International Journal of Science Education

ISSN: 0950-0693 (Print) 1464-5289 (Online) Journal homepage: http://www.tandfonline.com/loi/tsed20

The role of involvement and emotional well-being for preschool children's scientific observation competency in biology

Janina Klemm & Birgit J. Neuhaus

To cite this article: Janina Klemm & Birgit J. Neuhaus (2017): The role of involvement and emotional well-being for preschool children's scientific observation competency in biology, International Journal of Science Education, DOI: 10.1080/09500693.2017.1310408

To link to this article: http://dx.doi.org/10.1080/09500693.2017.1310408

Published online: 25 Apr 2017.

INTERNATIONAL JOURNAL OF SCIENCE EDUCATION, 2017
http://dx.doi.org/10.1080/09500693.2017.1310408

The role of involvement and emotional well-being for preschool children's scientific observation competency in biology

Janina Klemm[a] and Birgit J. Neuhaus[b]

[a]Munich Center of the Learning Sciences, LMU Munich, Munich, Germany; [b]Biology Education, LMU Munich, Munich, Germany

ABSTRACT
Observation is one of the basic methods in science. It is not only an epistemological method itself, but also an important competence for other methods like experimenting or comparing. However, there is little knowledge about the relation with affective factors of this inquiry method. In our study, we would like to find out about the relations of emotional well-being and involvement with children's observation competency. Seventy preschool children participated in our test observing a living mouse, a snail and a fish. From their behaviour in the test situation, we coded their observation competency as well as their emotional well-being and involvement. The data show that both emotional well-being and involvement are significant predictors of children's observation competency. Further analyses confirm our hypothesis of a mediating role of involvement between well-being and the performance in the observation task. In conclusion, theoretical and practical implications of these results are discussed.

ARTICLE HISTORY
Received 4 August 2016
Accepted 20 March 2017

KEYWORDS
Early science; preschool; observation; deep-level-learning; student engagement; biology

Introduction

Observation is a central scientific method (Eberbach & Crowley, 2009). There are some aspects that speak for having a look at this specific research method: firstly, observing is a common method for humans to learn (Rogoff, Paradise, Arauz, Correa-Chávez, & Angelillo, 2003). Secondly, it is a good starting point into research – on the one hand, it is a basic skill that is needed for all other inquiry methods (Wellnitz & Mayer, 2011); on the other hand, it does not require some competencies that are needed for experimenting, e.g. understanding the control of variable strategy, which students tend to have problems with (Zimmerman, 2000). However, observation should not be mixed up with 'just-looking'. Being a scientific method, a good observation should include epistemic activities like questioning, hypothesising, evidence generation and evidence evaluation (Fischer et al., 2014). In addition, scientific observations depend upon the perception of specific, relevant details (Oguz & Yurumezoglu, 2007).

CONTACT Janina Klemm janina.klemm@psy.lmu.de Munich Center of the Learning Sciences, LMU Munich, Winzererstraße 45, Munich DE 80797, Germany

So far, research has analysed the influence of cognitive factors, such as prior knowledge, on observation competency (Alberdi, Sleeman, & Korpi, 2000; Eberbach & Crowley, 2009; Kohlhauf, Rutke, & Neuhaus, 2011). Little attention has been on the role of emotional aspects during observation. In general, it is assumed that emotions influence scientific reasoning (Fischer et al., 2014). Based on this background, the research question of this study is whether children's affective state and their observation competency are related.

Research on scientific observation

Observation is a highly complex research method involving the ability to distinguish between relevant and irrelevant details, to raise questions and generate hypotheses (Oguz & Yurumezoglu, 2007). Observation has been conceptualised as a process underlying the scientific method in general that all scientific knowledge must be based on (Kosso, 2011). On the other hand, it has also been defined as a unique research method, standing next to other methods such as experimenting, comparing and observing, each with their own structure and difficulties (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). While the role of observation as a process underlying all scientific methods has to be acknowledged, this study follows the conceptualisation of observation as a specific research method that may have specific demands on the person applying them (Bybee, 2006). In recent years, the focus has been on the method of experimentation, with a lot of research on the structure of the competency and influencing factors (e.g. Mayer, Sodian, Koerber, & Schwippert, 2014). However, it cannot be said that the same rules apply for different methods. Norris (1984) defines observation competency as the ability to make observations well, report them well and correctly assess reports of observations. In recent literature, there have been two studies that look into the structure of observation competency (Eberbach & Crowley, 2009; Kohlhauf et al., 2011). Eberbach and Crowley (2009) reviewed literature on scientific observation. Based on their findings, the authors formulate four components of scientific observation: noticing of relevant objects or circumstances, expectations and coordination of observations and theories, observational records (cognitive, physical or virtual), and productive dispositions – that is, the extent of the engagement with the observed object. They also propose that there are three states of observation: everyday, transitional and scientific. The literature they reviewed suggests that knowledge in the domains, as well as the right tools and experience are needed in order to obtain information from observations. With regard to the tools, a lot of research has investigated the role of documentation (Fox & Lee, 2013) and the possibilities to facilitate observing with technology (Tokarczyk, 2015).

Kohlhauf et al. (2011) developed a competency model specifically for observation, differentiating three dimensions: the first dimension, describing details, focuses on the number of specific and unspecific details a person describes, the second dimension, scientific reasoning, consists of questioning, hypothesising and testing, and the third dimension, interpreting, focuses on the ability to differentiate between observation and interpretation. In all three dimensions, there are the three ascending levels of incidental observation, unsystematic observation and systematic observations. In order to validate the model, they analysed the observation behaviour of 110 study participants aged between 4 and 29 years. The results confirm the model. Additionally, their data show that prior knowledge of the object of investigation has a positive impact on the observation

competency. For children, they found an influence of language abilities on their performance. This study will follow the model of Kohlhauf et al. (2011), as the goal is here, too, to identify children's observation competency at a specific point in time, and investigate influencing factors.

There is some literature on the interplay between interest and observation. Tomkins and Tunnicliffe (2007) could show that children are generally interested in observing biological objects, especially animate ones, and that these objects trigger their desire to learn more about it. Interest will drive children's investigation, and many factors can play a role here, like the gender of the child and the observed organism (Tomkins & Tunnicliffe, 2001). Johnston (2009) claims that children will only observe what they are interested in. However, Kohlhauf et al. (2011) could not find an influence of general interest in the domain, measured with a self-report. The authors themselves consider the fact that thereby they are not measuring situational interest, as the other studies did.

The influence of emotions on reasoning processes

Although there are no studies investigating the influence of emotions on observations, there is some knowledge about the influence of emotions on reasoning in general. Several types of emotions can be expected to have an effect (Fischer et al., 2014). Epistemic emotions, like surprise or curiosity, can have a positive impact on reasoning processes (Pekrun & Stephens, 2010). Achievement emotions, such as pride or shame, play a role for reasoning as well. The topic itself can also trigger emotions that can have an impact on the quality of reasoning. Boredom, for example, has negative effects on students' performance (Pekrun, Hall, Goetz, & Perry, 2014). Depending on the situation, there can also be social emotions, and of course the incidental emotions and moods a person already brings into the situation (Fischer et al., 2014).

These results on the impact of emotions on reasoning processes mostly originate from research with secondary school students or even adults (Pekrun & Linnenbrink-Garcia, 2012). How is the situation for younger children?

First of all, there is less data on younger children because it is harder to measure their emotions. While for older students, self-assessment is generally seen as a valid method for data collection (Pekrun & Bühner, 2014), preschoolers' ability to assess emotions still varies and may be biased toward positive feelings (Fabes, Eisenberg, Nyman, & Michealieu, 1991). Therefore, the data have to be gained either from observation or physiological measures. The latter poses the problem that physiological measuring can limit the mobility and, consequently, the options of tasks participants can work on. For this reason, we will focus on observation measures.

There are both qualitative and quantitative studies in the early childhood research field that measure emotions. Fleer (2013) investigated learning situations to find out if affective imagination enhances science learning in preschool. When analysing the interactions between the teachers and children, she saw that teachers emotionally charged situations in order to focus children on specific details, which led to more scientific noticing. In this study, qualitative analysis of the dialogue between children and teachers made it possible to notice circular processes between emotions and children's noticing.

An example for a scale that makes quantitative analysis of children's emotionality possible is Laevers' scale for emotional well-being and involvement. Laevers (1993) proposes the idea that involvement is needed for deep-level-learning. In his deep-level-learning model, involvement and emotional well-being are the relevant process factors that mediate the impact of the context on the outcomes. He illustrates the theory with results from a study on preschool children's understanding of swimming and sinking in an inquiry situation. Based on these first results, Laevers (2003) developed an observation tool to measure children's emotional well-being and involvement. For this purpose, the author formulated and operationalised several indicators for the two factors. Openness, flexibility, self-confidence, assertiveness, vitality, inner peace, enjoyment and feeling at ease are indicators for children's emotional well-being. Their involvement can be assessed by noting their concentration, energy, creativity, facial expression, persistence, precision, reaction, verbal utterances and general satisfaction with their learning process in the situation. This instrument, the Leuven Well-Being and Involvement Scale, has since been used to investigate which environmental factors are needed to enable children to be involved, so that deep-level-learning can take place (Aydoğan, Farran, & Sağsöz, 2015; Declercq, 2011; Goldspink, Winter, & Foster, 2008). Pascal, Bertram, Mould, and Hall (1998) investigated the impact of involvement on children's school grades and found that involvement explained 16% of the variance in the grades.

On the level of theory, emotional well-being and involvement can be linked to several other constructs. These relations will now be further explained.

Emotional well-being/positive mood

Emotional well-being has been conceptualised as 'the degree to which children feel at ease, act spontaneously, and show vitality and self-confidence' (Laevers, 2000, p. 24). This definition cannot be reduced to just being a measure of mood, but mood is definitely part of it. Although the results are not completely conclusive, positive mood has been linked to higher engagement and achievement (Linnenbrink, 2007). Positive mood has been found to have a specific impact on learning achievements in science lessons (Laukenmann et al., 2000). While the control-value theory (Pekrun & Perry, 2014) differentiates the dimensions of valence (positive–negative) and activation (activating–deactivating), this differentiation is often not found in studies. In general, positive mood could be linked to holistic thinking, while negative mood would go along with a better reception of details (Pekrun & Perry, 2014). However, in the study of Murray, Sujan, Hirt, and Sujan (1990), the results are reversed. They induced positive or neutral mood and then gave the test subjects a categorisation task. Participants in a good mood found both more similarities and more differences, which might indicate that they in general noticed more details than the participants in a neutral mood. This could be due to the fact that their participants in a positive mood were also more activated and therefore doing better in the tasks. As vitality is one facet of Laevers' emotional well-being scale, it probably also measures positive activated mood and we would expect similar results to those of Murray et al. (1990).

Involvement/engagement

The description of involvement includes concentration, intensity and endurance during the task (Laevers, 2000). It is related to both intrinsic motivation and flow. Flow is defined as a state of consciousness, during which people experience deep enjoyment,

creativity and involvement in the task (Csikszentmihalyi & Csikszentmihalyi, 1992). Intrinsic motivation is the desire to explore and seek out learning situations in order to extend one's knowledge and competencies (Ryan & Deci, 2000). There are also parallels to the concept of engagement. Engagement not only is defined as task participation or enjoyment, but also has cognitive aspects like investment, perseverance and use of deeper strategies (Fredricks, Blumenfeld, & Paris, 2004). It can therefore be seen as a mediator between emotions and achievements (Pekrun & Linnenbrink-Garcia, 2012). Sinatra and Taasoobshirazi (2011) postulated that it needs engagement for conceptual change, and motivation for engagement. In their study, they found that student motivation predicts conceptual change in physics (Taasoobshirazi & Sinatra, 2011).

Hypotheses

Concluding from these prior results, we expect to find relations between emotional well-being, involvement and observation competency. As the emotional well-being scale measures positive, activated emotionality, we expect the relation to be positive. For involvement, we also expect higher involved children to make better observations. At the same time, we expect involvement to partly mediate the relation between emotional well-being and the observation quality.

Method

Sample and procedure

The data were collected in five preschools. Two of these were in an urban environment and three in a rural area. Three of the preschools were run by municipal authorities, one by church and one by parent initiative. All kindergartens had core groups for the children but also group-overarching activities.

We analysed the data of 70 children who were in their last year before starting school. The age ranged from 4;9 to 6;7; the mean age was 5;5 (65.2 months (SD = 4,40)). Thirty-four (49%) of the children were females and 36 (51%) were males.

In order to make sure that the differences between kindergarten did not influence the results, we checked for differences between the groups in age and language development. For children's age, there were no statistically significant differences between group means as determined by one-way ANOVA ($F(4, 70) = .47$; $p = .76$). For the language test, we used the CITO, which is a computer-based test constructed to assess the language abilities of children prior to starting school. Here again, there are no statistically significant group differences ($F(4, 70) = 2.39$; $p = .06$).

The testing took place in the preschools in a separate room. The testing was recorded on videotape. If the child did not want to be tested alone, one of the preschool teachers would come along to the testing.

The children's parents or legal guardians had been informed about the study beforehand and had given their consent. They had the possibility to withdraw their consent at any time and ask for the deletion of already recorded data. The children themselves also had the possibility to cancel the testing at any time. Parents had the opportunity to ask for their own children's test results.

Instruments

The observation situation

We used the testing situation from Kohlhauf et al. (2011). Here, the participants observe a living fish, snail and mouse. The test starts with the introduction of a hand puppet and explaining tools the children can later on use for their observations (magnifying glass, ruler, stopwatch, scales and thermometer). At this point, the animal's cages are still hidden under blankets. After that, they are shown the first animal, which is always the fish. The puppet is closing its eyes and the children are asked to describe the animal to the hand puppet. When the child has finished the description, the puppet opens its eyes again and the experimenter asks the child for a research question ('what do you want to find out about the fish?'). If the child does not come up with a question, the puppet offers one. The test is designed to find out if the participants are able to come up with a research question, can formulate a hypothesis, do the testing and interpret their observation. Therefore, as little prompting as possible was given by the instructor. If the child got stuck, did not do one of the steps themselves or asked for help, prompts or help were given either by the instructor or the puppet. After observing the fish, the same procedure follows with the snail and lastly the mouse. The observation of each animal lasted between four and six minutes, depending on children's research question and testing methods.

The whole interaction was videotaped and later on coded for observation competency and involvement and well-being. The coding schemes are introduced in the following two sections.

Analysing children's observation competency

We first analysed the situation according to the procedure of Kohlhauf et al. (2011). In their analysis, there were 15 items: 5 per animal; per animal one each for details, questioning, hypothesising, testing and interpreting. This worked well for their sample that had an age range from preschoolers to students but proved to be too imprecise for our sample. The children showed bottom effects and we were unable to reach satisfactory inter-rater reliability. We therefore developed a new coding scheme with more items and more gradations.

After the new scoring, the observation competency test consisted of 39 items. Nine of these items focus on children's perception of details: both during children's first description of the animal and during the testing phase, the number of dimensions (e.g. form, colour) and details (e.g. form or colour of a specific body part) the children mention are counted. The 18 items that are on children's inquiry are coded starting with the research question until the end of their investigation: both their autonomy and the quality of their questioning, hypothesising and testing are scored. Finally, 12 items are on children's interpretation of the results: here, children's summary of the results, relating to the hypothesis, and differentiation between observation and interpretation are scored. An overview of all the items can be found in Table 1. The items differed in the number of gradations they had. However, for the overall score, each item had the same weight, meaning children could reach an overall score between 0 and 39. A second rater coded 10% of the data. Due to the fact that we looked at ordinal data, we calculated Spearman correlations. All values were above .6, for the subscales inquiry and interpreting they were all above .9.

Table 1. Items and gradation of the observation competency coding.

Dimension		Item	Gradation
Describing details		Dimensions	Number of mentioned dimensions
		Unspecific details	Number of mentioned details that are not related to the question
		Specific details	Number of mentioned details that are related to the question
Inquiry	Questioning	Research question	• Spontaneous • Prompted • With help • No question
		Use of question	• Child's question was used • Emil's question was used
	Hypothesising	Spontaneous hypothesis	• Spontaneous • Not spontaneous
		Prompting	• Prompted • With help • No hypothesis
	Testing	Activity	• Autonomously • Help with either idea or implementation • Idea and implementation by experimenter
		Quality	• Real observation • No observation, confirmation bias
Interpreting		Summary of results	• Autonomously • Prompted • None/wrong
		Spontaneous relation to hypothesis	• Spontaneous • Not spontaneous
		Prompted relation to hypothesis	• Correctly when prompted • None/wrong
		Differentiation between observation and inferences	• Present • Not present

Note: for each item, a score according to the number of gradations was given.

While the overall scale was reliable ($\alpha = .74$) and the subscale for details is also reliable ($\alpha = .72$), the values for the subscales inquiry ($\alpha = .63$) and interpretation ($\alpha = .40$) are not sufficient. When treating inquiry and interpretation as one scale, we again reached satisfactory reliability ($\alpha = .76$). For our further analyses, we will only use the overall scale.

Analysing involvement and well-being

A different coder also coded children's involvement and well-being from the videos. For each child, the scoring was done separately for each animal, assessing the affects from the first moment the child sees each animal until the child and test instructor turns away from that animal to the next task. As we were looking at a specific situation in which the children all do the same task, we adapted the observation sheet of the Leuven Well-Being and Involvement Scale looking at the signals of involvement and well-being (Laevers & Schlömer, 2006). We therefore had eight items for emotional well-being (openness, flexibility, self-confidence, assertiveness, vitality, inner peace, enjoyment, feeling at ease) and nine items for involvement (concentration, energy, creativity, facial expression, persistence, precision, reaction, verbal utterances, satisfaction). Table 2 shows the items with a description of clear signs for each item. For each item, a score of 1 (no signs), 2 (some signs), 3 (clear signs) or 0 (missing) was given. The mean value of the scores was calculated for both

Table 2. Description of coding items for involvement and emotional well-being.

Scale	Item	Description
Involvement	Concentration	Turning body to animal or experimenter, no digressing, full concentration on the object
	Energy	Happy on the task, energy related to the task
	Creativity	Introducing new, own ideas; if low: child just following instructions from the experimenter
	Facial expression	Attention to the object; relaxed but also excitement in facial expression
	Persistence	Not distracted, fully concentrated permanently
	Precision	Precise describing; precise, meticulous work with the tools; precise observing
	Reaction	Following the instructions of the experimenter; good use of given prompts
	Verbal utterances	Fluency in language, coherent phrases
	Satisfaction	Fascinated facial expression; positive exclamations; silent satisfaction
Emotional well-being	Openness	Responding to experimenter; telling private stories; open attitude
	Flexibility	Responding to task; use of tools; linguistic competence
	Self-confidence	Natural behaviour, freely interacting with objects and materials
	Assertiveness	Voicing own opinions and ideas, knowing what one wants
	Vitality	Emitting vitality; reasonable desire to move
	Inner peace	Seeming relaxed, if low: signs of nervousness
	Enjoyment	Laughing/smiling; positive exclamations; satisfied facial expression
	Feeling at ease	Relaxed posture; relaxed facial expression

Note: for each indicator, a score of 1 (no signs), 2 (some signs), 3 (clear signs) or 0 (missing) was given.

Table 3. Reliabilities for the scoring of involvement and well-being.

	Fish	Snail	Mouse	Overall
Emotional well-being	.52	.62	.53	.84
Involvement	.84	.87	.81	.93

scales, both for each animal individually and overall for the whole observation situation, Table 3 shows the reliabilities for the scales. As the subscales for emotional well-being do not all show satisfactory reliabilities, we focus our analyses on the overall scales. A second rater coded 10% of the data. The Spearman correlations were all above .7.

For the data analysis, we calculated correlations and regressions. In order to understand the relations between some of the influencing factors better, mediation analyses were conducted. For this, the program PROCESS (Hayes, 2012) was used, which provides not only the results of the Sobel test but also the confidence interval for the indirect effect of X on Y in the mediation. The results of the analyses will be discussed in the following.

Results

Description of children's observation competency, involvement and well-being

In general, the children showed high well-being and involvement. As can be seen in Table 4, the mean value for involvement was 2.43 and for well-being it was 2.78. In

Table 4. Means, standard deviations and intercorrelations for observation competency, involvement and well-being.

Variable	*M*	SD	1	2	3
1. Observation competency	15.06	4.14	–	.58**	.59**
2. Involvement	2.43	0.35		–	.46**
3. Well-being	2.78	0.21			–

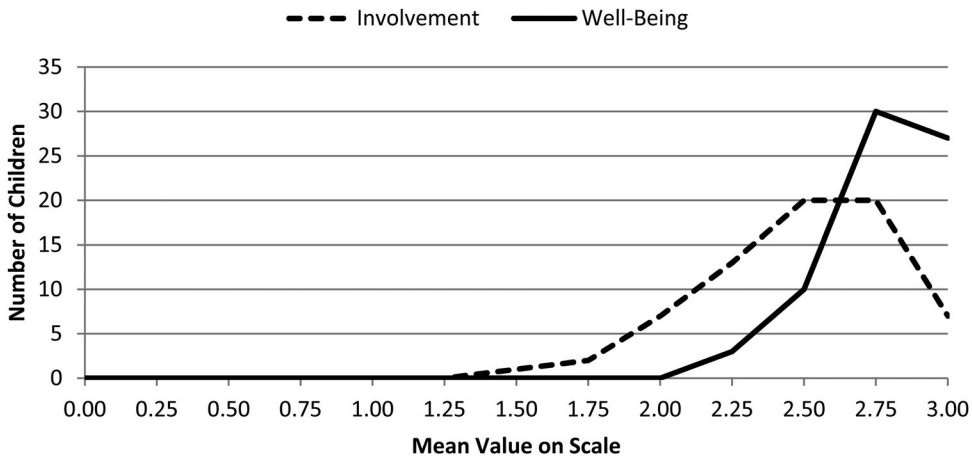

Figure 1. Distribution of children's overall involvement and well-being scores.

Figure 1, we can see that in involvement children's overall values are never below 1.5 and most children have values between 2.5 and 2.75. Looking at the items, the most negative values were on energy, persistence and verbal utterances. For well-being, children's overall scores are even better, with no mean value being below 2.25 and most children scoring 2.75 or above. The low scores are on the items flexibility, assertiveness and self-confidence.

Table 4 also shows that there is a correlation of .46 between involvement and well-being. This can be expected, as the general well-being will influence children's involvement. It is still just a moderate and not a large correlation, which indicates that the two measurements are in fact separate constructs.

The influence of involvement and well-being on observation competency

Table 4 also shows the correlations of involvement and well-being with observation competency. With values of .58 and .59 these can be interpreted as large. To further investigate the influence of our affective measurements on children's observation competency, we conducted a regression analysis (see Table 5). Both predictors together explained 46% of the variance ($R^2 = .46$, $p < .001$).

Since we also found a correlation between our two predictors, we checked for collinearity. As can be seen in Table 6, the Condition Index of Collinearity Diagnostics is higher than 30 in one case, which suggests collinearity. However, the variance proportions show that the factors do mainly load on different dimensions.

We therefore went on with a mediation analysis to see if involvement is mediating the effect of emotional well-being on observation competency (see Figure 2). We used the

Table 5. Regression analysis summary for involvement and well-being predicting observation competency.

Variable	*B*	*SE B*	*β*	*t*	*p*
(Constant)	−21.74	5.41		−4.02	.00
Involvement	5.01	1.30	.39	3.85	.00
Well-being	8.73	2.16	.41	4.04	.00

Table 6. Collinearity diagnostics.

			Variance proportions		
Dimension	Eigenvalue	Condition index	(Constant)	Involvement	Well-being
1	2.99	1.00	.00	.00	.00
2	.009	18.08	.13	.92	.04
3	.002	36.77	.87	.08	.96

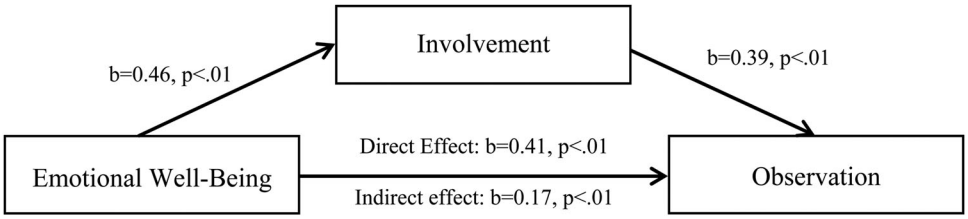

Figure 2. Mediation model for involvement and well-being predicting observation competency.

software PROCESS (Hayes, 2012). There was a significant indirect effect of emotional well-being on observation competency through involvement ($b = 0.18$, BCa CI [0.08, 0.30]). The Sobel test was significant ($p < .01$).

Discussion

Our results show that affects and children's performance in a scientific observation situation are in fact related. According to the deep-level-learning model (Laevers, 2000), this direction of this relation is an effect of the emotional well-being and involvement on the learning in a situation. It is therefore not only relevant to have domain knowledge about the observed objects (Eberbach & Crowley, 2009), but also to be involved in the situation (Laevers, 2000). While Kohlhauf et al. (2011) could not find an influence of general interest in the domain for a sample across different age groups, the actual engagement in the situation actually is important for preschool children's ability to observe details, come up with a research question and hypothesis to test, as well as interpreting their observations. But also their general mood and well-being are crucial for them being in a spot where they can focus on the observation task. Johnston (2009, p. 2512) states that 'children observe only what interests them', but this is seemingly more true for the situational interest and motivation than for a general interest in a domain.

The Leuven Well-Being and Involvement Scale proved to be a good, reliable instrument to measure children's affective state. This study has shown that it is not only feasible for finding differences between settings as has been shown in previous studies (Declercq, 2011; Goldspink et al., 2008), but also for finding differences in children when the setting is the same, and thereby predict children's outcome. The results confirm the deep-level-learning model (Laevers, 2000), which assumes an influence of children's process on their learning outcome. We could also show that the influence of emotional well-being is partly mediated by involvement, which is in line with the assumption that engagement is a mediator between emotions and performance (Pekrun & Linnenbrink-Garcia, 2012).

However, we have to be careful with the directional interpretation of the results, as the research findings are based on correlational analyses. In the case of affects, reciprocality

can be expected (Pekrun & Linnenbrink-Garcia, 2012). We founded our hypotheses on the deep-level-learning model, and therefore, interpret the relation as directional: children who were emotionally well had the capacities to get involved in the task, which helped them making good observations. However, it is also possible that participants who better understood what they had to do also enjoyed participating more and were more perseverant than the participants who were overwhelmed by the assignments. It is also possible that a mixture of these mechanisms leads to the results.

Another factor that has to be kept in mind is the heterogeneity of the sample. While participants from different kindergartens did not differ in age and language abilities, there might have been other factors leading to differences between the kindergarten groups and thereby having an influence on our results.

All measures were derived by observation methods. Although the coding was conducted by two different raters for observation competency and the affective measures, it cannot completely be ruled out that spill-over effects may have partly led to the high correlations. However, we hope to have diminished such effects by having specific items for all scales. Additionally, if these effects influenced our measures, we would expect it to be worse for the Leuven scales as they were coded by the same rater. This is not the case, as the correlation between well-being and involvement is lower than the correlations of these two with the observation competency.

The definition of well-being and involvement is related to several concepts of motivation and emotion, like mood, flow, intrinsic motivation and engagement (Laevers, 2000), and we cannot differentiate between those with the Leuven instruments. As there are studies that find differences between these constructs (Meyer, Klingenberg, & Wilde, 2014), it would be interesting to look at the constructs separately. However, this is not possible with observational methods, but only with self-reports, so such a differentiation has to be done with another age group.

Our study focused on the influence of affective states on the research method of observation. We thereby expand the insights of the research of Kohlhauf et al. (2011) and Eberbach and Crowley (2009). However, we do not know how much our results can be transferred to other scientific methods, like experimentation. As they do share some commonalities, like the inquiry part with questioning, hypothesising and testing, it could be expected that similar relations could be found. Further research could investigate this in order to broaden the relevance of our results.

In conclusion, our study sheds first light on the relations between affective states and observation competency in preschoolers. Although this may seem obvious to a practitioner, in research there is little consideration of examining the emotions in the learning process. Though motivation and interest are sometimes investigated, the emotions will not be considered. It seems timely to consider this variable more in the future. For practitioners, our results mainly show the importance of children's affective state in the learning situation. It is not enough to provide the children with the knowledge and the necessary instruments, but also to make sure that their emotional well-being is sufficient so that they can be involved in the situation to then observe and learn. There are different ways to enact that. One facet of that is having materials that meet children's individual performance level in order to neither demand too much or too little from them and thereby keep them motivated. Another factor is the support by the teacher: Aydoğan et al. (2015) investigated classroom factors that are important for high engagement of

children, differentiating between instructional support and emotional tone. They found both of these factors to be relevant for children's engagement; the instructional support being especially effective when the emotional tone was positive. Combining their results with ours, this means that children need an emotionally positive environment in order to feel well themselves and thereby get involved in tasks, so that they can show their full abilities in an inquiry situation.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Elite Network of Bavaria [grant number K-GS-2012-209].

References

Alberdi, E., Sleeman, D. H., & Korpi, M. (2000). Accommodating surprise in taxonomic tasks: The role of expertise. *Cognitive Science*, *24*(1), 53–91. doi:10.1207/s15516709cog2401_2

Aydoğan, C., Farran, D. C., & Sağsöz, G. (2015). The relationship between kindergarten classroom environment and children's engagement. *European Early Childhood Education Research Journal*, *23*(5), 604–618. doi:10.1080/1350293X.2015.1104036

Bybee, R. W. (2006). Scientific inquiry and science teaching. In L. B. Flick & N. G. Lederman (Eds.), *Scientific inquiry and nature of science* (pp. 1–14). Dordrecht: Springer. doi:10.1007/978-1-4020-5814-1_1

Csikszentmihalyi, M., & Csikszentmihalyi, I. S. (1992). *Optimal experience: Psychological studies of flow in consciousness*. New York, NY: Cambridge University Press.

Declercq, B. (2011). Levels of well-being and involvement of young children in centre-based provision in the Free State Province of South Africa. *South African Journal of Childhood Education*, *1*(2), 64–80. doi:10.4102/sajce.v1i2.85

Eberbach, C., & Crowley, K. (2009). From everyday to scientific observation: How children learn to observe the biologist's world. *Review of Educational Research*, *79*(1), 39–68. doi:10.3102/0034654308325899

Fabes, R. A., Eisenberg, N., Nyman, M., & Michealieu, Q. (1991). Young children's appraisals of others' spontaneous emotional reactions. *Developmental Psychology*, *27*(5), 858–866. doi:10.1037/0012-1649.27.5.858

Fischer, F., Kollar, I., Ufer, S., Sodian, B., Hussmann, H., Pekrun, R., … Eberle, J. (2014). Scientific reasoning and argumentation: Advancing an interdisciplinary research agenda in education. *Frontline Learning Research*, *2*(3), 28–45. doi:10.14786/flr.v2i2.96

Fleer, M. (2013). Affective imagination in science education: Determining the emotional nature of scientific and technological learning of young children. *Research in Science Education*, *43*(5), 2085–2106. doi:10.1007/s11165-012-9344-8

Fox, J. E., & Lee, J. (2013). When children draw vs when children don't: Exploring the effects of observational drawing in science. *Creative Education*, *4*(7A1), 11–14. doi:10.4236/ce.2013.47A1002

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*(1), 59–109. doi:10.3102/00346543074001059

Goldspink, C., Winter, P., & Foster, M. (2008). Student engagement and quality pedagogy. In *European Conference on Educational Research in Goteborg* (pp. 10–12). Retrieved from http://www.learningtolearn.sa.edu.au/tfel/files/links/Student_Engagement_and_Qu_1.pdf

Hayes, A. F. (2012). *PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling*. Retrieved from http://www.afhayes.com/public/process2012.pdf

Johnston, J. S. (2009). What does the skill of observation look like in young children? *International Journal of Science Education*, *31*(18), 2511–2525. doi:10.1080/09500690802644637

Kohlhauf, L., Rutke, U., & Neuhaus, B. (2011). Influence of previous knowledge, language skills and domain-specific interest on observation competency. *Journal of Science Education and Technology*, *20*(5), 667–678. doi:10.1007/s10956-011-9322-3

Kosso, P. (2011). *A summary of scientific method*. Dordrecht: Springer Science & Business Media. doi:10.1007/978-94-007-1614-8

Laevers, F. (1993). Deep level learning: An exemplary application on the area of physical knowledge. *European Early Childhood Education Research Journal*, *1*(1), 53–68. doi:10.1080/13502939385207351

Laevers, F. (2000). Forward to basics! Deep-level-learning and the experiential approach. *Early Years*, *20*(2), 20–29. doi:10.1080/0957514000200203

Laevers, F. (2003). Experiential education: Making care and education more effective through well-being and involvement. In F. Laevers & L. Heylen (Eds.), Involvement of children and teacher style: Insights from an international study on experiential education (pp. 13–24). Leuven: Leuven University Press.

Laevers, F., & Schlömer, K. (2006). *Die Leuvener Engagiertheits-Skala für Kinder: LES-K; deutsche Fassung der Leuven involvement scale for young children*. Berufskolleg Erkelenz, Fachschule für Sozialpädagogik.

Laukenmann, M., Bleicher, M., Fuss, S., Gläser-Zikuda, M., Mayring, P., & Rhöneck, C. v. (2000). Eine Untersuchung zum Einfluss emotionaler Faktoren auf das Lernen im Physikunterricht. *Zeitschrift Für Didaktik Der Naturwissenschaften*, *6*, 139–155.

Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching*, *39*(6), 497–521. doi:10.1002/tea.10034

Linnenbrink, E. A. (2007). The role of affect in student learning: A multi-dimensional approach to considering the interaction of affect, motivation, and engagement. In P. A. Schutz & R. Pekrun (Eds.), *Emotion in education* (pp. 107–124). San Diego, CA: Elsevier.

Mayer, D., Sodian, B., Koerber, S., & Schwippert, K. (2014). Scientific reasoning in elementary school children: Assessment and relations with cognitive abilities. *Learning and Instruction*, *29*, 43–55. doi:10.1016/j.learninstruc.2013.07.005

Meyer, A., Klingenberg, K., & Wilde, M. (2014). The benefits of mouse keeping—an empirical study on students' flow and intrinsic motivation in biology lessons. *Research in Science Education*, *46*(1), 1–12.

Murray, N., Sujan, H., Hirt, E. R., & Sujan, M. (1990). The influence of mood on categorization: A cognitive flexibility interpretation. *Journal of Personality and Social Psychology*, *59*(3), 411–425. doi:10.1037/0022-3514.59.3.411

Norris, S. P. (1984). Defining observational competence. *Science Education*, *68*(2), 129–142. doi:10.1002/sce.3730680206

Oguz, A., & Yurumezoglu, K. (2007). *The primacy of observation in inquiry-based science teaching*. Paper presented at the International Workshop: Science Education in School. Retrieved from http://eric.ed.gov/?id=ED498653

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

Pekrun, R., & Bühner, M. (2014). Self-report measures of academic emotions. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 561–579). New York, NY: Routledge.

Pekrun, R., Hall, N. C., Goetz, T., & Perry, R. P. (2014). Boredom and academic achievement: Testing a model of reciprocal causation. *Journal of Educational Psychology*, *106*(3), 696–710. doi:10.1037/a0036006

Pekrun, R., & Linnenbrink-Garcia, L. (2012). Academic emotions and student engagement. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 259–282). New York, NY: Springer.

Pekrun, R., & Perry, R. P. (2014). Control-value theory of achievement emotions. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 120–141). New York, NY: Routledge.

Pekrun, R., & Stephens, E. J. (2010). Achievement emotions: A control-value approach. *Social and Personality Psychology Compass*, *4*(4), 238–255. doi:10.1111/j.1751-9004.2010.00259.x

Rogoff, B., Paradise, R., Arauz, R. M., Correa-Chávez, M., & Angelillo, C. (2003). Firsthand learning through intent participation. *Annual Review of Psychology*, *54*(1), 175–203. doi:10.1146/annurev.psych.54.101601.145118

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68–78. doi:10.1037/0003-066X.55.1.68

Sinatra, G. M., & Taasoobshirazi, G. (2011). Intentional conceptual change: The self-regulation of science learning. In B. Zimmermann & D. Shunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 203–216). New York, NY: Routledge.

Taasoobshirazi, G., & Sinatra, G. M. (2011). A structural equation model of conceptual change in physics. *Journal of Research in Science Teaching*, *48*(8), 901–918. doi:10.1002/tea.20434

Tokarczyk, S. (2015). *Using technology and phenology to increase students' observation skills* (Master's thesis). Hamline University, Saint Paul, Minnesota. Retrieved from http://digitalcommons.hamline.edu/hse_all/162/

Tomkins, S. P., & Tunnicliffe, S. D. (2001). Looking for ideas: Observation, interpretation and hypothesis-making by 12-year-old pupils undertaking science investigations. *International Journal of Science Education*, *23*(8), 791–813.

Tomkins, S., & Tunnicliffe, S. D. (2007). Nature tables: Stimulating children's. *Journal of Biological Education*, *41*(4), 150–155.

Wellnitz, N., & Mayer, J. (2011). *Modelling and assessing scientific methods*. Annual Meeting of the National Association of Research in Science Teaching (NARST), Orlando, FL. Retrieved from https://www.uni-kassel.de/fb10/fileadmin/datas/fb10/biologie/didaktik/Publikationslisten/Artikelanh%C3%A4nge/Wellnitz_NARST2011.pdf

Zimmerman, C. (2000). The development of scientific reasoning skills. *Developmental Review*, *20*(1), 99–149. doi:10.1006/drev.1999.0497