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GRADE 6 & 9 STUDENT AND TEACHER PERCEPTIONS OF TEACHING AND LEARNING APPROACHES IN RELATION TO STUDENT PERCEIVED INTEREST/ENJOYMENT TOWARDS SCIENCE LEARNING

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Abstract. *Student perceptions of science teaching could be expected to differ in grade 6 compared with teaching in grade 9, as could student interest in science learning. To compare Estonian grades 6 and 9, lower secondary school student and science teacher perceptions of teaching/ learning approaches as well as student perceived interests/enjoyment on science learning, an instrument was developed taken into account 18 different teaching approaches that could take place in science lessons. An analytical, exploratory structural equation modelling (ESEM) approach supported 4-factor models differentiating between teacher-centred and constructivist approaches for both teachers and students, each having acceptable model fits. Based on outcomes, a regression model was developed associating student interest to learn science with the frequency of teaching and learning approaches explored. Results indicated that approaches associated with teacher-centred approaches were those most frequently undertaken in science classes when compared with those seen as social constructivist and student-centred, both among science teachers and students. Regression analysis showed that there was a relationship between student interest/enjoyment towards science subjects and the frequency, in which different teaching and learning approaches took place in the classroom.*
Keywords: *exploratory structural equation modelling, regression analysis, social constructivism, student interest/enjoyment, teaching-learning approaches*

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Introduction

In recent years, research in science education has focused on how to teach science effectively in a way that initiates and increases student interest and motivation towards science learning. This focus has been stressed, because there is a tendency for declining interest, motivation and attitudes among lower secondary school students (Osborne et al., 2003; Potvin & Hasni, 2014). Research has shown that the teaching approach can also play an important role. In teacher-centred approaches, both interest and student learning are shown to be limited, whereas for student-centred approaches, where students actively participate in the learning process (e.g., inquiry-based learning, hands-on activities) these have been shown to positively promote student interest (e.g., Potvin et al., 2017; Wang et al., 2015). Furthermore, research studies have shown that student interest towards science learning is influenced by the manner in which science learning is initiated and presented to students (Hasni & Potvin, 2015; Häussler & Hoffmann, 2000; Teppo et al., 2017).

The Teaching and Learning International Survey (TALIS) (OECD, 2019) indicated that Estonian teachers were only using cognitive activation approaches (e.g., students working in groups, undertaking critical thinking, or solving complex tasks) to a relatively low extent, although this was dependent on the school subject involved. For example, science and mathematics teachers used such approaches less than other teachers. Not surprising, therefore, Estonian PISA 2015 (OECD, 2016) results indicated that, in science lessons, students rarely undertook practical activities and had few opportunities to plan experiments, compared with the OECD average. These findings pointed to a predominance of teacher-centred approaches in the teaching of science subjects.

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The Estonian curriculum has tried to promote competence-based teaching (National Curriculum for Basic School, 2014) and has long advocated a student-centred approach. Nevertheless, teachers have pointed to obstacles, such as a cognitive, factual dominance in external assessment methods and a lack of teaching time and resources. Not surprising, such perceived obstacles can be expected to hinder the promotion of student-centred approaches as an effective teaching and learning process in science classes.

Learning Approaches in Science Teaching

Student learning of science in schools and the role of the teaching and learning environment have been research topics for decades. Generally, studies on the approach to teaching and learning have been characterised through researching student activities and practices conducted in science lessons. According to Anthony's hierarchical model (Richards & Rodgers, 2001) an approach is a wide conception, referring to the philosophy (theory) related to how teaching and learning occurs, while method of teaching is taken to be procedural, indicating a systematic way of teaching that forms an implementable technique so as to help learners learn and achieve their goals. For example, researchers have undertaken investigations of approaches in science teaching and learning using a variety of terminology, e.g., teaching methods (Hasni & Potvin, 2015; Kousa et al., 2018), teaching and learning activities (Hampden-Thompson & Bennett, 2013), teaching and learning practices (Ebenezer & Zoller, 1993). More specifically, Juuti et al. (2010) have used the term teaching method as a synonym for an instructional method/model/strategy, student activity, or classroom practices that is designed to help students achieve learning goals.

A Social Constructivism Approach to Teaching

Teaching and learning can be generally organised into two main categories: a teacher-centred approach vs. a student-centred approach, which are often used as synonyms for traditional vs. constructivist forms of teaching. A teacher-centred approach is recognised as teaching in which the teacher is dominant and plays the leading role. The teacher behaves as an instructor, frequently using science textbooks for communicating new information (e.g., giving a lecture), while students passively receive knowledge or work individually using workbooks on independent tasks, with student learning measured through tests with assessment viewed as separate from teaching (Arends, 2012; Concept to Classrooms, 2020; McLeod, 2019). Student centred learning is much more diverse, expecting the student to play an active role and aiming at developing learning autonomy and independence (Jones, 2007) while striving towards developing skills and practices that enable lifelong learning (Young & Paterson, 2007).

The central idea of constructivist teaching is that people actively construct or make their own knowledge and build this on previous learning experiences (Arends, 1998; Elliott, et al., 2000). Social constructivism, as a sub-set of constructivism, emphasises that learning is dependent on interactions with others, i.e., learning is socially and culturally constructed in an active way, focusing on the learner as part of a social group, and learning is determined by the complex interplay between a learner's existing knowledge, the social context and the problem, or situation to be solved (Taber, 2011). This suggests learning, within the classroom, is actively promoted in a social constructivist way through collaboration among students and between students and teachers.

The social constructivist learning theory (Palincsar, 1998) underpins a variety of student-centred teaching approaches and techniques, which contrast with a traditional view of education, whereby knowledge is simply transmitted passively by teachers to students. In the social constructivist approach, the teacher role in the learning process is to be a collaborator, advisor and educator, creating and facilitating a collaborative problem-solving environment, in which students become active participants in their own learning (Good & Lavigne, 2018; Lalley & Miller, 2007). From this perspective, the teacher organises the educational process to support students and makes use of a variety of teaching methods, guiding student to meet learning objectives (Sharples et al., 2016).

In science classes, teachers do not always apply only a teacher-centred approach, or a student-centred approach and hence the teaching can include elements from both approaches. Nevertheless, the teacher has an important role and responsibility, both to increase student interest in learning and also to develop student competencies as stipulated in the curriculum and to do so through selecting the most relevant learning approaches in any given situation (Ebenezer & Zoller, 1993).

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Teaching and Learning Approaches and Student Interest/Enjoyment

Numerous studies have researched different teaching and learning approaches on student interest and motivation towards science learning (e.g., Ebenezer & Zoller, 1993; Hampden-Thompson & Bennett, 2013; Hasni & Potvin, 2015; Juuti et al., 2001; Kousa et al., 2018; Sturm & Bogner, 2008). For instance, both stimuli, such as the use of puzzles, challenging tasks, or well-organised texts, or simply providing students with choices in the way and what they learn, have been used to increase situational interest, focusing attention and, as such, increasing levels of learning (Hidi, 1990; Hidi & Renninger, 2006). Additionally, Bergin (1999) has suggested that hands-on activities, novel learning stimuli, social interaction via group work, modelling of experts, etc. have been shown to increase student interest/enjoyment. Furthermore, research by Hampden-Thompson and Bennett (2013) has indicated that 15-year-old student motivation and enjoyment of science has increased the more activities are related with interactions (debates, discussions, explanations), hands-on activities (doing experiments, drawing conclusions based on experiment) and applications in science (relevance of science concepts to student lives).

Juuti et al. (2001) have used a two-fold approach to explore how grade 9 students have evaluated teaching methods used in science teaching - in the current practice and preferred (desired) situations. They have also explored student perceptions of school science (e.g., interest, difficulty, importance of science and technology for society, becoming a scientist, etc.), in addition to relationships between student demographic backgrounds (girl-boy, number of books at home and academic performance), perceptions of school science and teaching methods. Their findings have shown that interested students perceived school science to be relevant in their everyday life and wished to undertake more creative activities, such as brainstorming and project work. In addition, their results have identified gender differences related with teaching methods, in that boys seemed to be more satisfied with the current teaching, while girls preferred group discussions, debates and group projects.

Hasni and Potvin (2015) have shown, by exploring grade 5-11 student interest towards science and technology aspects, including a general interest towards science and technology education (e.g., school science is fun, boring), plus preferences for relevant teaching methods that students have tended to learn science through spending more time doing exercises, such as using handout or workbooks, etc. As a result, they have noted a moderate to weak positive correlation between general interest towards science and technology and different teaching methods. In addition, their results have indicated that students express a desire to participate when the teaching methods are seen as enabling students to be active i.e., make observations, experimenting, participating in debates, etc. and showed lower preference for putting forward explanations, using textbooks, etc.

Research Aim and Research Questions

Taking into consideration the declining student interest towards science learning and the teacher-centred teaching environment, the aim of the current research was to explore the perceptions of Estonian science teachers and students towards teaching and learning approaches being implemented in science classes, associating this with student interest (in terms of interest/enjoyment) towards science and the teaching/learning approaches being used. Specifically, this research focused to answer the following research questions:

1. What perceptions do students and science teachers hold regarding teaching and learning approaches used in science classes and how do such perceptions differ from teaching in grade 6 and grade 9?
2. What is the effect of teaching and learning approaches in grades 6 and 9 on student interest/enjoyment towards learning in science subjects?

Research Methodology

Current Research

The initial focus of this research was the development of a general model interrelating teaching approaches. The model was constructed, based on a cross-model of teaching initiated by Bundsgaard (2009), but adapted based on the Estonian science learning environment (National Curriculum for Basic School, 2014). The horizontal axis distinguished between a science content approach and social constructivist teaching, while the vertical axis identified teacher-centred vs. student-centred teaching.

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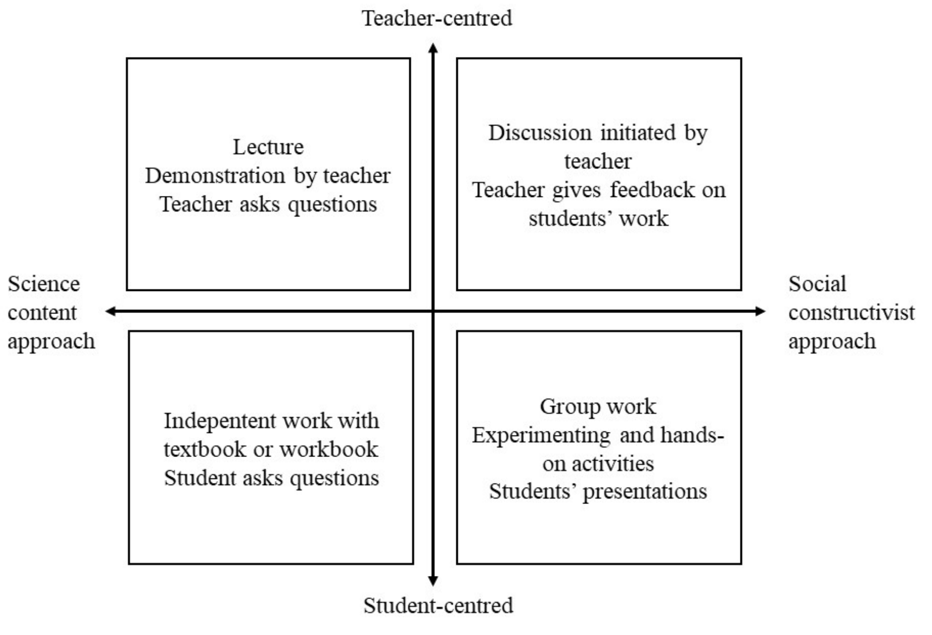
Figure 1
Teacher versus Student centred Learning Model Distinguishing between Science Content and Social Constructivism Approaches (Adapted from Bundsgaard, 2009)



The research focused on gathering data from both students and teachers from two perspectives – perceptions about using teaching and learning approaches and student perceived interest/enjoyment towards science learning (Table 1), taking into account the divisions within the theoretical model of teaching and learning approaches presented in Figure 1.

Sample

The student and teacher samples were derived as part of a large-scale research project focusing on student and teacher perceptions of teaching and learning approaches, carried out in science lessons associated with student interest towards science learning. The student sample for the study was formed from a representative sample of the Estonian 6 and 9 grade population. The school location and number of students were taken into account for sampling (for detailed description of the sampling process see Pedaste et al., 2017). The sample comprised of a total of 3521 students from 6th grade ($N = 2673$, average age 12.6) and 9th grade ($N = 848$, average age 15.6). In addition, for comparative purposes, data were also collected from science teachers ($N = 205$) from the same schools, related to the teaching and learning approaches used.

Information about the research project (e.g., purpose, use of data, expected outcomes) were provided for students, their parents, science teachers and schools representatives. At the beginning of the research, written permission from parents were asked related to their students' participation. Only students who had received parental approval were included in the research. Science teachers voluntarily participated in the research.

Instrument Development

To undertake this research a questionnaire was developed enabling data gathering with respect to (a) perceptions about using teaching and learning approaches and (b) perceived student interest/enjoyment towards science learning (Table 1). Taking into account the theoretical model of teaching and learning approaches presented in Figure 1, the measurement tool included 18 teaching and learning approaches chosen and modified based on earlier research (Ebenezer & Zoller, 1993; Holbrook & Rannikmae, 2014; Juuti et. al, 2001; Pedaste et al., 2015). The

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interest/enjoyment section comprised 3 items appropriately worded to be used in a science class, or separately in biology, geography, physics and chemistry classes.

Table 1
Overview of the Instrument Used for Measuring Perceptions of Grade 6 and 9 Students and Science Teachers on Teaching and Learning Approaches and Students' Perceived Interest/Enjoyment towards Science Learning

Measures	Grade 6 students	Grade 9 students	Science teachers
I. Teaching and learning approaches			
science	∨	-	∨
biology	-	∨	∨
geography	-	∨	∨
physics	-	∨	∨
chemistry	-	∨	∨
II. Interest/enjoyment in			
science	∨	-	
biology	-	∨	Not measured
geography	-	∨	
physics	-	∨	
chemistry	-	∨	

Note. ∨ - measured in corresponding grade.

Both teachers and students in grade 6 and grade 9 were asked to evaluate the frequency in which certain teaching and learning approaches occurred in science lessons using a 3-point scale (1 - never; 2 - sometimes, 3 - often) e.g., "New content is presented by the teacher as a lecture", "Individual work with textbook or workbook", "Student plans and carries out the experiment". In addition, teachers were asked to evaluate all given approaches based on how they liked using them in their teaching, using a 3-point scale (1 - less; 2 - same, 3 - more).

The items determining student interest/enjoyment were taken from one of the sub-scales in the Intrinsic Motivation Inventory Instrument (Deci & Ryan, 2016) which was adapted to consist of the three following items: "I enjoy studying science", "Science learning is very interesting" and "Science learning is fun". These items were included in the science questionnaire for grade 6 and in each of the biology, geography, physics, chemistry questionnaires for grade 9. All items in the interest/enjoyment section were presented in a 5-point Likert scale (1-disagree, 2-rather disagree, 3-neutral, 4-rather agree, 5-agree).

Reliability and Validity

The internal consistency of the instrument measures was determined based on Cronbach alpha. Acceptable values were found - .81 for teachers and .84 for students within the teaching and learning approach component and .95 for the interest/enjoyment sub-scale among students.

The instrument was piloted with grade 6 and 9 students before the main study was carried out to increase the validity of the instrument. Based on student feedback, minor changes in wording were made.

Content validity was used to evaluate whether the instrument represented the teaching and learning approaches and was considered familiar to students in both grades and practiced by science teachers. To achieve content validity, three experts evaluated the instrument's accuracy (usability, relevance) within the Estonian science learning environment. Separate interviews with a science education professor, researcher and science teacher were undertaken to validate teaching and learning approaches suitability for lower secondary school students. Finally, the validation was based on expert consensus (agreement rate was 85%).

Construct validity of the instrument and its sections was measured using factorial analysis, specifically using an exploratory structural equational modelling approach (ESEM) among both students and teachers. The corresponding statistics were presented in results section.

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Data Collection

In Estonian lower secondary schools, science is taught as an integrated subject from grades 1-7, while biology and geography are separate additions in grade 7, followed by the addition of physics and chemistry and removal of integrated science from grade 8. Thus, while grade 6 students were asked to indicate their interest/enjoyment and teaching and learning approaches in science, grade 9 students provided data for just one of the different science subjects (each science subject was evaluated by a randomly selection of approximately 25% students for each subject in the whole sample).

The data were gathered as part of the project "Smart technologies and digital literacy in promoting a change of learning" (2015-2020) using two sections of a larger instrument. Students completed the questionnaire electronically, either in a school computer class, or with tablets. Similarly, teachers answered to an electronic form, which was sent by e-mail to all science teachers who taught at the same schools where the student survey was conducted, asking teachers to participate in the study.

Data Analysis

Descriptive statistics (frequencies, mean, mode, standard deviation) were used to describe perceived frequencies of teaching and learning approaches and interest towards science learning. The Independent Samples *t* Test was used to compare the means of grade 6 and 9 students in order to determine whether there was statistical evidence of difference between groups. Descriptive statistics and comparative analyses were conducted using SPSS Statistics 26.

To reduce the dataset and assess the factor structure of the teaching and learning approaches, an ESEM (exploratory structural equation modelling) approach was used. ESEM integrated confirmatory and exploratory factor analyses (CFA and EFA) as a preferable method to test for model fit, being robust for non-normality of data. Based on Asparouhov and Muthén (2009), the selection of the optimal number of factors was made using model fit information. Well-established indices and criteria were used to assess the goodness of fit of the measurement models, based on CFI and TLI ranging from 0 to 1, with higher values indicating a better fit, and with values above .90 usually seen as-associated with a good model fit (Hair et al., 2010). However, a value of .95 was taken as the expected standard for both CFI and TLI (Hu & Bentler, 1999).

For RMSEA, it was accepted that lower values indicated a better fit, whereas acceptable values were taken to be between .03 - .08, at a 95% confidence level, depending on the sample size (Hair et al., 2010). All models were tested using Mplus 8.4 software (Muthén & Muthén, 1998–2017) with maximum likelihood robustness (MLR), currently considered to be the most accurate estimator where there was no normal distribution of items with categorical data. The Geomin oblique rotation was used as the default.

After determining the factor structure for the teaching and learning approaches, the predictive ability of different independent factors (teaching and learning approaches) on interest/enjoyment sub-scale (as dependent variable) towards science learning was investigated separately for grade 6 and 9, using linear regression analysis. Assumptions associated with linear relationship, multivariate normality, no or little multi-collinearity, no autocorrelation, and homoscedasticity were checked and found to be valid for use.

Research Results

Grade 6 and 9 Student Perceptions about Teaching and Learning Approaches

As shown in table 2, the perceptions by grade 6 and 9 students about the use of different teaching and learning approaches had similar tendencies. Both grades of students perceived lecturing, asking questions and individual work with textbook, or workbook as the most often used approaches in science lessons (51-79% of the student opinions depending on the approach). On the other hand, role play (plus brainstorming in grade 9) were indicated as the least used approaches (59% grade 6 students and 71% of grade 9 students indicated a never response). These results were supported by mode values, correspondingly '3' for the value that appeared most often and '1' for the least often. Variability (*SD*) in student answers ranged from 0.49 to 0.70 indicating quite moderate divergence in responses. The teaching "new content is presented by the teacher as a lecture" had the least variability in student

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answers. It was also the most often used approach in science lessons as perceived by both grade 6 and 9 students. At the same time, role-play, as the least used approach, had greater variability in student responses.

Table 2
Items for which Students' Expressed their Perceptions about Usage of Different Teaching and Learning Approaches Conducted in Their Science Classes

Items	Grade 6 students (*N*=2673)						Grade 9 students (*N*=848)					
	Distribution of responses (%)			*M*	*Mo*	*SD*	Distribution of responses (%)			*M*	*Mo*	*SD*
	Never	Some-times	Often				Never	Some-times	Often			
1. New content presented by the teacher as a lecture	2	19	79	2.78	3	0.45	3	21	76	2.74	3	0.49
2. Class discussion	4	38	58	2.55	3	0.57	10	40	50	2.40	3	0.66
3. Students ask questions	3	33	64	2.60	3	0.55	8	42	50	2.44	3	0.62
4. Teacher asks questions	2	28	70	2.68	3	0.51	4	32	64	2.60	3	0.57
5. Student individual work with textbook/ workbook	3	36	61	2.59	3	0.54	5	44	51	2.46	3	0.59
6. Students work in small groups	6	62	32	2.26	2	0.56	21	58	21	2.00	2	0.65
7. Role-play	59	36	5	1.47	1	0.60	71	25	4	1.34	1	0.56
8. Have debate during the lesson	33	53	14	1.81	2	0.65	38	47	15	1.77	2	0.69
9. Brainstorming	40	46	14	1.73	2	0.68	47	40	13	1.66	1	0.70
10. Compiling the poster or presentation	22	57	21	1.99	2	0.65	37	49	14	1.77	2	0.68
11. Teacher gives feedback on student work	5	47	48	2.42	2	0.59	11	46	43	2.32	2	0.66
12. Formulation of hypothesis or research questions	26	57	17	1.91	2	0.65	31	52	17	1.86	2	0.68
13. Student plans and carries out the experiment	32	56	12	1.79	2	0.63	44	46	10	1.67	2	0.66
14. Teacher undertakes a demonstration	28	58	14	1.86	2	0.63	36	49	15	1.79	2	0.68
15. Students make conclusions based on experiments	23	55	22	1.99	2	0.67	31	49	20	1.88	2	0.71
16. Students seek information from differ-ent sources	7	55	38	2.30	2	0.60	16	57	27	2.10	2	0.65
17. Solving everyday-life related science problems	33	53	14	1.81	2	0.66	20	58	22	2.02	2	0.65
18. Socio-scientific decision making	33	53	14	1.82	2	0.66	23	57	20	1.98	2	0.66

Note. M – Mean; *Mo* – Mode; *SD* – standard deviation. Items are presented in the order in which they appeared in the student questionnaire.

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Grade 6 and 9 Student Perceived Interest/Enjoyment towards Science Learning

Results indicating student interest/enjoyment towards science learning were as shown in Table 3. Learning science in grade 6 and learning biology in grade 9 were perceived as the most interesting subjects for students (agreement rate is close to 50%), while studying chemistry and physics in grade 9 was generally uninteresting, not enjoyable, or being indicated as less fun for a third of the students. Across all items, more than a third of students did not express a clear opinion towards science learning, i.e., they had not revealed their polarity about their interest towards science learning. Results indicated large standard deviations across items showing higher variability in student answers (1.04 < *SD* < 1.21) compared with teaching and learning approaches.

Table 3
Comparison of Grade 6 and 9 Student Perceived Interest/Enjoyment towards Science Learning

Items/grades	*M*	*SD*	Distribution of responses (%)		
			Agree	Neutral	Disagree
Science, grade 6 (N=2673)					
I enjoy studying science at school	3.45	1.12	48.4	34.8	16.8
Learning science is very interesting	3.49	1.12	50.0	33.6	16.4
Science learning is fun	3.40	1.11	44.7	37.7	17.6
Biology, grade 9 (N=220)					
I enjoy studying biology at school	3.45	1.11	47.7	35.9	16.4
Learning science is very interesting	3.52	1.09	50.9	34.5	14.6
Biology learning is fun	3.47	1.09	49.5	34.1	16.4
Geography, grade 9 (N=216)					
I enjoy studying geography at school	3.19	1.04	34.7	43.5	21.8
Learning geography is very interesting	3.23	1.06	38.4	39.8	21.8
Geography learning is fun	3.16	1.09	33.8	42.6	23.6
Physics, grade 9 (N=192)					
I enjoy studying physics at school	3.20	1.20	43.5	28.5	28.0
Learning physics is very interesting	3.17	1.20	40.9	30.6	28.5
Physics learning is fun	3.11	1.20	37.3	31.6	31.1
Chemistry, grade 9 (N=220)					
I enjoy studying chemistry at school	3.06	1.13	34.1	39.1	26.8
Learning chemistry is very interesting	3.11	1.18	35.9	37.3	26.8
Chemistry learning is fun	3.12	1.21	38.6	34.1	27.3

Note. M – Mean; *SD* – standard deviation. Mean values are presented on 5-point scale.

Science Teacher Perceptions about Teaching and Learning Approaches

Science teachers were asked to express their perceptions about teaching and learning approaches to include in their teaching (less, same, more) comparing with the current situation (never, sometimes, often) in their science classes (Table 4). The results showed that role-play, debating, brainstorming, formulation of hypothesis or research questions, planning experiments and teacher undertaking demonstrations were the approaches teachers wished to include more often, compared with their current situation. Undertaking the rest of the approaches were desired with the same, or less frequency. Similar to the outcomes from students, teachers indicated that teacher-directed approaches (teaching new content, asking questions, giving feedback to students) were most frequently used in science classes, although teachers expressed a wish to use them significantly less than in their current practice.

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Table 4
Items for which Science Teachers (N = 205) Expressed their Current and Preferred Perceptions about Usage of Teaching and Learning Approaches

Items	Current situation						Preferred situation					
	Distribution of responses (%)			*M*	*Mo*	*SD*	Distribution of responses (%)			*M*	*Mo*	*SD*
	Never	Some-times	Often				Less	Same	More			
1. New content is presented by the teacher as a lecture	2	15	83	2.82	3	0.42	23	72	5	1.82	2	0.50
2. Class discussion	2	25	73	2.72	3	0.48	1	68	32	2.31	2	0.48
3. Students ask questions	4	28	67	2.63	3	0.57	1	56	44	2.43	2	0.51
4. Teacher asks questions	1	18	82	2.81	3	0.40	6	85	9	2.02	2	0.40
5. Individual student work with textbook/ workbook	18	45	37	2.19	2	0.72	10	81	9	2.00	2	0.44
6. Students work in small groups	5	59	36	2.31	2	0.57	1	75	24	2.23	2	0.45
7. Role-play	59	37	4	1.45	1	0.57	2	52	47	2.45	2	0.53
8. Have debate during the lesson	47	46	7	1.60	1	0.62	1	51	49	2.48	2	0.51
9. Brainstorming	39	46	15	1.76	2	0.70	1	61	39	2.38	2	0.50
10. Compiling the poster or presentation	17	52	31	2.14	2	0.68	1	76	23	2.23	2	0.43
11. The teacher gives feedback on student work	2	12	86	2.84	3	0.41	1	79	21	2.20	2	0.41
12. Formulation of hypothesis or research questions	28	55	17	1.89	2	0.67	2	53	45	2.42	2	0.54
13. Students plans and carry out the experiment	37	52	11	1.75	2	0.65	1	42	57	2.57	3	0.51
14. Teacher undertakes demonstrations	24	57	19	1.95	2	0.66	1	57	42	2.41	2	0.51
15. Students make conclusions based on experiments	17	36	47	2.31	3	0.74	1	66	33	2.32	2	0.50
16. Students seek information from differ-ent sources	3	37	61	2.58	3	0.55	1	70	29	2.29	2	0.47
17. Solving everyday-life related science problems	6	49	44	2.38	2	0.60	1	66	34	2.33	2	0.48
18. Socio-scientific decision making	9	52	39	2.30	2	0.62	1	63	36	2.35	2	0.50

Note. M – Mean; *Mo* – Mode; *SD* – standard deviation. Items are presented in the order in which they appeared in the teacher questionnaire.

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Exploratory Structural Equation Modelling

Exploratory structural equation modelling (ESEM) was carried out separately within the student (as the factor pattern of 6th and 9th grade students was the same) and teacher data. Different factor models (2-4) were tested, reaching acceptable fit indices for solutions for four factors among students and teachers. The four-factor solution was the easiest to interpret related to item content and factor loadings higher than .30. However, since, two items in the student and teacher analysis (student individual work and teacher giving feedback to student work), plus, in addition (new content presented by the teacher as a lecture) within the teacher analysis, had loadings < .3, these were excluded, and factor analysis was carried out with the remaining 16 items among students and 15 items among teachers. As shown in Table 5, the fit statistics for the final four-factor model for both students and teachers indicated acceptable fit indices.

Table 5
Goodness-of-fit Statistics for Four-Factor Model

4-factor models	χ^2	*df*	*p*	CFI	TLI	RMSEA
Students (16 items)	688.67	62	< .001	.96	.93	.05
Teachers (15 items)	79.68	51	.006	.96	.93	.05

These final four factors were meaningfully named as: teacher-centred, cooperative approaches, experimental approaches, plus solving problems and decision making. The number of items per factors varied from two to seven. Standardised loadings between the factors ranged from .23 to .64. The internal consistency of all four factors had acceptable values (Cronbach alpha ranged between .70 - .86).

The factor "teacher-centred" included four approaches in the student model (new content presented by the teacher as a lecture, class discussion, students ask questions and teacher asks questions i.e., items 1-4) and the same (minus new content presented by the teacher as a lecture i.e., item 1) in the teacher model. As these covered teaching approaches mostly initiated, or carried out by the science teacher, this factor was classified as the teacher-centred approach. The largest factor included seven items, related with different cooperative approaches (items 6-10, 14, 16), mostly collaborative in nature and requiring active participation by all students, was interpreted as a constructivist approach. The "experimental approaches" factor was formed from activities related to experimenting – formulate research questions/-hypothesis, carrying out experiments and making conclusions (items 12, 13, 15), indicating a student-centred and constructivist approach. The factor "solving problems & decision making" included two highly correlated items (solving everyday-life related science problems and socio-scientific decision making i.e., items 17, 18), which students practice in science lessons and thus could be seen as a further constructivism way of teaching/learning.

Correlation Analysis between the Factors among Science Teachers

Correlation analysis showed positive relationships between the 4 factors among science teachers, regarding to the current situation (Table 6). Weak positive correlations ($r < .30$) (Cohen et al., 2007) were identified among teacher-centred approaches compared with cooperative, experimental and problem solving/decision making approaches. Moderate correlations ($r > 0.4$) appeared among cooperative, experimental and problem solving/decision making approaches.

Table 6
Descriptive Statistics and Correlations between Factors

Factors	*M*	*SD*	1	2	3	4
1. Teacher-centred approaches	2.72	.36	1.00			
2. Cooperative approaches	1.96	.37	.30**	1.00		
3. Experimental approaches	1.98	.53	.23**	.46**	1.00	
4. Problem solving and decision making	2.34	.55	.29**	.44**	.45**	1.00

Notes. Spearman's rank correlation coefficient (*rho*) was used for analysis.
** $p < .001$

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Grade Differences in Student Perceptions of Teaching and Learning Approaches

Table 7 compared grade 6 and 9 grade student differences in their perceptions according to fours factors. Statistically significant grade differences were indicated across all factors, in a way that teacher-centred, cooperative and experimental approaches were given higher mean scores by grade 6 students compared with students in grade 9. However, for problem solving/decision making approaches, grade 9 were shown to give a higher mean value compared with grade 6. Among teacher-centred and cooperative approaches students had less variability in their answers than within the experimental and problem solving/decision making approaches.

Table 7
Grade differences in Student Perceptions of Teaching and Learning Approaches

Factors	Grade 6 (N=2673)		Grade 9 (N=848)		*t*	*MD*	*SE*	95% CI	
	M	*SD*	*M*	*SD*				*LL*	*UL*
Teacher-centred approaches	2.65	.38	2.54	.43	7.08*	.11	.02	.08	.14
Cooperative approaches	1.92	.38	1.78	.47	9.22*	.14	.02	.11	.17
Experimental approaches	1.90	.51	1.80	.55	4.74*	.10	.02	.06	.14
Problem solving and decision making	1.82	.62	2.01	.61	-7.63*	-.18	.02	-.23	-.14

Note. M – mean; *SD* – standard deviation; *SE* – standard error; *MD* – mean difference; CI – confidence interval; *LL* – lower limit; *UL* = upper limit.
*$p < .001$

Associations between Teaching and Learning Approaches and Student Interest/Enjoyment towards Science Learning

The regression coefficients shown in table 8 for the interest/enjoyment of science (as dependent variable) using a linear regression approach explored the potential predictors among the four teaching and learning factors (as independent variables). Five models were estimated in total - Model 1 for grade 6 students and Models 2-5 for grade 9 students (Table 8). In all models, maximum variance inflation (VIF) was established such that there were no multi-collinearity problems.

Among grade 6 students, results indicated that there was a positive and significant association between increased frequency of teaching and learning approaches for all factors, especially those related to teacher-centred approaches ($\beta = .22$). The increase in the frequency in approaches (the more teacher-centred activities practiced in science classes) resulted in higher student interest/enjoyment in science learning.

In grade 9, student responses towards interest to learn science were given separately with respect to each of the separate science subject. Nevertheless, similar to grade 6 outcomes, results showed a tendency for there to be a positive association between increased frequency of teaching and learning approaches among all models, but especially related with teacher-centred approaches in models 3 (geography) and 5 (chemistry). In models 2 (biology) and 4 (physics), the problem solving/decision making factor was the strongest and most significant predictor of interest/enjoyment (accordingly $\beta = .26$ and $\beta = .34$), indicating that the more everyday-life problem solving/decision-making activities were carried out, the more students were interested in learning biology and physics at school. Interest/enjoyment towards the four science subjects in grade 9 involving cooperative approaches did not significantly associate with each other, as was the case with experimental approaches among biology and chemistry subjects.

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Table 8
Standardised Coefficients (β values) for Teaching and Learning Approach Variables on Student Interest/Enjoyment

Variables	Model 1 – science	Model 2 - biology	Model 3 - geography	Model 4 - physics	Model 5 - chemistry
	Grade 6	Grade 9			
Teaching and learning approaches					
Teacher-centred approaches	.22**	.17*	.28**	.06	.34**
Cooperative approaches	.07*	.04	.05	-.00	.09
Experimental approaches	.09**	.04	.15*	.17*	.11
Problem solving and decision making	.08**	.26*	.15*	.34**	.16*
Sample size (N)	2673	220	216	192	220
Adjusted R2	.10	.15	.19	.20	.24
Max VIF	1.43	2.20	1.69	1.42	1.41

* $p < .05$, ** $p < .001$

Discussion

The current research explored science teacher and grade 6 and 9 student perceptions of using different teaching and learning approaches in science class and the relationship with student interest/enjoyment towards science learning. The results indicated that both students' and teachers' perceived teacher-centred approaches were more frequently used in science classes than those student-centred (cooperative and experimental), both in grade 6 and grade 9. Specifically, students indicated that lecturing, asking questions and class discussions were approaches most often implemented compared with role-play, debate, brainstorming and carrying out experiments/making conclusions. These findings were similar to findings by Juuti et al. (2009) and Hasni and Potvin (2015), who also showed teacher-centred methods were perceived to be most often used in science classes, even though students expressed a desire to participate more. These findings were also supported by the TALIS international study (OECD, 2019), which concluded that teacher classroom practices were often teacher-centred, students passively adopting knowledge from the teacher and, of much concern, students were not perceived to be cognitively active. Somewhat more contradictory results were put forward by Hampden-Thompson and Bennett (2013), whose findings showed that the majority of 15-year-old students perceived investigations occurring in most, or all, science lessons, but only about half the students reported interactions, in terms of hands-on activities and applications in science, occurring in most, or all, lessons. Nevertheless, as their results were based on a PISA 2006 UK survey (Hampden-Thompson & Bennett, 2013) and taking into consideration limited activities, it was not actually possible to draw parallels, for example, with perceptions of teacher-centred activities (e.g., lecturing) as included in the current research. From a teacher perspective, the current research findings showed that science teachers did desire to use more student-centred (collaborative and experimental-related) approaches, although unfortunately, based on responses related to the current situation in the classroom, it seemed the current practice was the opposite i.e., science teachers most often used teacher-centred approaches.

Results from the current research indicated a relationship between student interest towards science subjects and the frequency of different teaching and learning approaches being used in science lessons. Specifically, the results pointed to the teaching and learning approaches being positively associated with student interest/enjoyment to learn science subjects at school, but not to the same degree. For example, both for grade 6 student interest in science and grade 9 student interest in geography and chemistry, learning was mostly predicted by teacher-centred approaches (e.g., lecturing, asking questions), while grade 9 student interest towards biology and physics was triggered by everyday life problem solving and decision-making approaches. These results were consistent with study by Hasni and Potvin (2015) who found also positive (moderate to weak) correlations between general interest in S&T at school and teaching methods factors (e.g. desire to spend more time exposed to traditional teaching methods, degree of student involvement in developing the inquiry process, desire to spend more time exposed to teaching practices based on open investigation), indicating that some teaching methods were better predictors of general interest in S&T than others. For example, hands-on activities appeared to have little effect on interest comparing with preference for open investigation methods and for traditional teaching methods.

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Noting that teaching and learning could take on many formats, an analysis of the current research outcomes showed four factors associated with the teaching and learning approaches, distinguishing between teacher-centred (1 factor), or constructivist approaches (3 factors). The first factor related to teacher-centred approaches (new content presented by the teacher as a lecture, teacher asks questions) and indicated these approaches were more often carried out, as perceived by both by students and teachers, compared with other approaches. Of the 3 factors identified with social constructivist approaches, two could be categorised as being more collaborative in nature (i.e., factors identified as group learning and experimenting). Approaches within these factors focused on being student-centred, including activities that students usually implemented in a social group (brainstorming, debates, carrying out experiments, formulating research questions or hypotheses, etc.) and perceived to be carried out in science lessons, at most, only sometimes. The factor, identified as less collaborative, related to problem solving/decision making and indicated a potential controversial outcome, arising, perhaps, through student and teacher lack of familiarity with these terms when applied to student-centred, or teacher-centred operations. Results of correlation analysis based on teacher data (related with the current situation) indicated that the four factors had a positive weak relationship with each other, rising to a more moderate correlation among cooperative, experimental and problem solving/decision making factors. This showed a significant relationship for the use of a variety of student-centred approaches for those teachers adopting a more student- centred approach in their teaching.

The results exhibited in Figure 1 indicated that teachings in science classrooms were heavily teacher-centred with very little emphasis on social constructivist approaches. At the same time, teachers wished to use more social constructivist approaches in the classroom, such as those involving cooperative and experimental teaching in an inquiry setting. However, a constructivist approach in teaching and learning required different behaviours by both teachers and students, as well as different classroom management and assessment compared with teacher-centred approaches (Arends, 2012). More consideration needed to be placed on social constructivist ways of teaching and learning, whereby the teacher's role was seen as initiating and maintaining interest/enjoyment towards science learning through the incorporation of cooperative and experimental activities, taking into account the students' prior knowledge (Good & Lavigne, 2018).

Conclusions

The current research points to a general perception of science teaching and learning in schools to be teacher-centred, involving direct teaching of whole groups of students, and providing little time for collaborative and experimental activities, even though international surveys highlight the importance of student-centred teaching approaches.

The results from this research demonstrate that while science teachers indicate a desire to use more cooperative and experimental related approaches, perceptions of current teaching by grade 6 and 9 students and also science teachers relate to teacher-centred approaches. Nevertheless, the results also indicate grade differences in that science classes perceived by grade 6 students tend towards being a mixture of teacher centred, cooperative and experimental, while problem solving/decision making approaches are perceived to be implemented more in grade 9 classrooms.

The analysis indicates that there is a positive association between both grade 6 and 9 student interest towards science subjects and the frequency with which different teaching and learning approaches take place in the classroom having subject differences. Teacher-centred approaches tend to predict grade 6 student interests in science, as well as grade 9 student interests in biology, geography and chemistry, although an orientation towards everyday-life related problem solving/decision making is seen to have a positive effect in biology and physics.

Recommendations

Noting that the manner in which science is taught, the curriculum presented, and the classroom approaches are conducted needs to take into account student perspectives if student interest is to be meaningfully promoted, teachers need to be encouraged to put more emphasis into the use of social constructivist approaches in science teaching.

Limitations

The following limitations need to be taken into consideration.-

1. The research instrument includes a limited range of teaching and learning approaches and thus the results of the study cannot be generalised to other approaches used in school science lessons.
2. The study sample covered lower secondary school students (grade 6 and 9); therefore, the results are valid only for these age groups.

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3. The purpose of the current study does not include examining casual, nor longitudinal effects of the perceptions of teaching and learning approaches used in science classrooms on student interests or motivation. This can be considered as one aspect for future research.

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