



Article

Bringing Out-of-School Learning into the Classroom: Self- versus Peer-Monitoring of Learning Behaviour

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Abstract: Based on classroom management fostering autonomy support and intrinsic motivation, this study examines effects of reciprocal peer-monitoring of learning behaviours on cognitive and affective outcomes. Within our study, 470 German secondary school students between 13 and 16 years of age participated in a multimodal hands- and minds-on exhibition focusing on renewable resources. Three groups were separated and monitored via a pre-post-follow up questionnaire: the first conducted peer-monitoring with the performance of specific roles to manage students' learning behaviours, the second accomplished a self-monitoring strategy, while the third group did not visit the exhibition. In contrast to the latter control group, both treatment groups produced a high increase in short- and long-term knowledge achievement. The peer-monitored group scored higher in cognitive learning outcomes than the self-monitored group did. Interestingly, the perceived level of choice did not differ between both treatment groups, whereas peer-monitoring increased students' perceived competence and simultaneously reduced the perceived level of anxiety and boredom. Peer-monitoring realised with the performance of specific roles seems to keep students "on task" without lowering indicators for students' intrinsic motivation. Herewith, we are amongst the first to suggest peer-monitoring as a semi-formal learning approach to balance between teacher-controlled instruction and free-choice exploration.

Keywords: peer-regulation; self-regulation; peer monitoring; workbook guidance; mobile science centre; semi-formal learning; hands-on learning; intrinsic motivation; autonomy in group learning; classroom management

1. Introduction

School research, teachers and institutions must have an interest in improving students' engagement and academic success. Teachers' supporting autonomy style and the basic psychological needs for autonomy, competence, and relatedness are major predictors for school engagement and academic success [1–3]. As a basis for this, firstly, stimulating learning environments are needed to foster students' active involvement and capacity to take responsibility for their learning. Secondly, strategies of classroom management are required that reduce teachers' role of being authoritarians but are still tailored to the demands of teaching.

1.1. Bringing the Science Centre into Schools

In contrast to everyday school life, "Scientific field trips to science centres can generate a sense of wonder, interest, enthusiasm, motivation, and eagerness to learn, which are much neglected in traditional formal school science" [4] (p. 125). Science centers often present fluid transitions between

education and entertainment [5], providing opportunities for cognitive [6] as well as social and affective learning [7,8]. They offer authentic experiences with natural and technological phenomena combined with an autonomous, active and student-centred learning. This focus on a person's active involvement during a task should address students' engagement in a particular way [9]. Especially parameters such as intrinsic motivation, science learning achievement, interest in science and self-confidence can benefit from these learning experiences [10,11].

Although advantages of out-of-school learning seem obvious, mainly monetary or logistic constraints (e.g., due to location, organization and implementation of scientific fieldtrips) often prevent field trips in daily school routine [11,12]. Efficient practical approaches for the implementation of scientific activities inside schools are still rare.

Bringing portable exhibits into schools could valuably complement out-of-school learning offers [4]. This "semi-formal" learning approach should be adapted simultaneously to teachers' and students' needs: Curriculum connection is one of the most often mentioned motivations for teachers to leave the classroom [13–15]. Used as a supplement to "normal" classroom instruction, portable exhibits provide opportunities to reinforce or expand the classroom curriculum [16]. Exhibits can easily be presented within a conceptual framework; they introduce a learning topic, summarize it, or deepen and extend it. Portable exhibits, put up in schools could link student-centred attributes with pre-determined learning objectives.

For the developed of exhibits and related tasks in alignment with school curricula and practical implementation schools, science centres and museums should cooperate to create a shared vision [4,17]. The integration of portable interactive augmented reality approaches into teaching have already shown positive effects on learning [18]. However, little literature considers the structure needed to support semi-formal learning environments [19] and the question remains which strategies could balance between teachers' control and students' autonomy.

1.2. Structure and Autonomy Support

1.2.1. What Is the Right Degree of Structure?

Degrees of structure usually are discussed controversially. In particular, the relationship between autonomy support and structure has been portrayed in different ways: from being antagonistic to curvilinear, and independent [20], whereas Cheon and colleagues found a positive correlation [21]. Teachers often prefer "structured student engagement" (e.g., docent-led guidance, worksheets or other writing activities) to free-choice learning [22,23]. Besides curricular specifications, the demand to keep students "on task" seems to be triggered by teachers' concerns about their ability to manage or control student behaviour, in particular within learning environments outside the classroom [11]. A feeling of not being able to maintain control is frequently cited as heightening teachers' stress [24,25].

In contrast, informal learning settings often provide unstructured and non-sequential learning environments [26,27]. Less structure, missing accountabilities and an oversupply of stimuli as well as information may hamper a student's focus on predetermined learning objectives [9] and intended connections, underlying the different types of exhibits [9,28]. Minimal guidance has been criticized regarding the achieved knowledge gain, see, e.g., [29–31]. A meta-analysis of Alfieri and colleagues clearly showed that directly guided instruction significantly improved knowledge gains in comparison to non-guided discovery learning settings [32]. Unlike rigid or unstructured formats, the more structured ones are often associated with an increase of feelings such as autonomy and achievement compared to either rigid or completely unstructured formats [33–36]. Different approaches seemingly minimize the amount of choice in favour of a combination of guidance and exploration [37–40]. Still, teacher-controlled guidance often reduces the opportunities to explore and is not always adjusted to the students' needs, in particular when taking intrinsic motivation and learning emotions into account [41,42].

1.2.2. Intrinsic Motivation as a Predictor for Students' Engagement and Academic Success

According to Self-Determination Theory (SDT), intrinsic motivation results from the perception that one's basic needs for autonomy, competence and relatedness are satisfied [43]. Needs for competence imply to interact effectively with one's environment, to have opportunities to express one's abilities and to experience skilfulness [43]. The need for relatedness is associated with a feeling of connectedness to others within a social context rather than being isolated from others [44]. Autonomy is defined as the need to be the origin of one's own behaviour and the experience of volition, choice, and self-regulation [43].

Students' basic needs satisfaction predicts students' school engagement for learning activities, see, e.g., [45–47]. As a multidimensional construct, school engagement represents the way in which students act, feel and think [48] and in which they participate. It involves a behavioural, cognitive and emotional dimension: Behavioural engagement includes the compliance with school rules, students' involvement and persistence in school-related activities [49]. Cognitive engagement includes the understanding and use of self-regulated learning strategies such as planning, monitoring and evaluating one's own progress [50] and the motivation to learn [33]. Emotional engagement includes the emotional quality of a person's active involvement; it refers to students' attitudes towards learning, classmates and teachers and their personal identification with school and schoolwork [51].

Melchor and colleagues [2] assumed a mediation model (Figure 1) that is based on the positive correlation between autonomy support, psychological needs satisfaction, school engagement and academic success. They confirmed this model in a survey with 2034 Angolan students and 2302 Dominican Republic students.

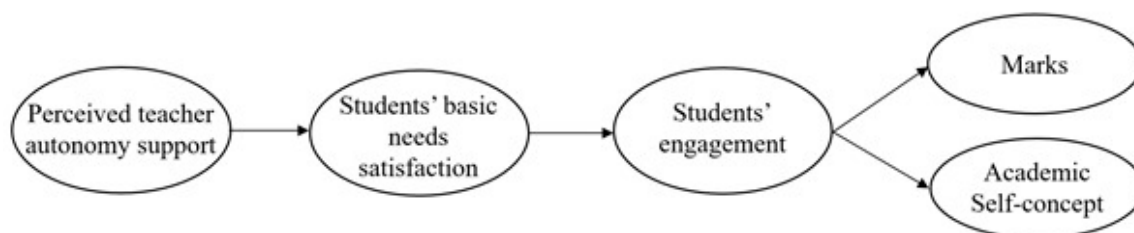


Figure 1. Predictors for cognitive outcomes and academic self-concept hypothesized by the mediation model [2].

In line with SDT, the mediation model stresses the importance of autonomy-supportive strategies to support students' engagement and academic success. Stimulating learning environments should clearly foster students' perception of having control over their learning process, but they should also meet school demands [20]. Peer-monitoring could be a promising approach to combine both, autonomy support and structure within group learning activities.

1.3. Peer- versus Self-Monitoring to Regulate Students' Learning Behaviour

As a student-centred learning approach, group learning is frequently used within formal and informal learning settings. Cooperative learning environments and learning settings in which one person (the tutor) imparts knowledge to another person (the tutee) combine cognitive activity with social interactions [52–55]. In comparison, instructional monitoring is typically based on behavioural activity, making it particularly suitable for classroom management. Hereby, self-monitoring is a self-management strategy that involves observing, assessing and regulating one's own behaviour [56]. It has been found to be a key process in self-regulated learning [57]. In contrast, reciprocal peer-monitoring implies monitoring classmates as well as being monitored. Brown and colleagues [58] defined peer-monitoring as peer-observing and checking the behaviour of others within the group regarding appropriateness and effectiveness. For both strategies of monitoring teachers as well as students could define target behaviours. Self-monitoring usually requires minimal training and is easy

to implement [59], in contrast previous training for peer-monitoring depends on monitor variables (e.g., single vs. multiple behaviours) and the specific behaviour that is required. Interventions of self-monitoring, e.g., in [60–64] and peer-monitoring, e.g., in [58,63] have been applied to promote academic performance and “on-task” learning behaviours among students of different ages and across a variety of learning disabilities and emotional-behavioural difficulties. Thereby, self-monitoring was often used in learning settings with no possibilities for teacher control and in multiple contexts like math [65] and writing or reading performance [60].

Previous research can only be compared to a certain extent: Self-monitoring is mostly used in learning settings where students work on their own (e.g., while doing homework); whereas, peer-monitoring always implies social interactions. The scope of monitoring within and between both methods could differ from very little to intensive monitoring. In addition, monitoring could be used within different learning contexts and in combination with other instructional approaches, such as the use of a graphic organizer [60]. Thus, outcomes could differ fundamentally.

In the majority, both self- and peer-monitoring supported desired behaviours within the specific contexts and revealed to be equally effective, or superior to, teacher-directed procedures when knowledge gain was taken under consideration (see [58,66] for peer-monitoring and [67,68] for self-monitoring).

In contrast to positive effects of self-regulated learning on intrinsic motivation, self-efficacy and self-awareness [57], results of peer-monitoring are ambiguous. Henington and Skinner [67] stated that “peer monitoring can bring about both positive and negative social, emotional, and cognitive changes in students who are being monitored, as well as in those students doing the monitoring.” (p. 251). Within the mediation model [2] autonomy support is an important predictor of students’ intrinsic motivation. Peer-monitoring as “learners keeping an eye on whether their partners are going through appropriate and effective processes and procedures of learning” [58] (p. 174), could minimize students’ perception of self-control in comparison to self-monitoring. Still, there is some evidence that regulation is not correlated with a feeling of restriction if guided by a person of the same age [46] and reciprocal peer-monitoring could establish a positive interdependence among students. Additionally, taking cooperative learning into account, peer-monitoring can strengthen prosocial behaviour [69]. In conclusion, so far, students’ perception of peer-monitoring in comparison to self-monitoring is difficult to predict.

1.4. Study Question

To answer the research question if reciprocal and similar-age peer monitoring of students’ activities should be recommended as guidance within semi-formal learning environments, we compared it with self-monitoring. Thus, we are among the first to test self- versus peer-monitoring with regard to effects on students’ (1) cognitive achievement, (2) intrinsic motivation (perceived competence and perceived choice) and short-term learning emotions (anxiety, boredom, interest and well-being) as predictors of students’ emotional engagement. Differences of previous literature in research designs, learning settings and the scope of monitoring prevents us from drawing concrete hypotheses, e.g., [63,70]. The comparison with self-monitoring could reveal important tendencies if peer-monitoring might be a key to guide group learning activities within semi-formal learning.

2. Materials and Methods

2.1. Instructional Concept

We designed a mobile exhibition to test for differences between peer- and self-monitoring. In line with an “Education for Sustainable Development” (ESD), our exhibits focused on the potential of renewable resources to replace fossil fuels, especially by focusing on bioenergy. As an interdisciplinary educational goal, ESD became part of the curriculum across all schools in most federal states within Germany. Content-wise, it addresses the Sustainable Development Goals (SDGs), defined as

17 interlinked goals “to achieve a better and more sustainable future for all” [71]. As an essential part of the Agenda 2030 for Sustainable Development, the SDGs were set by the United Nations General Assembly in 2015 and are intended to be achieved by the year 2030. As part of young students’ scientific literacy, it is not only imperative to sensitise their awareness of the finiteness of fossil fuels, but also to inform them about possible alternatives and related technologies. In contrast to wind, water and solar energy, educational approaches concerned with the topic of bioenergy are still limited and many students show only little knowledge of the use of biomass as an energy source [72,73]. This lack of knowledge seems to be independent of age and origin [74,75]. Within the exhibition, references can be made in particular to SDG 7, which proposes to “Ensure access to affordable, reliable, sustainable and modern energy for all” and to SDG 12, which calls to “Ensure sustainable consumption and production patterns”.

Our exhibition offers eight mobile exhibits that focus on the heterogeneous nature of products based on renewable resources and used for bioenergy. They could be presented in out-of-school settings as well as inside schools. Exhibit modules can be used independently as solitary elements. We placed a special focus on the application of “hands-on” exhibits in combination with multi-sensory exploration as they are considered more attractive and leading to longer-lasting attention compared to non-participatory exhibits [76,77]. Exhibits 1–4 covered a comparison of products based on renewable resources and mineral-oil-based products by including four aspects:

1. sorting of different products based on their ingredients and the process of degradation;
2. using vision to compare natural and synthetic fibre structures with a microscope;
3. using touch in a haptic comparison of natural and synthetic fibre structures;
4. smelling and tasting of natural products used as food colorants and their assignment to associated products.

Exhibits 5–7 showed application forms of bioenergy based on renewable gaseous, solid and liquid biomass-based fuels; they included:

5. a miniature model of a biogas plant;
6. an “energy organ” consisting of eight columns (energy “content” of 1 kW each) filled with renewable and fossil fuels. Students compared volumes and energy values of renewable and fossil fuels;
7. the production of sunflower oil with a manual seed press, including its tasting and burning (conducted under supervision).

Exhibits 8 presented an interactive computer game as a voluntary learning activity that was not included in the knowledge questionnaire. The “energy race” required physical effort (displayed as kW) by riding a fixed bicycle on a roll.

2.2. Workbook Guidance

In favour of one independent variable, we combined both peer- and self-monitoring with an instructional workbook, providing learners with guidance about how to interact with the exhibits—cf. [78] (p. 162 ff.). Following Krombaß and Harms [79], the workbook consisted of a closed task setting and was subdivided into sections; each section corresponded to a “hands-on” exhibit. The informational sheets provided clearly defined solutions and were, together with the workbook contents, subsequently monitored in the knowledge questionnaire. We focused on factual information in favour of a between-groups comparison with only one independent variable (peer- versus self-monitoring). Thus, we deliberately avoided open-ended tasks—cf. [4], in favour of group comparisons.

2.3. Implementation

Within the framework of “Bringing the science centre to school” the mobile exhibition was offered to secondary schools (Level 2 of the International Standard Classification of Education) in Bayreuth (Bavaria) and the surrounding area. The data were collected by carrying out a questionnaire survey with a pre-, post- and retention-test design, including a control.

In total, 470 students (8th/9th grade) participated, with an average age of 14 years (8th) and 15 years (9th grade). Classes from different schools were randomly assigned to the experimental groups, but students from the 8th and 9th grades were not mixed.

The visit of the exhibition was part of an educational programme: Two groups, a self-monitored group ($n = 218$, female: 47.7%) and a peer-monitored group ($n = 230$, female: 49.4%) participated in our preliminary session (20 min), the workbook-guided visit (90 min) of the exhibition and the debriefing session (15 min) (see Figure 2). An additional control group ($n = 22$, female: 34.8%) did not participate in the educational programme. The preliminary session of the programme was divided in two parts: The first part comprised a topical introduction that provided background knowledge for a more profitable learning experience. The second included an introduction to the process of monitoring (see Section 2.4). The debriefing session (15 min) summarized the learning outcomes. The same person conducted the preliminary and the debriefing sessions to avoid any “teacher effects” within test results; during the workbook-guided visit of the exhibition, there was no teacher guidance. Per day, two classes visited the exhibition with a time frame of 135 min per class. The number of students in the exhibition did not exceed 34 at any given moment. Classes were randomly divided into self- and peer-monitored groups and subdivided, also randomly, into groups with up to four students each. Both treatment groups completed identical exhibit-related and workbook-guided activities. We specified different rotation sequences for each group in the workbook to provide a smooth cycle between exhibits. Each group had a time frame of up to 15 min per exhibit.

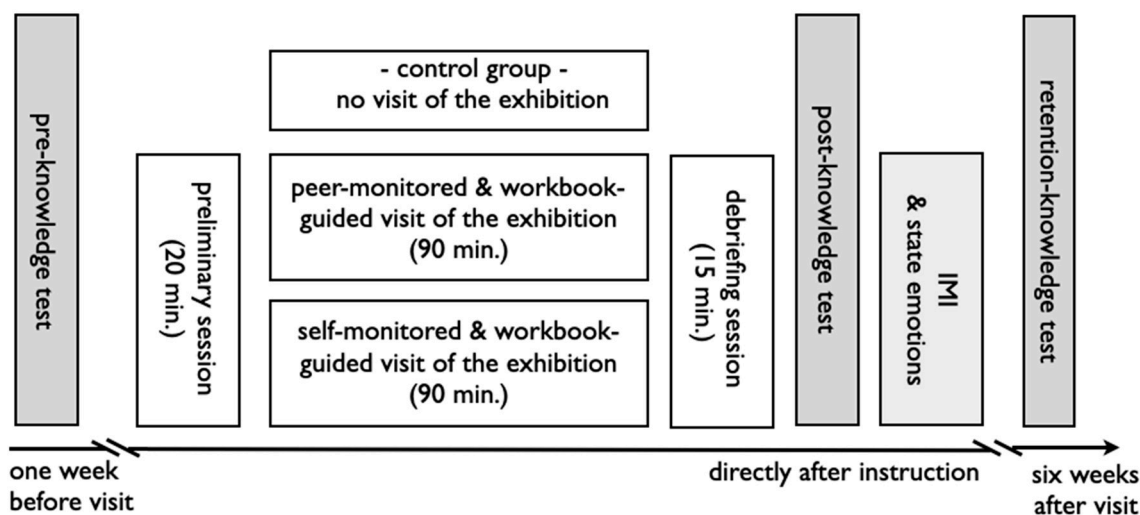


Figure 2. Overview of the study design including the two interventions and the control group (white boxes), applied scales (grey boxes) and time of testing indicated by an arrow.

2.4. Self- versus Peer-Monitoring

The experimental groups differed in internal regulation (self-regulated behaviour) and externally regulated behaviour (peer-regulated behaviour). We defined particular target behaviours that should help students to keep the focus on specific learning objectives—see [66], which were communicated to both groups. The self-monitored group assessed individual learning behaviour by checkmarks that were placed on supplementary sheets. In addition, behavioural rules were fixed on a poster that was put up in front of the class (self-monitored group) or connected with specific roles and written down

on role cards (peer-monitored group). Each peer-monitored group received a little bag with the same amount of role cards as group members. Before starting with an exhibit, each person had to draw a card out of the bag and put it back when finished. Meanwhile, role card holders were responsible for the adherence of role instructions (Table 1) by the rest of the group. Requisites visualized specific roles; e.g., glasses for the role as a reader.

Table 1. Description of role-specific instructions as target behaviours for peer-monitoring.

Reader Read out to the Rest of the Group ...	Moderator Monitored That Peers ...	Material Guard Monitored That Peers ...	Inspector Monitored That Peers ...
short operating procedures at each exhibit.	stayed focused on the topic.	handled materials with care.	tried to solve all exhibit related activities.
information written down in the workbook.	did not disturb other groups and worked quietly (measured by a sound level meter).	left each exhibit tidy and neat.	recorded all results in the workbook.
	finished each exhibit-related task that had been started.		finished activities before the comparison of own results with provided solutions.

2.4.1. Measurement of Science Learning Outcomes

We applied a pre-, post- and retention test to monitor pre-knowledge as well as the short- and long-term learning effects of the self- and peer-monitored groups. For the assessment of knowledge achievement (as the dependent variable), we developed a multiple-choice questionnaire with 21 items and four distractors per item. A pilot study validated the multiple-choice questionnaire on the basis of 25 students (female: 45.8%) without visiting the exhibition. Questions covered factual knowledge with regard to workbook tasks and information sheets (see Table 2).

Table 2. Listing of four item examples of the science achievement questionnaire ¹.

1. Which Plant Is Used for Liquid Fuel Production in Germany?	2. Which Source of Energy Is Based on Mineral Oil?	3. The Origin of Bioenergy Is Based on ...	4. Mineral Oil Arises from ...
(a) barley	(a) gasoline	(a) wind	(a) dinosaur fossils
(b) rye	(b) heating oil	(b) sunlight	(b) underground methane bubbles
(c) wheat	(c) biodiesel	(c) water	(c) emissions of black smokers in the deep sea
(d) rape	(d) plastic	(d) geothermal energy	(d) dead marine organisms

¹ Note that more than one correct answer could be given.

We used the same questions and students' incorrect answers as distractors in the multiple-choice questionnaire and conducted a distractor analysis ($n = 51$, female: 36.2%; note that gender distribution was not balanced). Based on this analysis, we selected distractors with a solution probability that varied from 20% to 80%. We applied an item difficulty index of about 25% easy items, 50% medium items and 25% difficult items [80]. Multiple-choice items had a sufficient level of internal consistency, determined by Cronbach's alpha coefficients ($n = 470$) of 0.651 (pre-knowledge), 0.751 (post-knowledge) and 0.688 (retention-knowledge) [81]. In the main study, students completed the pre-test one week before participation, the post-test immediately after, and the retention test six to eight weeks later (Figure 1). Students were not informed about the test schedules or repeated applications; see, e.g., [82].

Additionally, students were assured that their responses would have no influence on their school marks. We advised teachers not to make any thematic connection to the exhibition until finishing the study with the retention questionnaire. In order to exclude external learning variables not due to the programme—e.g., [83], a control group ($n = 22$, female: 34.8%) completed the questionnaire three times without participating in the programme. In the statistical analysis, we considered gender differences because the distribution was not balanced.

2.4.2. Measurement of Predictors for Short-Term Learning Emotions and Intrinsic Motivation

Within the post-questionnaire, we assessed students' short-term learning emotions and indicators for students' intrinsic motivation as dependent variables. The German translation [84] of the subscales—perceived competence (6 items, e.g., “I was pretty skilled at this activity.”) and perceived choice (7 items, e.g., “I did this activity because I wanted to.”)—of the intrinsic motivation inventory [85] was applied as well as subscales for the short-term learning emotions (4 items each, which also included reversed items) of anxiety (e.g., “I felt under pressure during the activity.”), boredom (e.g., “I felt bored.”), interest (e.g., “I want to learn more about that topic.”) and well-being (e.g., “I enjoyed the activity.”); based on Gläser-Zikuda and colleagues [86] and adapted by Meissner and Bogner [87]. Both instruments used a 4-point Likert scale (1 = very high, 4 = very low). We assessed sufficient Cronbach's alpha coefficients between 0.730 and 0.849 for all scales [81].

2.5. Statistics

SPSS Statistics was used for data analysis. The effect size ($r = z/\sqrt{N}$) was calculated according to Field [88] with 0.10 regarded as a small, 0.30 as a medium, and 0.50 as a large effect size [89]. We conducted a non-parametric Mann–Whitney test for inter-group differences and a Wilcoxon signed-rank test for within group differences, due to the non-normal distribution of our scores (Kolmogorov–Smirnov test, $p < 0.05$). Additionally, a binary logistic regression measured the relationship between the post- or retention knowledge (categorical dependent variable) and scenario, pre-knowledge and gender (independent predictor variables). Results display the odds ratio as a probability score where the independent variable is a predictor of the dependent variable. We included the effect of pre-existing knowledge, gender and the interaction as predictor variables. The odds ratio shows the effect of the variables in the equation (reference category: peer-monitored group, right answer, male); odds ratio = 1 reflects no difference in knowledge gain, odds ratio >1 indicates a higher, and odds ratio <1 —a lower probability to give correct answers.

3. Results

For none of the group comparisons significant differences were calculated for different grades or gender.

3.1. Within-Group Comparison of the Control Group

A control group ($n = 22$) completed our questionnaires at the three test intervals. A comparison between pre-test (25th/75th, $P = 6.0/11.25$, median = 10), post-test (25th/75th, $P = 8.75/12$, median = 10) and retention test (25th/75th, $P = 6/13$, median = 10) revealed neither external short- and long-term nor persistent learning effects: Pre- versus post-test ($z = -1.28$, $p = 0.2$, $r = 0.27$); pre- versus retention test ($z = -0.68$, $p = 0.50$, $r = 0.15$); post-test versus retention test ($z = -0.49$, $p = 0.63$, $r = 0.10$).

3.2. Science Learning Outcome

Sum scores of correct answers of both peer- and self-monitoring showed a highly significant knowledge increase in short- and long-term learning outcomes in comparison to pre-knowledge. Long-term achievement decreased in both groups in comparison to short-term learning outcomes (Figure 3).

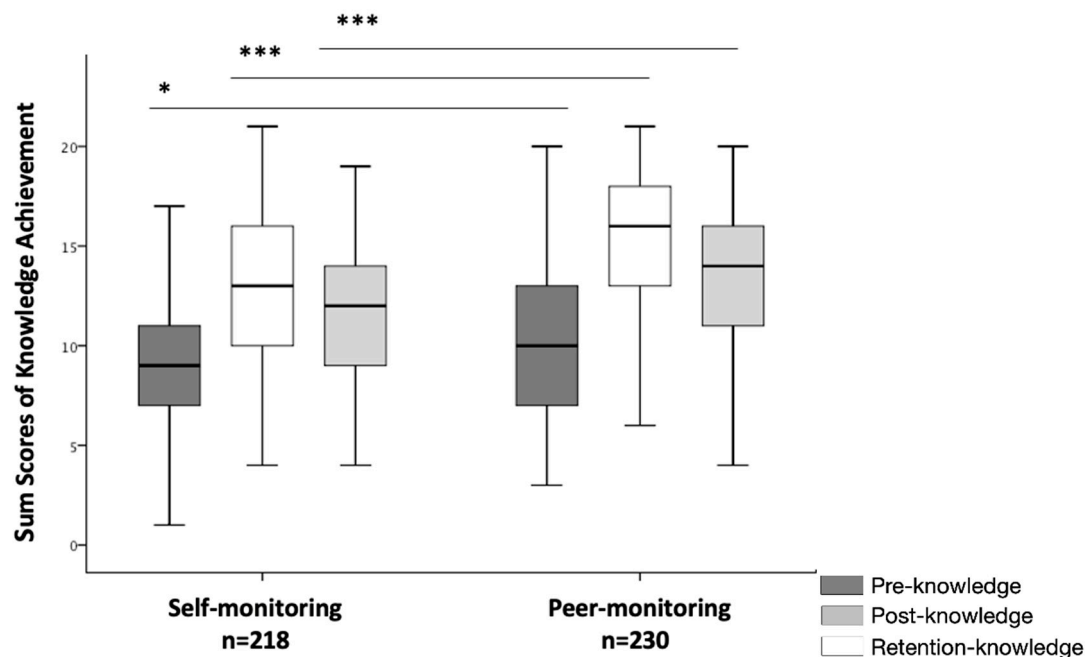


Figure 3. Box-and-whisker plot showing sum scores of knowledge achievement of the self- and peer-monitored group at the three times of testing. Note: The box-and-whisker plot indicates the median, lower and upper quartile and the 9th and 91st percentile; *** significant at <0.001, * significant at <0.05.

3.3. Peer- versus Self-Monitoring

At all testing times, the peer-monitored group showed higher achievement outcomes (pre-, post- and retention test) than the self-monitored group (Table 3). Differences remained if effects of the predictor variables of pre-knowledge and gender were excluded. In detail: Our inter-group comparison of science knowledge achievement scores (21 items) showed that, immediately after the programme, the peer-monitored cohort (25th/75th, P = 13.0/18.0, median = 16) performed significantly better than the self-monitored cohort (25th/75th, P = 10.0/16.25, median = 13), ($U = 17837.50, z = -5.30, p < 0.001^{***}, r = 0.25$). The better performance of the peer-monitored group (25th/75th, P = 10.0/16.0, median = 14) compared to the self-monitored group (25th/75th, P = 9.0/14.0, median = 12) still persisted six weeks after the programme ($U = 18872, z = -4.54, p < 0.001^{***}, r = 0.21$). A higher score of the peer-monitored cohort (25th/75th, P = 7.0/13.0, median = 10) was already visible in the pre-knowledge test ($U = 21835, z = -2.37, p < 0.018^*, r = 0.11$) in comparison to the self-monitored cohort (25th/75th, P = 7.0/11.0, median = 9).

Table 3. Group comparison of science knowledge achievement between different times of testing.

	Self-Monitored Group (n = 218)			Peer-Monitored Group (n = 230)		
	T1	T2	T3	T1	T2	T3
25th/75th P	7.0/11.0	10.0/16.25	9.0/14.0	7.0/13.0	13.0/18.0	10.8/16.0
Median	9.0	13.0	12.0	10.0	16.0	14.0
	T1:T2	T1:T3	T2:T3	T1:T2	T1:T3	T2:T3
z	-11.52	-8.84	-6.20	-12.31	-10.62	-9.56
p	<0.001 ^{***}	<0.001 ^{***}	<0.001 ^{***}	<0.001 ^{***}	<0.001 ^{***}	<0.001 ^{***}
r	-0.78	-0.60	-0.42	-0.81	-0.70	-0.63

Note: Wilcoxon signed-rank test z; *** significant at $p < 0.001$, exact one-tailed significance; effect size r.

We applied a logistic regression to test for the influence of pre-existing knowledge and gender in post- (Table 4) and retention knowledge (Table 5). Asterisks indicate that all predictor variables (scenario, pre-knowledge and gender) for post- as well as for retention knowledge were statistically significant (with the exception of gender in step 5 for the retention knowledge): Depending on the predictor included in the model, the odds ratio reveals a probability, which is 33.1% (odds ratio = 0.669) to 39.8% (odds ratio = 0.602) higher, that the self-monitored group responds incorrectly in the post-knowledge test (Table 4). The retention knowledge test shows similar results, with a probability that is 22.3% (odds ratio = 0.777) to 40.8% (odds ratio = 0.592) higher (Table 4).

Table 4. Logistic regression predicting “post-knowledge” from scenario, pre-knowledge and gender by odds ratio.

Variable	Reference	Step 1	Step 2	Step 3	Step 4	Step 5
Intervention	peer-mediated	0.669 **	0.687 **	0.602 **	0.605 **	0.691 **
Pre-knowledge	right answer		0.387 **	0.347 **	0.353 **	0.350 **
Intervention × Pre-knowledge				1.230 *	1.222 *	1.238 *
Gender	male				0.798 **	916
Intervention × Gender						0.769 **
Constant		2.483 **	4.296 **	4.601 **	5.126 **	4.795 **

$n = 9534$ (* significant at $p < 0.05$, ** significant at $p < 0.01$).

Table 5. Logistic regression predicting “retention-knowledge” from scenario, pre-knowledge and gender by odds ratio.

Variable	Reference	Step 1	Step 2	Step 3	Step 4	Step 5
Intervention	peer-mediated	0.752 **	0.777 **	0.592 **	0.593 **	0.601 **
Pre-knowledge	right answer		0.353 **	0.281 **	0.284 **	0.283 **
Intervention × Pre-knowledge				1.572 **	1.567 *	1.569 **
Gender	male				0.890 **	902
Intervention × Gender						974
Constant		1.622 **	2.901 **	3.326 **	3.513 **	3.490 **

$n = 9534$ (* $p < 0.05$, ** $p < 0.01$).

3.4. Short-Term Learning Emotions and Intrinsic Motivation

Students of the peer-monitored group had a significantly lower perception of their level of boredom and anxiety and a significantly higher perception of their level of competence in comparison to the self-monitored group (Table 6). We did not record any differences with regard to the perception of choice, well-being and interest. Within all between-group comparisons, the effect size r was small.

Table 6. Between-group comparison of predictors for the perception of short-term learning emotions (left side) and intrinsic motivation (right side).

Variable		Well-Being	Interest	Boredom	Anxiety	Competence	Choice
Self-monitored ($n = 152$)	(25th/75th P)	1.3/2.3	1.5/2.5	2.8/3.5	3.3/3.5	2/2.5	1.6/2.6
	Median	1.8	2	3	3.5	2.3	2.1
Peer-monitored ($n = 230$)	(25th/75th P)	1.5/2.3	1.5/2.5	2.8/3.8	3.3/4	1.8/2.5	1.6/2.3
	Median	1.9	2	3.3	3.8	2.2	2
Between-group comparison	U	17254	17256	15298	14810	14377	16324
	z	-0.22	-0.22	-2.08	-2.59	-2.96	-1.1
	p	0.83	0.83	0.04 *	0.01 **	0.003 **	.27
	r	0.01	0.01	0.11	0.13	0.15	0.06

Note: Mann–Whitney U test and z; ** significant at $p < 0.01$, * significant at $p < 0.05$, exact one-tailed significance; effect size r .

4. Discussion

Based on the mediation model (see Figure 1), we assumed that peer-monitoring should support students' capacity to take control of their learning, if monitoring is not connected with a feeling of restriction. We proposed peer-monitoring of students' activities as an instructional guidance within semi-formal learning environments. In comparison to previous studies that had a strong focus on academic achievement, the study at hand examined not only students' learning outcomes, but also affective predictors for students' classroom engagement. The between-group comparison underlined that the application of peer-monitoring resulted in an increased level of knowledge combined with a better perception of competence, while anxiety and boredom levels diminished.

In favour of comparability, cognitive and affective effects are considered separately, even though engagement is a multifaceted construct and cognitive learning outcomes, intrinsic motivation and short-term learning emotions should not be regarded as isolated factors but as influencing each other; see [90,91].

4.1. Within-Group Comparison

Both the self- and the peer-monitored group demonstrated a significant increase in short- and long-term cognitive learning. This is in line with previous research in peer-monitoring [58,66] and self-monitoring [67,68] that focused on students' knowledge gain.

We did not compare workbook with non-workbook guidance, but we still can conclude that the applied workbooks provided guidance about how to interact with the exhibit and seemed to be effective with regard to factual knowledge. Our results support the combination of instructions for behavioural activity with an additional assistance to structure cognitive activity, such as workbooks. They are in accordance with Krombaß and Harms [79], who showed positive effects of worksheets for acquiring basic knowledge in a natural history museum. Researchers provide counterarguments like the restriction of exploration [92,93] and pro-arguments, e.g., facilitating group dialogues and curriculum connection [94] with regard to worksheets in an out-of-school learning setting. In accordance with Kisiel [14,23] we emphasize that not simply the presence or absence, but the realisation of well thought-out workbooks or -sheets matters. Especially workbooks that are in line with inquiry- and problem-based learning could be very engaging.

To conclude this point, well-designed workbooks that fit curriculum standards and the learning objectives intended by the design of exhibits can help to bring more scientific activities into the classroom and create a shared vision between schools, science centres and museums; see [4,94] (p. 1389).

4.2. Between-Group Comparison (Peer- versus Self-Monitoring)

4.2.1. Science Learning Outcomes

The peer-monitored instruction revealed better short- and long-term learning outcomes compared to the self-monitored group. Efficiency of peer-monitoring has been shown especially with regard to its function of keeping learners on track [58,66]. McCurdy and Shapiro revealed teacher- and peer-monitoring of process learning behaviours to be equally effective [95]. It seems likely that a higher percentage of "on-task" behaviour is also connected with better learning outcomes. Likewise, self-monitoring could increase "on-task" behaviours, particularly when incorporated with other instructional approaches [60]. The assessment of one's own learning behaviour requires self-regulation. However, this should be expected from the studies' participants who attended secondary school with an age range of 13 to 16 years. Particularly young children or student populations with high incidence of disabilities or learning difficulties face challenges in self-regulation during independent learning [95,96].

As an additional explanation, the distribution of tasks between learners within peer-monitored groups could have a positive effect on learning outcomes. King [97] introduced the idea of distributed

metacognition by the distribution of components of control among collaborating learners (p. 61, 70 f.). Although we did not perform an observational study, we detected interesting group dynamics within the self-monitored group: Some students took over a “leader function”, while others became passive followers. Scharfenberg and colleagues showed in a video analysis that even in hands-on lessons, passive followers remain passive [98]. In the peer-monitored group, activity cards challenged all participants to accept responsibility for a specific task, engaging thus both active and passive students, as well as low and high achievers.

4.2.2. Predictors for Students’ Emotional Engagement

Neither effect sizes of short-term learning emotions nor predictors for intrinsic motivation revealed high values (Table 3). Thus, significant differences between results should not be overestimated.

Students’ Intrinsic Motivation

In comparison to self-monitoring, peer-monitoring resulted in a higher perception of competence and choice, both subscales are indicators for intrinsic motivation; e.g., [45,99].

Peer-assisted learning promotes competence and autonomy among students, which has a positive effect on students’ self-conceptions; for a review, see [100,101]. However, peer-monitoring considered as peer-controlled learning behaviour should not be equated with peer-assistance. A higher perception of competence and choice in peer-monitoring, compared to self-monitoring, is an interesting result.

The assignation and performance of specific roles might be connected with the higher perception of competence. A feeling of competence implies to interact effectively with one’s environment and to have opportunities to express one’s abilities and to experience skilfulness. Reciprocal and same-age peer-monitoring could establish a positive interdependence among students that might trigger these characteristics. Within Self-Determination Theory, the three “psychological needs” of competence, relatedness and autonomy interact with each other; see, e.g., [45,47]. In favour of having a reasonable number of questionnaire items, we did not measure social relatedness, although collaboration and cooperation are seen as critical in learning and engagement [102]. Social relatedness is an important factor, in particular with regard to informal learning settings and might play an important role especially for young people [103,104]. Working in small groups in combination with the application of roles could have influenced group dynamics and social relatedness positively —cf. [105].

When coming back to our initial question, the lack of significant differences in the perception of control is a promising result. It indicates that in comparison to self-monitoring, peer-monitoring might not be perceived as an external control of behaviour. Finally, intrinsic motivation is a multifaceted construct and we cannot explain all interactions between the psychological needs, but we can still conclude that peer-monitoring seems to shape a social environment, which fosters single predictors for intrinsic motivation.

Short-Term Learning Emotions

Self- and peer-monitored instruction did not provoke notable effects on well-being and interest, but peer-monitoring lowered the perceived level of anxiety and boredom. Short-term learning emotions cannot always be expected to be long-lasting, but they can very much influence learning processes [106–108]. Anxiety and boredom are defined as specific “achievement emotions” which correspond to students’ learning achievements [91].

The application of roles that specified particular target behaviours may also explain why students felt less bored: Role keepers had to make sure that the rest of the group followed instructions connected with their specific role; additionally, their behaviour was monitored by group members. It is likely that both actions kept students more active than those in the self-monitored group.

Interestingly, Pekrun and colleagues [109] stated: “Self-regulating one’s own learning may induce positive feelings, whereas external control may induce anger, anxiety, or boredom” (p. 99). In 2010, they confirmed the inverse relation of boredom with self-regulation [110].

In view of this, peer-monitoring in combination with the performance of specific roles did not seem to be perceived as an external control and a loss of self-regulation. This may be due to the fact that peers are not perceived as an authority; each person in the group performs a specific task that could be experienced as part of a game, as “without rules there is no game” [111]. We tried to avoid the risks of comparisons within the groups, the “competence threat” and social divisiveness [112] by applying a structured switching of roles. Interestingly, Ryan, Stiller and Lynch [113] described pupils as internalizing extrinsic school regulations when they felt secure and cared for. The reduced perception of anxiety is an intriguing phenomenon; Gläser-Zikuda and colleagues [86] described self-regulated learning as requiring a variety of strategies that need to be performed before they may be experienced as emotionally positive and valuable. Although both groups were expected to follow similar behavioural rules, the higher perception of anxiety within the self-monitored group could be based on insufficient experience in self-regulated learning, creating insecurity. In different contexts, the new and unknown may have overwhelmed students and influenced the cognitive [114] as well as the affective outcomes [115] negatively. With the application of role cards, students knew and told each other how to behave, apparently being emotionally reassuring, and thereby reducing the level of perceived anxiety [116].

5. Conclusions

In accordance to Malcolm, Hodgkinson and Colley [117] we conceive “formality” and “informality” as attributes present in all circumstances of learning that should not be considered separately. We are amongst the first to suggest peer-monitoring conducted with the performance of specific roles in combination with workbook guidance to better link these attributes. The application of role cards provides an easy and cost-efficient implementation to define and target specific learning behaviours. Hence, peer-monitoring is not an informal support but refers to a learning situation planned by a professional teacher and the amount of structure ought to be adapted to requirements, purpose and context individually. In conclusion, peer-monitoring in combination with well-designed workbooks seems a fruitful approach that implies reduced teacher control but is still tailored to teachers’ needs. This could provide an enriching repertoire of student-centred learning opportunities, suitable not only in out-of-school contexts, but also during classroom teaching. Our research contributes to the fields of “semi-formal learning” as well as motivation and autonomy in group learning.

Limitations and Recommendations

Behind the background that autonomy support is a determining factor to improve students’ engagement and academic success, a limitation of this study was that the educational environment provided limited possibilities for students to be creative. In favour of a between-group comparison, we deliberately avoided open-ended tasks and had a focus on factual information. Learning tasks could have been presented in a much more stimulating way, especially when taking inquiry-based learning and problem solving into account. This also points out a research challenge: self-control individualises learning processes and makes it difficult to compare the efficiency of different methodologies. In a broader context politicians, economists and scientists should discuss approaches that bridge the gap between curricular demands, social structures characterised by comparability and students’ individual needs for autonomy.

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