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How Science Classroom Teaching Styles May Influence Interest Scores of Different Boredom Types

Sabine Gerstner[2] & Franz X. Bogner[1*]

[1] Centre of Math and Science Education (Z-MNU), University of Bayreuth, Institute of Biology, Education, D-95445 Bayreuth, Germany

[2] M!ND-Center, University of Wuerzburg, Emil-Hilb-Weg 22, D-97074 Würzburg, Germany

[*] Franz X. Bogner, Email: franz.bogner@uni-bayreuth.de

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Abstract

Our study deals with the application of a quantitative boredom item battery for testing the trait-boredom variable within science lessons of different classroom situations. 298 5th graders participated in this study. We monitored "mental underload", "unused learning time" and "mental overload" by extracting four boredom types by cluster analysis which we subsequently labelled "optimally challenged", "moderately challenged", "reluctant" and "bored". Our data identified 23% of our sample group as being bored during science instruction. Therefore we applied an innovative, alternative teaching style (in this case a student-centred, hands-on instruction). While Highest scores in interest and lowest ones in this new instruction generally were showed those boredom types which are associated with satisfied with science classroom situations. Our data identified 23% of our sample group as being bored during science instruction even when an innovative, alternative teaching style (in this case a student-centred, hands-on instruction) was applied. We conclude the knowledge about the described factors may substantially support science teachers to optimize their classroom efforts and to serve their students' individual needs in science lessons.

Keywords

boredom, interest, hands-on instruction, intrinsic motivation, trait-emotions, boredom types

1. Introduction

A first anecdotal paper about boredom dates back into the late 19th century, when Galton (1885) presented a narrative account of observed behavior of restless audience members during a scientific meeting. Subsequent papers followed, as boredom itself was increasingly associated with classroom situations, and monitoring boredom in classrooms became popular in educational research (see extract in Breidenstein, 2007). Boredom has two aspects, one related to classroom situations, where even primary school teachers regard boredom during instruction as unwelcome (Daschmann, 2013; Lohrmann, 2008); the other aspect, analyzing boredom as a psychometric construct, is far more complex but is desperately needed to support improvement in teaching situations (Vodanovic, 2003). Gallagher and colleagues (1997) studied gifted students pointed to a need for research, especially in the assessment go different instruction situations: Fifty percent of their students provided the feedback that they were not challenged in science instruction at all due to an overemphasis on repetition and/or in student-centered activities where instructions were lacking or insufficient. Boredom can be defined as "a state of relatively low arousal and dissatisfaction which is attributed to an inadequately stimulating environment" (Mikulas & Vodanovich, 1993).

Aspects of chronic student boredom seem to have complex origins, just as teacher strategies do when they need to reduce boredom, both for individual students and for whole classrooms (Schunk et al., 2014; Macklem, 2015): Mainly self-regulation, motivation, and engagement are supposed to provide the best strategies to control or even overcome boredom. Within educational research, boredom is often described as occurring during knowledge acquisition (Pekrun, 1998). Hill and Perkins (1985), Robinson (1975) and Ulich and Mayring (1992) described an increase in boredom when insufficient guidance evoked interactions with individuals and not with the teaching subject. Generally, student-centered experimental hands-on activities are supposed to be realistic strategies to overcome tendencies to boredom in classrooms (e.g., Randler & Bogner 2009; Schmid & Bogner, 2017). In particular, any cooperative working within small peer groups is seen as supportive when work-shared learning is offered (Schaal & Bogner, 2005). The preparation of this type of collaborative teaching is extremely time-consuming, as 6-8 self-explanatory lesson subunits need to be considered simultaneously. Nevertheless, such initiatives offer not only better motivational support (Geier & Bogner, 2010; Goldschmidt & Bogner, 2016) or emotional impact (Fröhlich et al., 2013), but also ensure longer-lasting cognitive learning, as often even after half or one year gaps, individual learning success is still sustained (Sellmann & Bogner, 2013; Schmid & Bogner, 2015; Sattler & Bogner, 2017).

Without any doubt, research is needed within this field as many different boredom types are expected due to individual perceptions of instructional settings, of different intentions of such settings and/or differences in the gap between signal-emitting teachers and decoding students (Daschmann et al., 2011). Pekrun (2000) showed boredom to be a relatively frequent issue in learning situations with a negative influence on learning processes and academic achievement scores. Even more, boredom is labelled as the greatest enemy of successful learning, as predominately high achievers seem easily to predict what will happen next within a lesson, whereas low achievers are deemed to suffer cognitive overload (e.g., Scharfenberg & Bogner, 2010). Studies of emotions indicate a wide range of different emotions during academic careers (Schutz & de Cuir, 2002). Those "academic emotions" have been shown to be directly linked with students' motivation and academic achievement (Pekrun et al., 2002). Dewey (1913) described the essential role of interest for self-paced learning by pointing to the importance of emotions such as satisfaction and pleasure: He highlighted interest as one of the most important variables contributing to satisfaction. Subsequent studies stressed the same relationship, as motivation and interest substantially increase achievement levels (Goldberg & Cornell, 1998; Gottfried, 1985). Intrinsically motivated students consistently show better results in high-quality learning and deeper conceptual understanding (Deci et al., 1991). Self-motivation again can be fostered by a feeling of competence, autonomy and relatedness (Deci & Ryan, 2000). Consequently, many studies have highlighted the benefits of student-centered instruction (e.g., Flick, 1993; Lord, 2001) and its positive influence on intrinsic motivation (Sturm & Bogner, 2008; Meissner & Bogner, 2012).

When boredom became a core interest of research, Kanevsky and Keighley (2003) isolated selected learning experiences which may influence the occurrence of boredom: control, choice, challenge, complexity and caring teachers. Hands-on, student-centered instruction seems to play a substantial role to allow teachers to change roles from the dominant instructor to a mentor or observer (who just renders assistance when needed). When participating in hands-on science instruction, students tend to report high levels of interest and of perceived choice and consequently low levels in external control pressure by teachers (Gerstner & Bogner, 2010; Scharfenberg & Bogner 2013). Research has already examined the hypothesis that different student types may be challenged differently in the conventional classroom: Feldhusen and Kroll (1991) separated “gifted” and “average” subsamples, but found no difference in level of boredom between the groups. However, when changing the type of instruction towards student-centered mode, boredom was found to be as an influential trigger which has been measured either by qualitatively (Gläser-Zikuda & Mayring, 2003; Kanevsky & Keihley, 2003) or by single-item tests (Shaw et al., 1996; Randler et al., 2011).

We had three research questions. First, whether some of the applied boredom battery subscales need modification when applied in regular 5th grade science classrooms. To answer this first question, by factor and reliability analyses we intended to confirm the hypothesized subscales of “mental overload”, “mental underload” and “unused time”. Our second question was whether there do exist different boredom types according to different levels of boredom in science classroom situations To answer the second question we conducted cluster analysis. Our third question was whether a new teaching style based on hands-on, student-centered experiments might affect interest and perception of tension (measured by two subscales of the “Intrinsic Motivation Inventory” of Deci & Ryan, 2000) of different boredom types.

2. Methods & Procedures

2.1 Study Design

298 5th graders (highest stratification level—“Gymnasium”) participated in our study. Gender was roughly balanced 170 boys and 128 girls (43%/57%) with an average age of 10.5 years participated. A sub-sample of 150 students participated either in a hands-on or in a conventional science lesson with the content “water—basis of life”; the test hypothesis focused on the correlation of interest and perceived tension with the two teaching styles. Both, the hands-on (I-1) and the conventional approach

(I-2) were taught by the same teacher in order to exclude potential teacher effects. The only difference between I-1 and I-2 was the instructional type, while contents and time spans were similar.

2.2 Applied Test Batteries

Table 1. Item Assembly of the BDIS-Questionnaire and the Three Subscales, Mental Underload, Mental Overload and Unused Time

	Item description	Scales
Item 3	I'm bored in science class if our teacher explains new homework although I have already understood it.	
Item 4	I'm bored in science class if we deal with something of whom I already know how it works.	
Item 5	I'm bored in science class if our teacher explains something that I have already understood.	
Item 6	I'm bored in science class if our teacher explains something that we have already done.	**Mental underload**
Item 7	I'm bored in science class if we exercise something that is easy for me.	
Item 8	I'm bored in science class if we repeat something that we have already dealt with.	
Item 10	I'm bored in science class if we deal with something that we have already done.	
Item 16	I'm bored in science class if we deal with something that I already know or can.	
Item 11	I'm bored in science class if we exercise something that is too difficult for me.	
Item 12	I'm bored in science class if we exercise with something that I don't understand.	**Mental overload**
Item 13	I'm bored in science class if we deal with something that is too difficult for me.	
Item 14	I'm bored in science class if our teacher explains something that I still don't understand.	
Item 1	I'm bored in science class if I finish something faster than others.	
Item 2	I'm bored in science class if I finish a test faster than others.	**Unused time**
Item 15	I'm bored in science class if I finish a task faster than the other children and I have to wait for them.	

Two subscales of the Intrinsic Motivation Inventory (IMI) (Deci & Ryan, 1990) were applied for quantifying interest and tension. The German version of the questionnaire was taken from Schaal and Bogner (2005). The Intrinsic Motivation Inventory, mainly designed for adults and adolescents, has been applied successfully to 6th graders in previous studies (Sturm & Bogner, 2010). The response pattern followed a five-point Likert-scale from "I totally disagree" to "I totally agree".

The BDIS-questionnaire exploring boredom in different classroom situations was initially developed by Lohrmann (2008) for primary students to assess emotions in conventional Math and German classes. The response pattern followed a four-point Likert scale from "I totally disagree" to "I totally agree". To measure mental underload, mental overload and the amount of unused learning time during their usual science classes, we applied three scales from that questionnaire (Table 1).

2.3 Factor Analysis of the Altered Scales of the BDIS-Questionnaire

Reliability analysis of the total BDIS-questionnaire yielded a Cronbach alpha of 0.92, for the mental underload scale 0.92, for the mental overload scale 0.89 and for the unused time scale 0.77. MSA-, KMO-values, the scree-plot and the explained total variance served as criteria for decision about the number of factors in the boredom-test battery. We used principle component analysis with oblique rotation. A three component model explains 63.98% of the total variance. The Kaiser-Meyer-Olkin value was 0.925. The Bartlett-test was significant $p < 0.001$, *Chi-square* = 2863.35 and $df = 120$. The MSA-values were consistently always > 0.84. The scree-test implied a three-factor model: the model-matrix showed consistently high factor loadings (Table 2).

Table 2. Model Matrix of the Three Components for the Three Scales of the Boredom-Questionnaire—Mental Underload, Mental Overload and Unused Time. Only Values > 0.5 are Listed Below

	Mental underload	Mental overload	Unused time
Item 3	0.704		
Item 4	0.710		
Item 5	0.776		
Item 6	0.904		
Item 7	0.523		
Item 8	0.680		
Item 10	0.889		
Item 16	0.580		
Item 11		0.862	
Item 12		0.832	
Item 13		0.906	
Item 14		0.784	
Item 1			0.739

Item 2			0.819
Item 9			0.523
Item 15			0.801
Intrinsic values	7.1	2.1	1.0

Extraction method: principal component analysis. Rotation method: Oblimin with Kaiser normalisation.

2.4 Cluster Analysis

We used the 16 items of the BDIS-questionnaire for clustering students based upon their feelings during the usual science classes. We extracted a four-cluster solution by an agglomerative hierarchical cluster analysis applying Ward's method (Norusis, 1993). For determining students' cluster membership, we used the K-Means cluster analysis procedure (Anderberg, 1973) specifying the cluster number as four. We validated this analysis by a cluster-wise cross-tabulation of the two methods and achieved a high level of agreement (coefficient of contingency $C = 0.90$ with $Cmax = 0.87$, $n = 298$, $p > 0.001$). According to Bacher (1994), clusters are homogenous if the standard deviations of each variable within each cluster are lower than the corresponding values in the sample as a whole. Cluster homogeneity was best in the four cluster model (see Table 3).

Table 3. Analysis of Cluster Homogeneity by Comparison of the Standard Deviation of each Variable within the Clusters with the Values in the Sample as a Whole

Category	All (n = 298)	Cluster 1 (n = 120)	Cluster 2 (n = 109)	Cluster 3 (n = 23)	Cluster 4 (n = 46)
Item 1	0.91	0.68	0.55	**0.99**[1]	**0.93**[1]
Item 2	0.94	0.72	0.58	**0.98**[1]	**1,17**[1]
Item 3	1.00	0.71	0.58	0.78	0.98
Item 4	0.98	0.70	0.44	0.85	0.71
Item 5	1.00	0.67	0.56	0.72	0.74
Item 6	0.96	0.71	0.60	0.85	0.67
Item 7	0.89	0.66	0.44	0.86	**0.98**[1]
Item 8	0.96	0.70	0.46	0.85	**1.05**[1]
Item 9	1.00	0.75	0.67	0.90	**1.18**[1]
Item 10	0.97	0.72	0.55	0.90	0.91
Item 11	0.73	0.68	0.26	**1.13**[1]	0.31
Item 12	0.79	0.70	0.36	**0.98**[1]	0.67
Item 13	0.77	0.72	0.21	**0.93**[1]	0.42
Item 14	0.82	0.71	0.42	**0.83**[1]	0.67

Item 15	1.00	0.77	0.62	**1.11**[1]	**1.12**[1]
Item 16	1.01	0.76	0.51	0.88	0.74

Note: Only 13 of 64 (bold) within-cluster values showed a higher level as the corresponding values in the sample as a whole.

3. Results

3.1 Cluster Analysis

We were able to characterize the four cluster types by plotting the means of the three subscales of the BDIS-battery for each of the four cluster types. We identified and labelled four clusters of students' emotions when applying the questionnaire in conventional science lessons: (1) "moderately challenged" students (n = 120), (2) "optimally challenged" students (n = 109), (3) "reluctant" (n = 23), and (4) "bored" students (n = 46). Cluster 2 contained the lowest scores of mental underload and unused time by contributing more towards mental overload compared to the other cluster groups (Table 3). We labelled cluster 2 as "optimally challenged", since mental underload as well as unused time scored lowest in that cluster. Cluster 1 we labelled "moderately challenged", as all three emotional scales scored similarly to "optimally challenged" but showed generally higher values of underload, overload and unused time. Cluster 3 we were labelling "reluctant", since it contained high scores of underload and unused time but also the highest scores of mental overload compared to the other clusters (Table 3). Cluster 4 we labelled "bored" as low levels of mental overload appeared together with high scores in mental underload and unused time.

A cluster-wise cross-tabulation and one-way ANOVA revealed neither gender effects (coefficient of contingency $C = 0.09$, $n = 298$, $p > 0.491$) nor age effects ($F = 0.793$, $df = 3$, $p = 0.498$) with respect to the cluster types.

Table 4. Interest- and Tension-Scores of the Four Cluster Types According to Preceding Modes of Teaching

	Teaching style	Cluster types							
		Cluster 1		Cluster 2		Cluster 3		Cluster 4	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Interest-values	Student-centred	3.80	± 0.49	4.11	± 0.64	3.08	± 0.77	3.42	± 1.05
	Teacher-centred	3.74	± 0.73	4.26	± 0.52	3.68	± 0.92	3.72	± 0.86
Tension-values	Student-centred	1,95	± 0.59	1,61	± 0.60	2,64	± 0.68	1,93	± 0.93
	Teacher-centred	1.60	± 0.47	1.50	± 0.52	2.13	± 0.48	1.54	± 0.37

3.2 Interest and Tension of Boredom Types during the Hands-on and Conventional Approach

Both teaching styles pointed to clear relationship with individual interest: As interest in both the conventional and the hands-on approach scored very high in all clusters, interest and tension did not differ between both modes of teaching within each cluster type (t-Tests, $p > 0.05$ in each case). However, one-way analysis of variance revealed cluster types differences with respect to interest scores in the conventional approach ($F = 3.152$, $df = 3$, $p = 0.030$). Post-hoc tests showed that interest in the conventional teaching mode was significantly higher in cluster 2 than in cluster 1 (Tukey test, $p = 0.05$). Cluster 2 showed the highest interest values in the conventional instruction compared to the other clusters; the "reluctant" students showed lowest interest scores (Table 4). The same was true for interest scores in hands-on instruction.

Interest in the hands-on approach also differed between the cluster types (one-way ANOVA; $F = 4.779$, $df = 3$, $p = 0.005$). We measured differences in interest comparing cluster 2 and cluster 3 (Tukey's test, $p = 0.015$) as well as comparing cluster 2 with cluster 4 (Tukey's test, $p = 0.030$). Tension values differed also in the conventional instruction between cluster types (one-way ANOVA; $F = 3.784$, $df = 3$, $p = 0.014$). Cluster 3 showed the highest values of tension and differed from all other cluster types significantly (cluster 3/cluster 1: Tukey's test, $p = 0.030$; cluster 3/cluster 2: Tukey's test, $p = 0.009$; cluster 3/cluster 4: Tukey's test, $p = 0.024$). Cluster 2 showed the lowest tension values in the conventional approach (Table 4). A significant difference in tension values was also found within the hands-on approach between different cluster types (one-way ANOVA; $F = 3.652$, $df = 3$, $p = 0.017$). Post-hoc tests revealed a significant difference in perceived tension comparing cluster 2 with cluster 3 (Tukey's test, $p = 0.012$).

4. Discussion

The main purpose of our present study was the performance of two educational interventions on different levels of interest and perception of tension. Here we can confirm our hypothesis that students who tend to be bored in regular science instruction settings showed higher interest scores in a more student-centered instruction type. The same is true for our expectation that interested individuals may experience a lower level of perceived tension in a hands-on approach. Additionally we identified four boredom types in science classes (extracted by cluster analysis) revealing "optimally challenged", "moderately challenged", "reluctant" or "bored" individuals. In contrast, hands-on instruction by itself may not produce a modified perception of tension and interest in reluctant and bored students.

4.1 Factor Structure and Cluster Types

As the BDIS-questionnaire (Lohrmann, 2008) has not yet been tested with our age group of 5th graders, a separate factor analysis was advisable. The pattern we obtained, however, in principal did match the hypothesized structure in supporting the reliability of the questionnaire. Application to our age groups was therefore acceptable. Even more, our results strongly reject the hypothesis of Robinson (1975) and Hill and Perkins (1985) that children of our age groups cannot yet distinguish between boredom and other negative emotions such as anxiety and anger. Our study, focusing on the categorization of boredom types on the basis of emotions during regular science classes, yielded four boredom types: “optimally challenged”, “moderately challenged”, “reluctant” and “bored”. Neither a gender nor an age effect appeared. Students of the “optimally challenged” cluster showed the lowest level of mental overload and unused time and also a very low level of mental overload. Over one third of our sample was associated with this group. 40% of our sample scored at least “moderately challenged”. They showed slightly higher values of overload, unused time and underload than the “optimally challenged” students. So we can conclude that 77% of our students were well or very well challenged in their regular science classes. Nevertheless, 23% of our sample group is either bored during their science instruction or is even unable to understand the subject at all. Nearly 8% of our students showed very high scores of mental overload and simultaneously a high level of unused time. Maybe students reported so much unused time because they were overloaded and consequently stopped following the lesson and started day-dreaming, for example. It is therefore possible to be both mentally unchallenged and overloaded at the same time. Our results showed students of cluster 4 with the same level of unused time as our “reluctant” students. In contrast to cluster type 3 this high level of unused time occurs as a result not of a high level of overload but rather to the fact that those students are unchallenged. In summary, although some three quarters of the students seemed to be pleased with the regular science class, almost a quarter of students were not satisfied with the instruction.

4.2 Influence of Teaching Style on Interest and Perceived Tension of Different Boredom Types

Another objective of our study was to examine whether an altered teaching style shows different effects on the interest and tension on the boredom types. So we employed both hands-on instruction and conventional instruction in our study. We hypothesized that those students who are bored in regular science classes or those who cannot follow instruction would be more interested in hands-on instruction. A more student-centered instruction should also induce lower levels of tension for the boredom types mentioned above. Contrary to our hypothesis the bored and reluctant students showed lower interest in the hands-on instruction method than the optimally and moderately challenged students. This is an unexpected result because many studies have reported the contrary, namely that student-centered, hands-on instruction increases interest (within all boredom types) as those approaches seem to enhance the feeling of competence and to reduce the perception of tension since students are enabled to gain new knowledge on their own (Deci & Ryan 1990). This should be especially relevant for those student groups not so interested in regular instruction. On the contrary, our “reluctant” students reported more tension during hands-on instruction than the “optimally challenged” ones. On the other hand, all boredom types showed overall high values of interest. The content “water” seems to present a popular topic among all students of this age-group, so the content could not be the explanation why the “bored” and “reluctant” students were not more interested than those students already challenged by instruction. We assume that higher tension and lower interest values of the “reluctant” students originate in the individual cognitive overload levels.

Cognitive load may emerge when students are confronted with different tasks, which apart from their traditional classroom experience are totally new to them (Scharfenberg & Bogner, 2013; Sweller et al., 1998). Compared to conventional approaches, hands-on instruction may confront students with many new instruments and may force to perform tasks in team work, which by itself may already increase cognitive load. Even authentic environments of outreach facilities seem to prevent harvesting the potential of such learning sites when undesired influences were not taken care to exclude (Fremerey & Bogner, 2015; Franke & Bogner, 2013). Nevertheless, sufficient reliability and validity of applied empirical measures often are lacking (Vodanovich et al., 2005), though the study of Randler et al. (2011) had summarized a series of studies to overcome this deficiency and first described a short subscale of boredom within a set of state-emotion variables.

5. Conclusions and Implications

Cluster analyses unveiled about a quarter of our participants as a bored subsample during instructional time or even stating that they had not followed or understood a classroom instruction. Our hypothesis that an introduction of new instructional methods may enhance interest and diminish the level of tension of reluctant students was not confirmed: hands-on instruction (as we had implemented) *per se* has not shown the capability to increase interest of reluctant students in science instruction. Potential reasons for this may lie in a delay of effects or a multiple necessity of experiencing such hands-on instructions. The failure of bored students to harvest their cognitive potential in classroom instruction is unacceptable in modern achievement-oriented societies (Daschmann, 2013). Any prevention of boredom is supposed to promote positive behaviors and to optimize the maturation ofyoung talents. Moreover, with the innovative vision of future classrooms in mind (Sotiriou & Bogner, 2011), boredom is supposed to less likely to appear, but a remaining portion of students always may persist. Science education needs to beat these odds as it cannot deserve to left them behind.

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