atencio, 2007). The fact that students can learn from the objects, indicates that the children must be able to perceive the objects' possibilities of action (affordances). To give meaning to an educational programme, museums should let children interact with museum objects, taken into account what the objects afford (Rowe, 2002). Therefore, these object affordances are included as educational element in this study.

However, it is difficult to translate these object affordances in to different characteristics that can be investigated, because no clear method for it can be found in the literature. In the present study three characteristics have been selected to define object affordances. First, object narrative is considered. Apart from action possibilities, objects can contain the non-physical aspect of a narrative. Narratives, that are the use of stories, are used in both formal and informal education, though types and functions differ (Glover Frykman, 2009). When an object contains a narrative, this can positively influence knowledge acquisition (Glaser, Garsoffky, & Schwan, 2009; Glover Frykman, 2009). This does not necessarily imply that a narrative leads to understanding, for example, scientific information is more likely to be remembered when it is central to the story (Glaser, et al., 2009). The narrative's positive influence results from its contribution to meaning making in education (Glaser, et al., 2009), but also because a narrative naturally engages children's attention and can define object meaning in museums (Glover Frykman, 2009). So even though the presence of a narrative is a non-physical part of an object, it has educational value in museums. For that reason, the presence of a narrative in an object is taken into account as object affordance in this study.

The second object characteristic considered, is the ability of the object to attract attention. This factor relates to children's perception. It is considered conditional for action with an object to take place, since interaction between perception and action is necessary. Finally, the ability of objects to open its 'black box' is considered. This relates to the goal of the object, if it is clear why it is there and what it can be used for. This can be found in the object's action possibilities or in the object's environment in the museum, since this environment can define conceptual coherence (Allen, 2004). This is the case for example when comparison of museum objects and trends and patterns in the objects are to be found (Griffin, 1998). The object can provide understanding when the 'black box' is opened: its goal is clear. This requires perception, since the object's affordance must be perceived, as well as action, which can be necessary to reach the object's goal. Shettel (1973) stresses the importance of museum exhibits to be able to attract attention and to enlighten in order to have educational effect. Because of this educational value, this study examined the ability of an object to attract attention and to open its 'black box' as object affordances.

Apart from object affordances a museum's learning environment contains cognitive affordances. There is, however, no clear interpretation of this kind of affordances. Kozma (2003) regards the ability to structure representations as the cognitive affordance in his research, while Zhang and Patel (2006) state that cognitive affordances are provided by cultural convention.

The learning tasks within an educational programme are structured. This relates to the fact that different activities have different purposes. Because of the different purposes of the activity, prior knowledge can be accounted for in processing information, which is part of learning (see Dewey, 1963; Piaget, 1972). This cognitive part of activities can support thinking, reasoning and meaning-making and direct attention to the scientific content (McGregor, 2008). Structuring these tasks in different learning phases, ordering the learning content from introduction to the bigger picture, facilitates knowledge construction (Driver, & Oldham, 1986). This study therefore operationalizes cognitive affordances in the task structuring of educational programmes. The present study chose to use the learning phases of Driver and Oldham (1986) as indicator of cognitive affordances, as they might help students in recognising object affordances, although evidence for this is lacking in the literature.

A third element contributing to the learning process in the informal learning setting of a museum is the social aspect. This includes interaction with museum educators, teachers, chaperones, etc. These social interactions are important, because they influence learning according to Vygotsky (e.g. 1979), and neurological insights support that social cues are important for what and when to learn (Meltzoff, Kuhl, Movellan, & Sejnowski, 2009). Through social interaction, children are stimulated to focus on objects or features of objects, are challenged to make explicit what they are experiencing (redescription of their mental representations) and are maybe even able to reflect upon it critically (Van Keulen, 2011).

Social interactions in museums can give children a better understanding (Blud, 1990) and thus improve learning outcome. More explicit, guidance in the form of question prompts can be important in knowledge acquisition (Xun, & Land, 2004), since they can direct students' attention. Because exact social interaction cannot be examined after the learning has taken place, this must be investigated during the learning process. This study therefore operationalizes social interaction by observation of guidance by question prompts.

Model for the Educational Potential of Museums

In the present study the educational potential of a museum is defined as the possibilities within a museum that facilitate learning to take place. In order to measure this, this study hereby presents a model to indicate this potential. In this model, elements of the educational setting, the learning process and the learning outcome, as described above, are encompassed. The model is depicted in Figure 1.

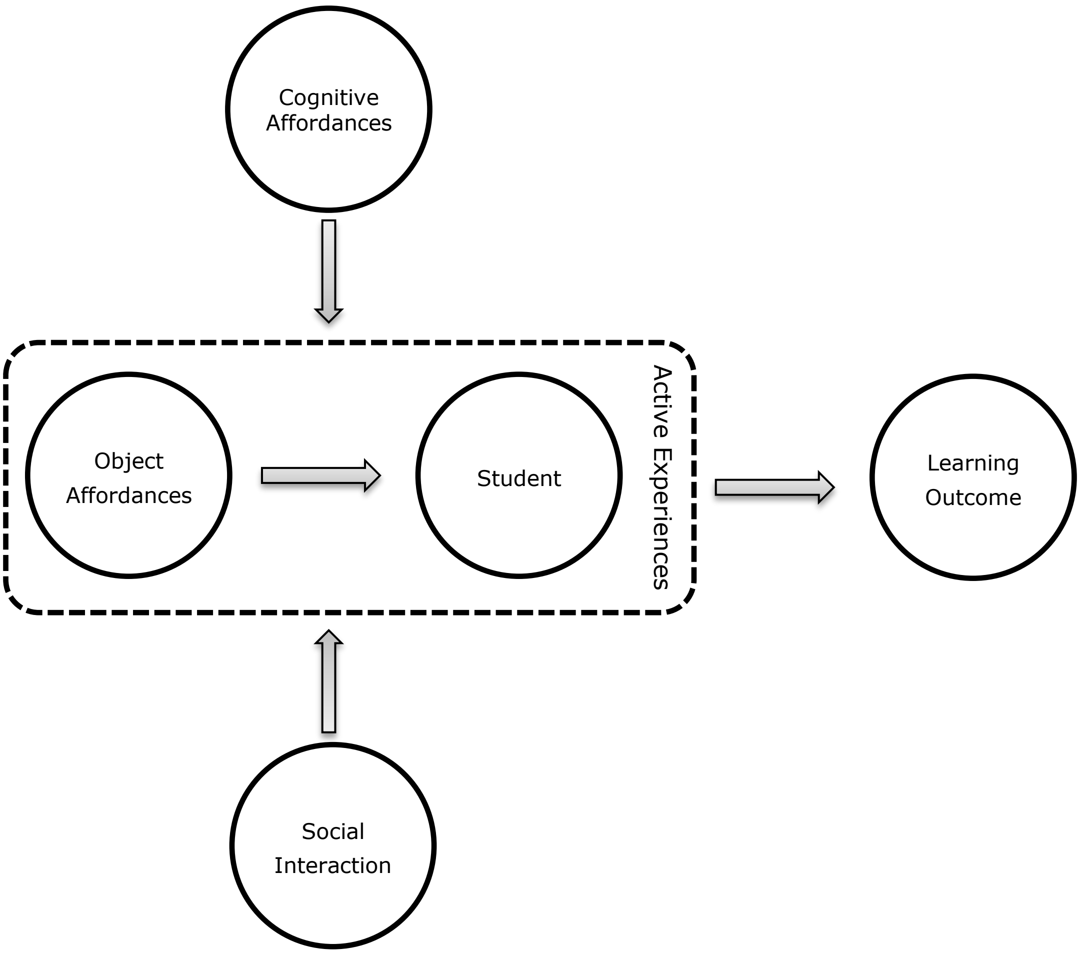

Figure 1 *Model of the Educational Potential of Museums*

In the model, action possibilities of museum objects must be perceived by the student, in order for the student to act with them. This handling of objects forms the active experiences, which is the learning process leading to an unknown learning outcome. Cognitive affordances and social interaction can influence knowledge acquisition and thus the learning process in this model.

The model shows the elements of a museum that drive the learning process and thereby facilitating learning to take place. This study presents and investigates a method to measure the educational potential of museums, focussing on learning process, based on this model.

Research aim and questions

The present study tries to build on and extend the current knowledge on learning science in the informal context of a science centre. This is done by focusing on the learning process, which is little done in previous research. To gain more insight in learning in science centres, the present paper focuses on using involvement as a measure of the educational potential of museums. The educational value of the process variable involvement is that it is an indication for deep level learning (Laevers, et al, 2011), for the more involved a child is, the more it uses its potential capabilities (Laevers, 1997).

The main research question studied here is how involvement can be used as a process variable in order to operationalize measuring the educational potential of museums. This question encompasses the entire model of the educational potential of museums (see Figure 1) and is answered by sub questions.

Sub question 1 is: Is the Leuven Involvement Scale a valid and reliable instrument in the informal educational setting of a science centre? The Leuven Involvement Scale (LIS) for primary education is used here as instrument to determine involvement. The LIS will be used as research tool to investigate involvement as a process variable of the learning process. This way, the active experiences of museums' educational potential are examined. Since the LIS has not yet been applied in the informal educational setting of a museum, it is examined if this instrument is valid and reliable in this setting. The hypothesis is that the LIS will be both valid and reliable. Regarding validity, it is expected that the LIS can be used in science centre education, as it is an instrument designed to assess various educational settings and its descriptions of the to be observed behaviour of children is adjusted to primary school students (Laevers, et al., 2011). Besides that, the students attend educational programmes during school hours, in the same group of students as they are in during school and accompanied by their own teacher. The situation is therefore comparable with the students' formal education.

To establish reliability, it was examined what levels of involvement educational programmes of science centres evoke, expecting high overall levels of involvement, but still a range from the lowest level (1) to the highest (5). High overall levels are expected because educational programmes of two science centres known for their quality were used in this study. The range across all levels of involvement is needed, because in order to use the LIS to measure involvement levels, there must be variation. This is because when only the two highest levels could be measured, it would make the tool insufficient, since little to no comparison is possible between two successive levels of involvement. It is expected that low levels are to be found in good quality programmes too, because individual differences between the students will probably lead to variation in involvement level.

Sub question 2 is: Which factors contribute to making involvement fitting as a process variable? In order to get a more complete picture of what contributes to learning outcomes in the educational potential of museums, not only the learning process is considered, but also elements contributing to that process. This sub question is answered by operationalizing object affordances into object narrative, the ability to attract attention and the ability to open the 'black box'. Furthermore, social interaction is operationalized in question prompts and cognitive affordances in learning phases. The effect of these elements on involvement is examined.

Regarding the three object affordances, it is expected that when a narrative is present in an object, involvement levels are higher than without narrative. This is because of its contribution to meaning making (Glover Frykman, 2009). The hypothesis for the other object affordances is that both objects that score higher on the ability to attract attention and objects that score higher on the ability to open the 'black box', will result in higher involvement levels. This is because of their importance for museum objects to have an educational effect (Shettel, 1973).

The model for museums' educational potential presents cognitive affordances as influencing the learning process. Cognitive affordances are operationalized here as learning phases, which are related to the goal of activities and thus always present. Therefore, not the effect of presence on involvement is investigated, but the effect of the different learning phases. It is expected that involvement levels differ among the learning phases, since the aim of learning activities might affect the influence on recognising object affordances. This indicates that the meaning making influence of learning phases (McGregor, 2008) differs between phases. However, this is just an assumption, since this way of operationalizing cognitive affordances is new.

Social interaction is expected to help in knowledge acquisition (Blud, 1990), and thus positively influence the learning process. Therefore, the hypothesis is that the presence of a question prompt results in higher involvement levels. Variation in involvement between different types of question prompts might occur, indicating different effects of different types of social cues.

Assuming that the educational programmes examined in this study are of good quality, since they are developed and implemented by experienced science centres, the hypothesis to the main research question is presented here. Based on the model for the educational potential of museums presented in the present paper, it is expected that involvement can be used as process variable to measure this potential. The hypothesis is that the Leuven Involvement Scale can be used as instrument to measure involvement in the informal educational setting of a science centre, forming a fitting method to measure the educational potential of museums, if complemented by tools to measure factors contributing to the learning process.

Methodology

Overview

The present study intends to present a method to investigate learning in science centres by using involvement as a measure of museums' educational potential. In order to include as many elements of this potential as possible in the research method, factors other than involvement are investigated as well. The Leuven Involvement Scale (LIS) was used to observe involvement. On top of that the presence of a narrative in the museum object present was observed, along with the learning phases and question prompts used. Observations were made on different days, at different times. The ability of the museum objects to attract attention and to open the 'black box' (achieving its goal) was scored by the museum staff. The validity of the LIS in this informal educational setting was examined during a session of the experimenter and two reviewers, using video-taped clips of educational programmes.

Research design

Different variables formed the data, of which involvement level was the dependent. This was measured using the Leuven Involvement Scale for Primary Education (Laevers, et al., 2011), this is a 5-point scale. Levels 1 to 5 of involvement are respectively: no activity, frequently interrupted activity, more or less continuous activity, activity with intense moments and sustained intense activity. Level 4 and 5 are regarded as high levels, whereas level 1 and 2 are the low levels. Determining the level of involvement is based on observing the following signals in a child: concentration, energy, complexity and creativity, persistence, facial expression and posture, precision, reaction time, verbal utterances and satisfaction (Laevers, et al., 2011). A short description of how to observe these signals is provided in appendix 1.

The general independent variables scored included age and gender of the observed child and if the children were part of the same group of students with the same teacher: the ‘class’ of the student. No effect of these variables was expected, because they are not regarded as factors important for/of influence on the learning process in the informal educational setting of museums. They were not included in the model for museums’ educational potential (see Figure 1), because of these expectations. Still, they were checked for possible influence, because of the variation. Another general independent variable was the educational programme attended, which was scored in order to determine if generalisation of educational programmes was possible. Since the educational programmes studied are assumed to be of good quality, no difference in involvement between the different programmes was expected.

For the independent variables of object affordances in the form of the ability of objects to attract attention and the ability to open the ‘black box’, 5-point Likert-scales were used. Object affordances in the form of the presence of a narrative were scored during observations, using ‘present’ and ‘not present’.

Learning phase, an independent variable, was used as measure for cognitive affordances. Based on the description of the five learning phases of Driver and Oldham (1986), the learning phase present during observation was noted. The first phase, Orientation, includes the introduction of purpose and lesson context. In the second phase, which is Elicitation of Ideas, students make their ideas explicit and/or focus on what they already think or know. Restruction of Ideas is the third phase, and includes the clarification and construction of new ideas or the restructuring of students’ own understandings. In the fourth phase, Application of Ideas, developed ideas are used in both familiar and novel situations, in order to consolidate and reinforce the students’ new conceptions. The final phase is the Review, containing reflection on what is learned.

The independent variable ‘question prompts’ was used to score social interaction. The presence of these prompts was studied during observation. If there was social interaction, the type of question prompt was observed. The three types used were: Procedural prompts, which is an instruction or explanation; Elaboration prompts, which are aimed at elicitation of thinking and own explanations; Reflection prompts, which stimulate reflection (Xun, & Land, 2004).

Participants and Setting

All participants were Dutch primary school students of 16 different classes. The data of three students were removed, when the educational programme proved to be not representative at moment of observation, due to technical constrains. A remaining total of 124 students was observed, of which 62 were female and 62 male. The age of the students ranged from 4 to 13 (M = 8.16, SD = 3.05).

The students attended existing educational programmes, developed and offered by the Dutch science centres Naturalis Biodiversity Centre (Leiden, the Netherlands) and Universiteitsmuseum Utrecht (Utrecht, the Netherlands). These museums are known for their good quality educational programmes, expert knowledge on museum education and skilled museum educators, because of years of experience and evaluations. Therefore, these science centres were asked to participate in a study on their programmes.

The schools initiated attendance of these programmes and teachers were contacted prior to their visit in order to get permission for observing their students. In Naturalis the programme ‘Schatkisten’, was studied. This programme is aimed at the two first years of primary school (that are often combined into one class), so students are normally between 4 and 6 years old. During ‘Schatkisten’, students discover different museum artefacts hidden in treasure boxes, which are dispersed throughout the museum. Most treasure boxes address the exhibition they are situated in as well. In the Universiteitsmuseum one of the programmes studied was: ‘Museum voor de Klas in het Jeugdlab’. This programme is mainly focused on 11-12 year olds. This programme, aimed at year 8 (grade 6) of primary school, is situated in a hands-on exhibition, the so called ‘youth laboratory’. The theme of the programme is to solve a crime (the theft of an ancient science object) with science. Most of these crime-solving activities are done using museum exhibits. The other Universiteitsmuseum programme studied was ‘Bouw van Mens en Dier’, focused on ages 7 to 10. This educational programme has two different versions: one aimed at year 4 (grade 2) and one at year 5 and 6 (grade 3 and 4). Both versions look into the theme of animal and human anatomy. The year 4 version is focused on teeth form and function, whereas the year 5/6 version is focused on skeletal form. The programme mainly takes place in a room specially designed for educational use, but there is one activity using museum exhibitions as well.

In total 52 students were observed attending ‘Schatkisten’, 40 attending ‘Museum voor de Klas in het Jeugdlab’ and 32 attending ‘Bouw van Mens en Dier’.

Procedure

The author served as experimenter in this study. A DVD training pack (Laevers et al., 2011) trained the experimenter with the adequate observation and evaluation techniques in order to use the LIS. Especially the signals (as listed in the appendix) concentration, energy, complexity and creativity, and persistence are of importance in determining the level of involvement. In order to fully master using the LIS and observing the other observation variables as well in the science centre setting, test-observations were made of 83 children of 11 classes attending one of the educational programmes used in the study. After this extensive training the experimenter was fully familiar with the observing procedure. However, as this study was conducted by only one experimenter, inter-observer reliability could not be determined. Although use of the LIS by the sole observer was most likely consistent over time due to thorough use, the experimenter’s observation technique was checked.

In order to check for reliability of the experimenter two educational programmes were video-taped with permission. One of the programmes recorded was one used in the test-observations (Museum voor de Klas in het Jeugdlab), the other was a different programme but was, like ‘Schatkisten’, one of the regular educational programmes for primary schools of Naturalis Biodiversity Centre. Clips of the video-tapes were examined and scored with the LIS by both the experimenter and two reviewers, who were both trained by the LIS DVD training pack (Laevers, et al., 2011) as well. If there was disagreement in involvement level observed in a video, the clip would be discussed in depth until agreement was achieved. This way, the experimenter altered her technique of observing involvement. This process served to gain higher reliability for the experimenter’s way of observing. In addition, the process served to validate the LIS as an instrument to measure involvement in the informal educational setting of a science centre.

After validation of the LIS and the experimenter’s training, the observation procedure was as follows. Upon arrival of the class, the experimenter introduced herself to the teacher, who had been contacted prior to visit. The students were not aware of the purpose of attendance of the experimenter, other than to just watch the educational programme. The educators of the science centres carried out the educational programme as usual. Up to eight children, 50% male and 50% female, were observed during the programme. Selection was done randomly by selecting every first, third, fifth and seventh boy and girl lining up to enter the exhibit of destination in the museums. Each child was observed for approximately one to two minutes before findings were documented. Subsequently other children were observed before returning to the first child for a next observation. One to eight observations per child were made. Observations of each child were written down on a form. The experimenter tried to keep a low profile during observations, in order to interfere as little as possible with the normal procedure of the educational programme. When enough observations were made or when the programme ended, the experimenter asked the observed children for their ages. On top of that, the child's gender, class and the programme attended were noted on its form. The form is presented in appendix 2.

A questionnaire concerning the museum objects used in the programmes was presented by e-mail to selected museum staff members, one for each educational programme. These staff members were considered experts, since they were concerned with the content of the educational programme in which the objects concerned were used. The questions concerned two properties of the museum objects, to score on a 5-point Likert scale. Descriptions of these two properties were given. Per object the questions presented on the questionnaire were 'the extent to which the object is able to attract attention is…' and 'the extent to which the object is able to open the 'black box' is…'. Definitions of these object abilities were given. Only the first and last point of the 5-point scales following the questions were labelled, with respectively 'low' and 'high'. An example of the questionnaire is given in appendix 3.

Data analysis

All statistical analyses were done using IBM SPSS Statistics 20. Found involvement levels were analysed by describing range, mean, median, mode and standard deviation and by examining the distribution. This was done following sub question 1 on the reliability of the LIS. To check for possible influences of the general factors of age, gender, class and different educational programmes, mean involvement levels per student were calculated. Means were compared using independent samples nonparametric tests for gender, class and educational programmes. A Spearman's rank-order correlation coefficient was conducted to test the effect of age.

Following sub question 2, the possible effect of object affordances, social interaction and cognitive affordances on involvement level was investigated. This was done by means of the variables object narrative, object attraction ability and object 'black box' ability, learning phases and question prompts. Question prompts and learning phases were investigated by comparing means with a Kruskal-Wallis H test. If a post-hoc test was needed, separate Mann-Whitney U tests were used. The effect of object narrative on involvement was analysed with a Mann-Whitney U test. The questionnaire items object attraction ability and object 'black box' ability were tested for internal consistency using a Cronbach's alpha reliability analysis. The influence of these two factors on involvement was analysed using Spearman's rho rank-order correlations.

Results

Validity and Reliability

In order to answer sub question 1, a review procedure (as described in the methods) took place to determine validity. The examiner and reviewers present were all able to score involvement of the children in video clips filmed during educational programmes. These involvement levels could be determined using the outline of the different levels and observation signals as described in the LIS DVD trainings pack (Laevers, et al., 2011). In addition, the reviewers were able to reach agreement on the involvement level assigned, after video clips were scored independently. Whenever there was disagreement, given scores were explained and discussed by asking if the behaviour of the student in the clip was interpreted in the same way, and if these interpretations were assumptions or well-reasoned for. During discussions, the examiner and reviewers encountered the problem of if the activity limited the highest level possible or if children were unlimited, and the highest involvement level could always be found. After watching different clips and discussing this thoroughly, it was determined that the former was the case. This was because some activities do not allow children to show creative and complex behaviour, which is the main indicator for a level 5 instead of 4. By following this rule and discussing observations, agreement on the involvement level assigned was possible in all cases.

In addition to validity, reliability was examined describing the levels of involvement found. Between the 124 participants, a total of 550 observations were made. Levels of involvement ranged from 1 to 5, with an overall mean of 3.84 (SD = .81) and both median and mode were 4 (see Table 1).

Table 1 *Descriptives of Level of Involvement (N = 550)*

	M	***SD***	***Mdn***	***Mode***	***Min***	***Max***	***Skewness***
Involvement Level	3.84	0.81	4.00	4.00	1.00	5.00	-0.64

This indicates that involvement levels were on average higher than 3, and thus high. On top of that, a distribution across all levels of involvement (1 to 5) was found, indicating that variation of results occur if the LIS is used in a museum setting. But the results also point towards a possible asymmetrical distribution of the data, that is confirmed by a skewness of -.64 (Table 1). The distribution of the involvement levels is shown in Figure 2, indicating that involvement levels were not normally distributed and the two high levels 4 and 5 cover the biggest part of al observations. So both descriptives and distribution indicate high levels of involvement.

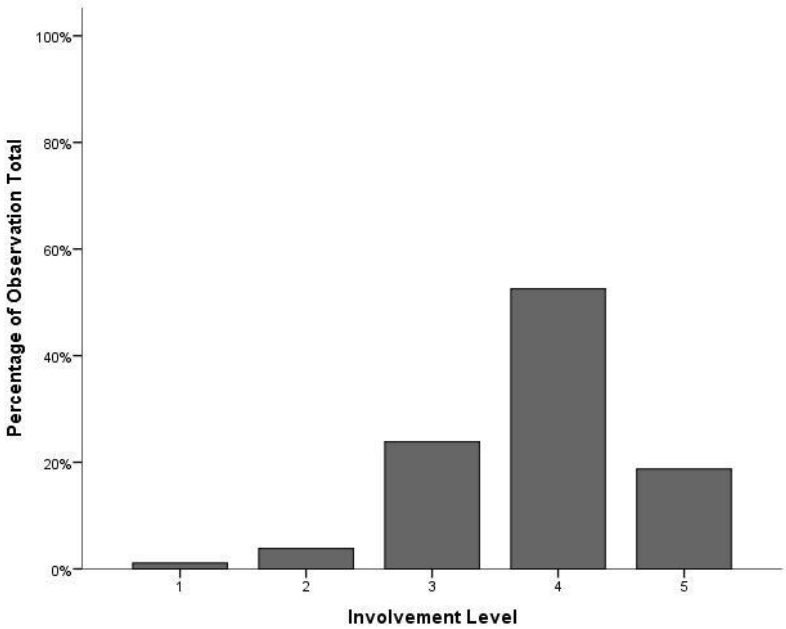

Figure 2 *Distribution of Involvement Levels (N=550)*

General factors

Mean level of involvement per participant was calculated in order to control for the effect of the general factors on the levels of involvement. The general factors are not concluded in a research question, but only checked to see if no unintended effect occurred. These general factors were the different classes (groups the students were in), the educational programme attended, gender and age. None of these factors were expected to affect mean involvement level. A Kruskal-Wallis test showed that the mean involvement level did not significantly differ between the different classes of the students: χ^2 (2, N = 124) = 20.73, p = .15. No significant difference was found in mean involvement level between the three different educational programmes either, χ^2 (2, N = 124) = 4.79, p = .09 (Kruskal-Wallis), nor did gender significantly influence mean involvement, since a Mann-Witney U test indicated Z

= -1.17, p = .24. A Spearman's rho revealed no significant relationship between age and mean level of involvement (r_s[124] = 0.08, p = .38).

So according to expectations, no significant effect of class, educational programme attended, gender or age was found.

Object affordances

By investigating the effects of the factors object narrative, object attraction ability and object 'black box' ability on involvement level, object affordances were covered, as part of sub question 2.

Since the scores of the ability of an object to attract attention and to open the 'black box' were determined using a questionnaire, the internal consistency of the items was determined. The two items proved to be reliable, α = .93.

As expected, a significant positive correlation, r_s = .13, p = .00, between an object's ability to attract attention and involvement level was found. A Spearman's correlation revealed a significant positive correlation between involvement level and an object's ability to open the 'black box' (r_s = .12, p = .01) as well.

A Mann-Whitney U test, Z = -.90, p = .37, showed that level of involvement did not differ significantly between objects containing and objects not containing a narrative. This was against expectations.

Cognitive affordances

A Kruskal-Wallis test, χ^2 (2, N = 550) = 18.58, p < .00, indicated that the level of involvement did vary significantly between different learning phases, indicating cognitive affordances, as element of sub question 2. Separate Mann-Witney U tests specified that the phase of Application of Ideas, which has the highest mean score (see Table 2), differs significantly from all other phases (Orientation Z = -2.70, p = .01; Elicitation of Ideas Z = -2.29, p = .02; Restruction of Ideas Z = -2.44, p = .02; Review Z = -3.83, p < .00). The lowest mean score was found for the Review phase, which differed significantly (Z = -2.52, p = .01) from Restruction of Ideas, the second highest mean. So some learning phases led to higher involvement levels than others, indicating that as expected, difference in learning phase affected involvement level.

Table 2 *Mean Level of Involvement of Learning Phases and Question Prompts (N = 550)*

	M **Involvement level**	***SD***
Orientation	3.79	.73
Elicitation of Ideas	3.71	.84
Restruction of Ideas	3.83	.83
Application of Ideas	4.05	.80
Review	3.59	*.73*

Social Interaction

The final element of sub question 2 was social interaction. This included the use of question prompts and the different types of prompts. Mean involvement levels for the different question prompts were calculated across the total of 550 observations (Table 3). Against expectations, the absence of question prompts led to the highest mean level of involvement. However, A Kruskal-Wallis test, χ^2 (2, N = 550) = 6.96, p = .07, indicated no significant effect of the different prompts, including when no prompts were used. This was not in line with the expectation that the use of question prompts would indicate higher levels of involvement and that involvement might vary when different prompts are used.

Table 3 *Mean Level of Involvement of Question Prompts (N = 550)*

	M **Involvement level**	***SD***
No prompt	3.93	.86
Procedural prompt	3.80	.76
Elaboration prompt	3.80	.81
Reflection prompt	3.75	.77

Conclusion and Discussion

Primary schools could use the informal educational programmes of science centres to complete science-related objectives of their formal curriculum, if it can be established that the students learn during those experiences. However, testing the increase of students' knowledge is not part of informal education. Measuring the learning process is therefore more fitting, but research on this is scarce. The present study aimed to gain more insight in the learning in science centres, by presenting and exploring a research method using involvement as a measure for museums' educational potential.

The Leuven Involvement Scale

A model for the educational potential of museums was presented (see Figure 1), and different aspects of it were encompassed in a research method. The active experiences were measured using involvement as process variable. For this purpose, the Leuven Involvement Scale (LIS) was used and tested for its validity and reliability in a museum setting. According to the hypothesis, the LIS proved to be valid, since it was applicable in the informal educational setting of a science centre. Use of the LIS was also found to be reliable, as it resulted in high levels of involvement found for educational programmes of good quality, while involvement still varied across the entire range of levels. So, it can be concluded that the LIS is a valid and reliable instrument in science centre education. This instrument can thus be used as an instrument to determine involvement levels, with involvement being a process measure for the educational potential of museums.

In order to use the LIS, experimenters must be trained with the training pack, and training with video clips is advised to improve inter-rater reliability. This can be done according to the methodology of the review process of the present study. This included independent scoring of the clips, discussing the scores afterwards to reach agreement and to form rules out of this discussion in order to score alike *in situ* (a full description can be found in the section ‘methodology’).

Factors Contribution to the Learning Process

The model of the educational potential of museums (Figure 1) encompasses factors of the museum context that drive the learning process. Because these factors might influence the learning process, their effect on involvement was explored in order to examine if they contribute to making involvement fitting as a process variable.

But first, the influence of other, more general factors was checked. These factors were the different groups in which the students attended the programme (their so called class), age and gender of the students and the educational programme attended. These factors should not influence the process, since no literature points towards effect of these general factors on learning process. But as they were variables, effect could unexpectedly have occurred and was therefore checked. No significant influence of the general factors on involvement was found.

A factor part of the active experiences is ‘object affordances’, which could influence the learning process. Object affordances were operationalized in the following variables: the presence of a narrative in the object, the ability of object to attract attention and the ability of object to open its ‘black box’ (achieve its goal). The effect of these variables on the process variable involvement was tested.

Considering the use of a story within an object, no indicator of involvement was found in the presence of a narrative. Since the use of a narrative as part of the object (e.g. a dramatized explanatory video) should contribute to meaning making, the result was against expectations. This could be caused by the fact that the distribution of museum objects with a narrative present to objects without, was unevenly. Another possible explanation could be that its contribution to the learning process is smaller than expected based on the literature. To conclude: the presence of a narrative has not been found to have a clear contribution to the process.

According to the hypothesis, both an object’s ability to attract attention and ability to open its ‘black box’ show a positive correlation with involvement level. This indicates a contribution of these object affordances to the process variable: when objects score higher on these characteristics they direct towards higher involvement.

The contribution of cognitive affordances on active experiences was checked for by examining the effect of different learning phases on involvement. Cognitive affordances contextualise active experiences through the structuring of the learning activities.

Differences in involvement between learning phases were examined, expecting that involvement would vary between the different learning phases. This is because the structuration of activities might influence if the child can be at the edge of the capabilities of its zone of proximal development (see Vygotsky, e.g. 1979) or not, since some learning phases support meaning making more than others. It was found that involvement did differ, mainly between the phase ‘application of ideas’ and the other phases. This phase showed a significant higher level of involvement, followed by the phase ‘restruction of ideas’, who differed significantly with the lowest scoring phase (‘review’). So, variation between phases is found, but it is limited. These results might be influenced by the number of observations per phase, which differs considerably from 34 observations of ‘elicitation of ideas’ to 251 observations of ‘restruction of ideas’. The conclusion is that it is difficult to determine the exact contribution to the process of cognitive affordances, when operationalized as learning phases. Still, structuring activities, causing clear goals, could influence the learning process, but it is not possible to determine how by measuring learning phases.

The social interaction element of the educational potential was operationalized by measuring the effect of question prompts and the kind of question prompts used. No influence of question prompts or of the different question prompts on involvement level was found.

This is not in line with the hypothesis, since social interaction should positively influence knowledge acquisition and thus be of effect on the learning process. This might however not be the case, making social interaction a factor of the educational setting of the museum that is independent of the process. The results could also be caused by the fact that question prompts might not be an adequate way of operationalizing social interaction. Another explanation for the results is that only adult-child interaction is accounted for in this operationalization and not peer interaction, while this can be important too (Xun, & Land, 2004). So for now, it can be concluded that social interaction does not contribute to involvement as process variable, when operationalized in presence and types of question prompts.

Operationalizing the Educational Potential

Here, this study presents a method to measure the educational potential of museums (Figure 1), using involvement as process variable. The focus of the method is on the part of the active experiences of the educational potential of museums. This is because exact learning outcomes are difficult to determine in a museum context. The active experiences are measured here as the learning process. This process is influenced by factors of the educational museum setting, which must be accounted for in order to encompass as much of the educational potential as possible into the research method. In this study involvement was used as process variable, using the LIS, to measure involvement during active experiences. On top of that context variables of the educational potential were measured for their contribution to the process.

The conclusion is that the LIS can be used in the informal educational setting of a science centre. It is possible to see boredom, or low levels of involvement, and to see high levels of involvement, which is regarded as indication of learning taking place. Therefore, involvement can function as a process variable to measure the educational potential of museums. A suggestion to complement the use of the LIS and thereby encompass more of museums' educational potential, is to measure factors that might be of effect on the process. Object affordances are of influence and can be determined by objects' ability to attract attention and open their 'black box'. Cognitive affordances could be measured using learning phases, but the precise effect of this is however unclear.

Science centres could use the method presented here - the operationalization of the educational potential of museums using the LIS, complemented by factors of the educational context of museums.

Science centres could improve the quality of their educational programmes, using this method. It can be examined if students are involved during the course of the programmes. Involvement is a process measure indicating that learning is taking place. Improving the involvement level therefore indicates improving the learning process of the educational programmes. This can be done by investigating factors contributing to this process. For example, improvement would be optimising the objects used in the programme by investigating if the object affordances could lead to high involvement levels (since the object's ability to attract attention and to open its 'black box' positively correlate with involvement).

Advantages for science centres to use the LIS together with the added factors include it being an easy to use method. The LIS and its training pack are designed for use by non-professional researchers as well (Laevers, et al., 2011). The measurement of the additional factors is simple in design, so mastering this measurement should be no problem either. This way, a museum's own staff can measure the educational potential. Another advantage is that, by measuring learning process, the tool presented does not interfere with the normal course of an educational programme or test exact results. It therefore fits the informal educational setting of a museum. If schools however do require exact results, in order to prove to what extent they are teaching their students science, it is their responsibility to consider assessing the students after attending an educational programme.

Limitations

This study is exploratory in nature, since examining learning in museums by focussing on the process is a relatively unexplored research domain. Because of this exploratory nature, choices had to be made in the theoretical background and methodology of the study. This limited the study in different ways, which are discussed here.

Although the choice to measure involvement, object narrative, object's ability to attract attention and open its 'black box', learning phases and question prompts was underpinned by literature, it remains mainly a choice in order to explore the educational potential of museums. This study is therefore limited, since it presents merely *a* tool, not *the* tool to measure a museum's educational potential.

The use of the LIS has different limitations. Firstly, because only one experimenter collected the data, reliability was low, even though scoring was probably consistent over time, the experimenter was trained thoroughly and her way of using the LIS was checked by two reviewers. The LIS itself is limited in the fact that only involvement during the learning process can be measured. This means that an indication of deep-level learning is possible, but nothing can be said about how deep. Therefore, the learning outcome part of the educational potential of museums can only be covered indirectly and this study focused on process and context. Furthermore, the differences between levels of involvement as used in the LIS are indistinct, leading to individual differences, because one child assigned a ‘4’ might be different from the other ‘4’. However, a comparison between the different levels remains possible, since the LIS is a scale. Additionally, this study is limited in the validation of the LIS as instrument for informal education. This validation (a description of this process can be found in the methodology section of this paper) was done within just a few hours. On top of that, the two reviewers present, were only trained with the DVD training pack to use the LIS, and not *in situ*. This might have made the validation process too brief to truly investigate validity. Besides, it was difficult to determine if this way of examining validity was a good way. The decisions on scoring involvement made during the validation, could for example have positively or negatively influenced the overall found involvement levels.

As for object affordances, the ability of objects to attract attention and to open the ‘black box’ was determined using a questionnaire. However, each museum object was scored by only one expert. This limits this study. Moreover, the correlations found between these two object affordances and involvement were somewhat weak (respectively 0.12 and 0.13). In addition, no effect of the object affordance variable ‘object narrative’ was found. This result was not in line with hypothesis, but might be supported by the small learning impact of narratives found by Allen (2004).

For the element of social interaction, only adult guidance was accounted for, while peer interaction might be of importance too (Xun, & Land, 2004). Furthermore, the adult guidance that was measured could have been inconsistent in quality, since in one of the educational programmes in this study (‘Schatkisten’) parents sometimes served as guides instead of museum educators.

This study used learning phases as way of investigation cognitive affordances. However, this is not an empirical method, merely an interpretation of accounting for these affordances. This might explain why the effect found on involvement is unclear. Both learning phases and question prompts are normal in a formal educational setting as well, limiting this study because the exact contribution of these variables to investigate informal educational settings is unclear. This points towards another limitation: it is not possible to assess if the same levels of involvement would have been found in a formal setting, because educational programmes depend mostly on the context of museum object affordances. If the same objects could be transported to a school, would this still lead to high levels of involvement, or is the entire setting of importance? Sturm and Bogner (2010) found that it was of importance. But again, their study is focused on learning results and not on process, so this question could still be investigated.

Finally, the research tool presented in this paper covers a lot. It might therefore be limited in being too elaborate to make it easily usable and analysable for science centre staff.

More research is necessary to further determine the usefulness of the method presented here, and to reduce the limitations. For example, many observations were made in this study. This might not be necessary if a museum would like to evaluate their educational programmes. The number of observations required to get stable results needs to be specified, by determining a desired result and investigated if a minimum number of observations is necessary to get this result. Besides, it could be investigated if the use of the presented method to evaluate and improve educational programmes functions. Furthermore, this study only examined museums' educational potential for primary education, further research could cover secondary or maybe even higher education as well. In addition, the method presented could be tested for its usefulness in museums other than science centres, to contribute to museum education as a whole. The method might even be examined to be of use to assess the educational potential of museum exhibits. Finally, further research could lead to other methods to measure the educational potential of museums, instead of exact learning results, if process variables other than involvement fit the informal educational setting of a science centre.

To conclude

The present study is an extension of the current knowledge on science centre education, by presenting a research method to gain more insight in learning in museums, by focussing on learning process and not on results. This tool serves as a measurement of the educational potential of museums, measuring involvement as process variable using the LIS and measuring the educational context variables object affordances and cognitive affordances, respectively by examining an object's ability to attract attention and to open its 'black box', and learning phases. The method presented could be used to optimise educational programmes of science centres for learning to take place. This is good news for primary schools seeking a way to meet the science-related requirements of their curriculum, because they could let their students learn science in science centres.

Operationalizing museums' educational potential this way, is just one attempt to gain more insight in learning in science centres. But the fact remains, that the tool presented fits this informal learning environment well, for it measures process using observation. The research method therefore does not interfere with the normal course of the informal learning during educational programmes. This makes the presented method stand out from methods to examine learning in science centre that are not common in informal learning, such as interviewing on learning results or testing knowledge gain.

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References

Allen, S. (2004). Designs for learning: Studying science museum exhibits that do more than entertain. *Science Education, 88*(S1), S17-S33. doi:10.1002/sce.20016

Astin, A. W. (1984). Student involvement: A developmental theory for higher education. *Journal of college student personnel,* 25(4), 297-308.

Bakker, M. (2012, December 5). VVD en PvdA: vak techniek al op basisschool. *De Volkskrant*. Retrieved from http://www.volkskrant.nl

Bamberger, Y., & Tal, T. (2008). Multiple Outcomes of Class Visits to Natural History Museums: The Students' View. *Journal of Science Education and Technology, 17*(3), 274-284. Retrieved from http://www.jstor.org/stable/41219421

Berger, J. B., & Milem, J. F. (1999). The role of student involvement and perceptions of integration in a causal model of student persistence. *Research in higher Education*, 40(6), 641-664.

Bertram, T., & Pascal, C. (2002). *Effective early learning programme child involvement scale*. Retrieved from http://www.decd.sa.gov.au/farnorthandaboriginallands/files/links/link_104984.pdf

Blud, L. M. (1990). Social interaction and learning among family groups visiting a museum. *Museum Management and Curatorship, 9*(1), 43-51. doi:10.1080/09647779009515193

Cox-Petersen, A. M., Marsh, D. D., Kisiel, J., & Melber, L. M. (2003). Investigation of guided school tours, student learning, and science reform recommendations at a museum of natural history. *Journal of Research in Science Teaching, 40*(2), 200-218. doi:10.1002/tea.10072

Dewey, J. (1963). *Experience and education* (2nd ed.). New York: Collier books.

Driver, R., & Oldham, V. (1986). A Constructivist Approach to Curriculum Development in Science. *Studies in Science Education, 13*(1), 105-122. doi:10.1080/03057268608559933

Falk, J. H. (1983). Time and behavior as predictors of learning. *Science Education, 67*(2), 267-276. doi:10.1002/sce.3730670214

Gazzaniga, M. S., Ivry, R. B., & Mangun, G. R. (2007). Methods of Cognitive Neuroscience. *Cognitive Neuroscience* (pp. 110-110-163). New York: Norton & Company.

Gibson, E. J., & Pick, A. D. (2000). *An ecological approach to perceptual learning and development*. Oxford [etc.]: Oxford University Press.

Glaser, M., Garsoffky, B., & Schwan, S. (2009). Narrative-based learning: Possible benefits and problems. *Communications*, 34(4), pp. 355-475. doi:10.1515/COMM.2009.026

Glover Frykman, S. (2009). Stories to tell? Narrative tools in museum education texts. *Educational Research, 51*(3), 299-319. doi:10.1080/00131880903156898

Griffin, J. (1998). Learning science through practical experiences in museums. *International Journal of Science Education, 20*(6), 655-663. doi:10.1080/0950069980200604

Guisasola, J., Morentin, M., & Zuza, K. (2005). School visits to science museums and learning sciences: a complex relationship. *Physics Education*, *40*(6), 544. Retrieved from http://stacks.iop.org/0031-9120/40/i=6/a=006

Hein, G. E. (1998). *Learning in the museum*. London [etc.]: Routledge.

Henderson, T. Z., & Atencio, D. J. (2007). Integration of Play, Learning, and Experience: What Museums Afford Young Visitors. *Early Childhood Education Journal, 35*(3), 245-251.

Hoover-Dempsey, K., & Sander, H. (1995). Parental involvement in children's education: Why does it make a difference. *The Teachers College Record*, 97(2), 310-331.

Izzo, C. V., Weissberg, R. P., Kasprow, W. J., & Fendrich, M. (1999). A longitudinal assessment of teacher perceptions of parent involvement in children's education and school performance. *American Journal of Community Psychology,* 27(6), 817-839.

Kozma, R. (2003). The material features of multiple representations and their cognitive and social affordances for science understanding. *Learning and Instruction, 13*(2), 205-226. doi:10.1016/S0959-4752(02)00021-X

Laevers, F., Declercq, B., & Jackaman, S. (2011). *Observing involvement in primary education, a DVD training pack.* Leuven, Belgium: Cego Publishers NV.

Laevers, F. (1997). Assessing the quality of childcare provision: ‘Involvement’ as a criterion. *Researching Early Childhood, 3,* 151-151-165.

McGregor, D. (2008). The influence of task structure on students’ learning processes: observations from case studies in secondary school science. *Journal of Curriculum Studies, 40*(4), 509-540. doi:10.1080/00220270701813282

Meltzoff, A. N., Kuhl, P. K., Movellan, J., & Sejnowski, T. J. (2009). Foundations for a New Science of Learning. *Science, 325*(5938), 284-288. doi:10.1126/science.1175626

Ministerie van Onderwijs, Cultuur en Wetenschap, OCW (2006). *Kerndoelen Primair Onderwijs.* Den Haag: DeltaHage. Retrieved from http://www.rijksoverheid.nl/onderwerpen/basisonderwijs/documenten-en-publicaties/brochures/2010/10/19/kerndoelen-po.html

Pascal, C., Bertram, T., Mould, C., & Hall, R. (1998). Exploring the relationship between process and outcome in young children’s learning: stage one of a longitudinal study. *International Journal of Educational Research, 29*(1), 51-67. doi:10.1016/S0278-4343(98)00013-5

Piaget, J. (1972). *Psychology and epistemology: towards a theory of knowledge*. Harmondsworth, Middlesex: Penguin University Books.

Ramey-Gassert, L., & Walberg, H. J. (1994). Reexamining connections: Museums as science learning environments. *Science Education, 78*(4), 345-363. doi:10.1002/sce.3730780403

Rennie, L. J., & Johnston, D. J. (2004). The nature of learning and its implications for research on learning from museums. *Science Education, 88*(S1), S4-S16. doi:10.1002/sce.20017

Rowe, S. (2002). The role of objects in active, distributed meaning-making. In S. Paris (Ed.), *Perspectives on object-centred learning in museums* (pp. 19-19-35). Mahwah, NJ: Lawrence Erlbaum.

Shettel, H. H. (1973). Exhibits: Art form or educational medium? *Museum News*, 52(9), 32-41.

Sturm, H., & Bogner, F. X. (2010). Learning at workstations in two different environments: A museum and a classroom. *Studies in Educational Evaluation, 36*(1–2), 14-19. doi:10.1016/j.stueduc.2010.09.002

Uren, N., & Stagnitti, K. (2009). Pretend play, social competence and involvement in children aged 5?7 years: The concurrent validity of the Child-Initiated Pretend Play Assessment. *Australian Occupational Therapy Journal*, *56*(1), 33-40. doi:10.1111/j.1440-1630.2008.00761.x

Van Keulen, J. (2011). *Onderzoekend leren in Naturalis.* Unpublished manuscript.

Verkenningscommissie wetenschap en technologie primair onderwijs (2013). *Advies: Verkenningscommissie wetenschap en technologie primair onderwijs.* Retrieved from http://www.platformbetatechniek.nl/WenT

Vygotsky, L. S. (1979). In Cole M. e. a. (Ed.), *Mind in society: the development of higher psychological processes* (2nd print. ed.). Cambridge, Massachusetts, [etc.]: Harvard U.P.

Wellington, J. (1990). Formal and informal learning in science: the role of the interactive science centres. *Physics Education, 25*(5), 247. Retrieved from http://stacks.iop.org/0031-9120/25/i=5/a=307

Wishart, J., & Triggs, P. (2010). MuseumScouts: Exploring how schools, museums and interactive technologies can work together to support learning. *Computers & Education, 54*(3), 669-678. doi:10.1016/j.compedu.2009.08.034

Xun, E. G., & Land, S. M. (2004). A Conceptual Framework for Scaffolding Ill-Structured Problem-Solving Processes Using Question Prompts and Peer Interactions. *Educational Technology Research and Development, 52*(2), p5, 18p.

Zhang, J., & Patel, V. L. (2006). Distributed cognition, representation, and affordance. *Pragmatics & Cognition*, *14*(2), 333-341.

Appendix 1

A short description of the observation signs of the LIS are presented here, adapted from Leavers et al. (2011) and Bertram and Pascal (2002).

Concentration

The attention of the child is directed toward the activity. Only intense stimuli can distract the child from his/her deep concentration.

Energy

The child invests much effort in the activity and is eager and stimulated. Physical energy is often expressed by loud talking. Mental energy can be deduced from facial expressions revealing mental effort. Both types of energy can be accompanied by transpiration.

Complexity and creativity

This signal is shown when a child freely mobilises his cognitive skills and other capabilities in more than routine behaviour. The child involved cannot show more competence - he/she is at his/her very 'best'. Creativity means that the child adds an individual touch, produces something new, shows something personal. The child is at the very edge of his/her capabilities.

Persistence

Persistence is the duration of the concentration at the activity. Children who are really involved do not let go of the activity easily; they are 'captured' by it. They want to continue with the satisfaction it gives them, and are prepared to put in effort to prolong it. They are not easily distracted.

Facial expression and posture

Nonverbal signs are extremely important in reaching a judgment about Involvement. It is possible to distinguish between 'dreamy empty' eyes and 'intense' eyes. Posture can reveal high concentration or boredom. Even when children are seen only from the back, their posture can be revealing.

Precision

Involved children show special care for their work and are attentive to detail. Non-involved children tend to race through activities: they show little care for it. They miss the point or important clues, that involved children don't miss.

Reaction time

Children who are interested are alert and react quickly to stimuli introduced during an activity. They can ‘jump’into action to a proposed activity and express motivation. They respond to new stimuli relevant for their activity.

Verbal utterances

Children can show that an activity has been important to them by their comments, for example: they can ask for the activity to be repeated, they state that they enjoyed it, they indicate their satisfaction of the activity by describing what they do/did.

Satisfaction

The children display a feeling of satisfaction with their achievements, though this is often implicit. The source of this feeling implies things such as ‘exploration’, being ‘facinated’ or ‘getting a grip on reality’.

Appendix 2

Observation form

Programme:
Class:
Gender: Age:

#	Involvement Level	Object	Narrative	Q-Prompts	Learning phase
1	1 2 3 4 5 Concentration Energy Complexity & creativity Persistence Facial expression & posture Satisfaction Precision Reaction time Verbal utterances				
2	1 2 3 4 5 Concentration Energy Complexity & creativity Persistence Facial expression & posture Satisfaction Precision Reaction time Verbal utterances				
3	1 2 3 4 5 Concentration Energy Complexity & creativity Persistence Facial expression & posture Satisfaction Precision Reaction time Verbal utterances				
4	1 2 3 4 5 Concentration Energy Complexity & creativity Persistence Facial expression & posture Satisfaction Precision Reaction time Verbal utterances				
5	1 2 3 4 5 Concentration Energy Complexity & creativity Persistence Facial expression & posture Satisfaction Precision Reaction time Verbal utterances				
6	1 2 3 4 5 Concentration Energy Complexity & creativity Persistence Facial expression & posture Satisfaction Precision Reaction time Verbal utterances				
7	1 2 3 4 5 Concentration Energy Complexity & creativity Persistence Facial expression & posture Satisfaction Precision Reaction time Verbal utterances				
8	1 2 3 4 5 Concentration Energy Complexity & creativity Persistence Facial expression & posture Satisfaction Precision Reaction time Verbal utterances				

Question Prompts

- **P**rocedural prompts
- **E**laboration prompts
- **R**eflection prompts

Learning phases

- **O**rientation
- **E**licitation of ideas
- **Res**tructuring of ideas
- **A**pplication of ideas
- **Rev**iew

Appendix 3

Example of the questionnaires used to determine objects' abilities to attract attention and open their 'black box':

Object	**Description of object**	The extent to which the object is able to attract attention is…	The extent to which the object is able to open the 'black box' is…
Gorilla schedel met draadwerk	Model van een gorillaschedel op een draadwerk in de vorm van de gorilla (bij de introductie getoond)	*low* ○ ○ ○ ○ ○ *high*	*low* ○ ○ ○ ○ ○ *high*
braakbal	Een uilenbraakbal wordt door de leerlingen uitgeplozen (met behulp van pincet en andere hulpmiddelen) en de gevonden muizenbotten worden bestudeerd. Een werkblad toont de namen van de botten en een vergelijking met het menselijk skelet.	*low* ○ ○ ○ ○ ○ *high*	*low* ○ ○ ○ ○ ○ *high*
Vergrootglas bij braakbal	Gebruik van een vergrootglas bij het bestuderen van de muizenbotten uit de braakbal.	*low* ○ ○ ○ ○ ○ *high*	*low* ○ ○ ○ ○ ○ *high*
skelet mens	Een model van een menselijk skelet wordt getoond om vergelijkingen te maken met skeletten van dieren.	*low* ○ ○ ○ ○ ○ *high*	*low* ○ ○ ○ ○ ○ *high*
skeletten in rariteitenkabinet: gorilla/mens	Aan de hand van een werkblad worden overeenkomsten en verschillen tussen het skelet van een mens en dat van een gorilla bestudeerd, die in een vitrine aanwezig zijn.	*low* ○ ○ ○ ○ ○ *high*	*low* ○ ○ ○ ○ ○ *high*
skeletten in rariteitenkabinet: goudhaas/nijlpaard	Aan de hand van een werkblad worden overeenkomsten en verschillen tussen de aanwezige skeletten van een goudhaas en een nijlpaard bestudeerd.	*low* ○ ○ ○ ○ ○ *high*	*low* ○ ○ ○ ○ ○ *high*