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Influence of Motivating Science Class, Family, and Peer Models on Students' Approaches to Learning Science: A Structural Equation Modeling Analysis

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Abstract Classroom environment, family, and peers are important factors in influencing students' science learning. The primary aim of this study was to examine the effects of three environmental factors related to science learning (motivating science class, family models, and peer models) on students' approaches to learning science (deep approach and surface approach). The sample comprised 308 students in grades 8 and 9 from ten secondary schools. Research instruments were Simpson-Troost Attitude Questionnaire-Revised (STAQ-R) (Owen et al. 2008) and Approaches to Learning Science (ALS) questionnaire (Lee et al. 2008). A structural equation modeling analysis procedure indicated that motivating science class and family models were the strongest predictors of students' deep approaches to learning science. Further, family models were found to have a significant direct and negative relationship with surface approaches to learning science. The results also revealed that motivating science class had a significant direct effect on peer models. In addition, other hypothesized relationships were not statistically significant. Accordingly, motivating science class and peer models had no significant association with surface approaches to learning science. Also, peer models were found to have no significant association with deep approaches to learning science. These pieces of evidence indicate that a motivating science class and a family who have positive attitudes towards science and are somewhat engaged with science may influence students to adopt deeper approaches to learning science. The results also offer implications for science teaching and learning and raise the potential role of science classroom, parents, and siblings in students' approach to learning science.

Keywords Motivating science class · Family models · Peer models · Approaches to learning science · Structural equation modeling

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Introduction

Over the decades, researchers have held interest in learning environment as a crucial determinant of student' science learning (Nolen 2003; Velayutham and Aldridge 2013). The term learning environment is defined as "a social system that includes the learner (including the external relationships and other factors affecting the learner), the individuals with whom the learner interacts, the setting(s) and purpose(s) of the interaction, and the formal and informal rules/policies/norms governing the interaction" (General Medical Council 2003, p. 3). According to this definition, the individuals with whom student interact (parents, peers, teacher etc.) and the settings (home, school, and classroom) comprise important parts of the social system of learning environment. There is also much empirical evidence that confirms the role of home and family (Breakwell and Beardsell 1992; Crowley et al. 2001; Dabney et al. 2013; Gennaro et al. 1986; George and Kaplan 1998; Kaya and Lundeen 2010; Owen et al. 2008; Perera 2014; Sha et al. 2016; Smith and Hausafus 1998), peers (Breakwell and Beardsell 1992; Owen et al. 2008; Panizzon and Levins 1997; Talton and Simpson 1985), and school (Entwistle and Tuit 1995; Fraser 2007; George and Kaplan 1998; Haladyna et al. 1982; Lawrenz 1976; Owen et al. 2008) as crucial components of learning environment in influencing students' attitudes and learnings.

Parental attitudes towards science is among several home factors including socioeconomic status, parenting style, and involvement that play roles in students' science learning and affect their attitudes towards science (George and Kaplan 1998; Kaya and Lundeen 2010; Owen et al. 2008; Perera 2014; Tare et al. 2011). Also, research confirms the influence of peer attitudes towards science on students' attitudes towards science and activities (Breakwell and Beardsell 1992; Owen et al. 2008; Talton and Simpson 1985). In addition, research shows that the influence of parental and peer attitudes towards science is mediated by science classroom environmental variables such as the science class motivational climate that could affect students' behavior and attitudes towards science (Owen et al. 2008; Simpson and Oliver 1990; Talton and Simpson 1986).

On the other hand, the literature suggests associations between these environmental factors and students' approaches to learning science (Baeten et al. 2010, 2016; Roman et al. 2008; Smith and Mathias 2010; Struyven et al. 2006). Accordingly, the deep and surface approaches that students adopt to learning science are affected by factors that are related to their science learning environment (Duarte 2007; Parpala et al. 2013; Zeegers 2001) and could be influenced by parents, siblings, and peers' attitudes towards science (i.e., family and peer models) and the science class motivational climate (i.e., motivating science class).

Hence, the aim of the present study is to examine the effects of three environmental factors related to science learning (family models, peer models, and motivating science class) on students' approaches to learning science (deep approach and surface approach). Since the science learning environment factors assessed here are attitudinal and motivational constructs in nature, in the following, the constructs of attitude and motivation in science learning are defined; the current research variables of family and peer models, motivating science class, and deep and surface approaches to learning science are explained, and based on previous research, the relations between variables are explained.

Theoretical Framework

Attitude Towards Science

Attitude is considered as "a psychological tendency to evaluate an object in terms of favorable or unfavorable attribute dimensions such as good/bad or positive/negative" (van Aalderen-Smeets et al. 2012, p. 161). Ajzen and Fishbein's (1980) theory of reasoned action is used to explain the relation between attitude, intention, and behavior. According to this theory, behavior is determined by intention, and intention, in turn, is a product of attitude towards behavior and beliefs about how other people would regard one's behavior. This theory also distinguishes between attitudes towards some "object" (e.g., attitudes towards science) and attitudes towards some specific action to be performed towards that *object* (e.g., attitudes towards doing school science) (Osborne et al. 2003).

Researchers consider attitude towards science as one of the different conceptualizations of motivation along with conceptions such as self-efficacy, interest, identity, engagement, and career aspirations of students in science learning (Vedder-Weiss and Fortus 2013). Klopfer's (1971) categorizing of affective behaviors in science education showed lack of clarity about the concept of "attitude towards science." van Aalderen-Smeets et al. (2012) assert that there is no consensus on the nature of the dimensions and subcomponents of the construct of attitude towards science; however, this construct is often divided into components of cognition, affect, and behavior (Eagly and Chaiken 1993). Potvin and Hasni (2014) in their systemic review of interest, motivation, and attitude towards science contend that the classical construct of "attitude towards science" consists of cognitive, affective, and behavioral components and the idea of positive or negative (like or dislike) inclinations towards an object. The cognitive component is a set of beliefs about the attributes of the attitudes' object, the affective component comprises feelings about the object, and the behavioral component concerns the way people act towards the object (Salta and Tzougraki 2004; van Aalderen-Smeets et al. 2012).

Some researchers also suggest that attitude is a complex construct that contains interest, enjoyment, and perceived difficultly (Potvin and Hasni 2014). According to Koballa and Crawly's definition (1985), attitude towards science is "a general and enduring positive or negative feeling about science" (p. 222). In this regard, statements such as "I like science," and "I hate science," explain a general positive or negative feeling towards the formal study of science or science as an area of research, so are considered to be expressions of attitudes towards science (Koballa and Crawly 1985). Schibeci (1983) suggests that attitudes towards science could also involve an attitude object such as science, science lessons, and laboratory works.

According to Osborne et al. (2003), "attitudes towards science" are "the feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves" (p. 1053). They suggest several components such as, attitudes of parents towards science, attitudes of peers and friends towards science, the nature of the classroom environment, the perception of the science teacher, and enjoyment of science, which studies on this construct have incorporated in their measures of attitudes to science. According to this notion of attitudes towards science, considering cognitive, affective, and behavioral components of attitudes towards science, Owen et al. (2008) incorporated the attitude-like variables of "family models" and "peer models" to assess feelings, beliefs, and values of parents, siblings, peers, and friends of students held about science. This understanding of attitudes towards science determines how individuals place importance on science and value it (Perera 2014). Accordingly, the attitudes of family members, peers, and friends towards science could influence students' attitudes and affect their science learning and achievement (Osborne et al. 2003; Perera 2014).

Family and Peer Models

The influence of family and peers on learning is based on socio-cognitive views of learning (Luce et al. 2017). According to Bandura's social cognitive theory, it is possible to learn from observing the actions of others such as peers, so that environmental agents can affect students' perceptions (Bryan et al. 2011; Harris 2005; Jones et al. 2008). Bandura's social cognitive theory is based on the reciprocity of the environmental, personal, and behavioral factors in students' learnings. This theory explains students' learnings and developments and their acquisition of knowledge within a social context, in which parents, teachers, and peers, as social models, play an important role (Bembenutty et al. 2016). Bandura (1986) contends that through modeling, students acquire information from their peers, family, and surrounding community (Jones et al. 2008). This view is also based on the educational productivity model proposed by Walberg (1984) who suggested two groups of factors including school-based factors and socio-environmental factors that have direct effects on students' learning outcomes (Chen et al. 2012). Reynolds and Walberg (1992) also suggested a third group of factors that indicate students' aptitude-attributes which include their motivation, prior achievement, and developmental level (Bruinsma and Jansen 2007). In this regard, school-based factors refer to curriculum, instruction, and psychological climate of the classroom (i.e., the emotional way in which students experience and perceive the psychological attitudes present within the classroom (Efstathiou et al. 2016)), while socio-environmental factors include variables such as home, classroom social group, peers, and mass media. Young and Reynolds (1996) assert that social-psychological environment including home, classroom, and peer environment in interaction with each other may affect students' learnings.

According to Sha et al. (2016), parental involvement is classified into categories of behavioral, personal, and cognitive/intellectual. The notion of personal involvement refers to parents' attitudes, values, and expectations about education, future, goals etc., which is conveyed to children during their interactions with parents. Behavioral involvement also refers to parents' physical presence in activities related to student education, while cognitive/intellectual involvement refers to activities such as visiting a science museum (Sha et al. 2016). Kaya and Lundeen (2010) contend that parents' involvement is a combination of their personal attitudes towards science as well as opportunities that are not provided by school. Accordingly, "family models," as employed by Owen et al. (2008) include items related to personal involvements of family members in science and also their behavioral involvement in activities related to science. The items such as "my mother likes science" could be considered parents' inclinations towards science, and the items such as "my family watches science programs on TV" could be referred to as family members' behavioral involvement in science. Research shows that these kinds of involvement could affect students' attitudes, learnings, and achievements in science (Hall and Schaverien 2001; Perera 2014). For example, Ho (2010) in a research on family influence on adolescent science learning concluded that parents' activities such as watching science program on TV and reading science books could affect adolescents' achievement in science. Hall and Schaverien (2001) also got the same result when investigated the effects of families' engagement with young children's science and technology learning at home.

On the other hand, peers and friends are known as an important part of environmental agents affecting students' perceptions. Attitude of peers and friends is considered as another factor that seems to be a significant determinant of attitude towards science (Osborn et al.

2003). George and Kaplan (1998) argue that attitudes are communicated to friends and peers and that peer groups have influence on students' science attitude. Research on peers' influence on students' performance in science also confirms the role of peers and friends' attitudes and activities. For example, Breakwell and Beardsell (1992) suggested that students who have scientific peers are more involved in extracurricular science activities and show better science performance. They assessed peers' attitudes towards science and their performance in science via students' responses to items on their peers' liking science subject, doing well in science, and wanting to be a scientist. The results of Owen et al. (2008) showed that peers' attitudes towards science influence students' perceptions of positive affect such as their feelings towards science. They used in their research the construct of "peer models," including the items such as "my friends like science" that refer to peers' attitudes towards science, and the items such as "most of my friends do well in science" that are related to peers' performance and activity in science.

Motivation in Science Learning

Motivation is stated as an "internal state that arouses directs and sustains goal oriented behaviors" (Potvin and Hasni 2014, p. 94). Modern theories of motivation consider the relation of beliefs, values, and goals (Eccles and Wigfield 2002). A group of these theories are about quantity of motivation and explain the magnitude of students' motivation; these include value-expectancy and attribution theories. On the other hand, theories such as self-determination theory and achievement goal theory highlight the quality of students' motivation (Eccles and Wigfield 2002; Vedder-Weiss and Fortus 2013).

The literature also suggests four orientations namely behavioral, humanistic, cognitive, and social to motivation that researchers adopt in science education. The focus of research on motivation with a behavioral orientation is on concepts such as incentive and reinforcement. The humanistic orientation considers students' capacity for personal growth and their desire to achieve and excel. While researchers with a cognitive orientation to motivation in science education focus on students' goals, plans, and expectations, researchers with a social orientation emphasize students' identities in their interpersonal relationships in learning communities such as science classrooms, museums, and nature centers (Koballa and Glynn 2007). These orientations to motivation in science learning are determined by constructs such as interest and curiosity, intrinsic and extrinsic motivation, self- determination, and self-regulation (Fortus and Vedder-Weiss 2014; Koballa and Glynn 2007).

Researchers in the field of motivation also distinguish between psychological and contextual dimensions which influence students' motivation. According to Azevedo's practice-centered theory (2011), any line of practice is defined by two structural elements that he names *preferences* (i.e., psychological dimensions) and *conditions of practice* (i.e., contextual conditions). While the psychological dimensions refer to deep, long-term goals, values, and beliefs that students develop in learning, the contextual conditions refer to conditions that could affect students' motivation in learning settings such as science classrooms (Azevedo 2011; Fortus and Vedder-Weiss 2014). According to the latter notion, the nature of students and teachers' activities affects students' motivation in learning science. For example, Pascarella et al. (1981) suggest that when science classrooms are more teacher-dominated, students show lower motivation in science. It highlights the role of contextual factors such as science teacher and science classroom activities in students' motivation. Accordingly, Owen et al. (2008) argue that the science classroom's affective and motivational climate is influenced by the teacher's structural arrangement and lesson planning.

Motivating Science Class

School is one of the most crucial parts of learning environment. In this regard, classroom learning environment is known as a factor that strongly influences student' outcomes in science (Fraser 2007). According to Fortus and Vedder-Weiss's (2014) classification of dimensions that affect students' motivation in science education, the construct of motivating science class could be considered as a contextual factor.

A "motivating science class" (Owen et al. 2008) could be described as a science classroom environment in which the science teacher's activities could lead to more student engagement. Vedder-Weiss and Fortus (2013) consider classroom engagement as an important factor that determines how much motivation students have in science classroom, so that the more engaged students in science classroom are more motivated in science learning. Classroom engagement refers to behavioral, cognitive, and emotional engagement. While behavioral engagement includes behaviors such as effort, attention, asking question, and contributing to class discussion, cognitive engagement contributes to construction of knowledge, and emotional enjoyment refers to students' reactions such as enjoyment, curiosity, anger, and boredom in the classrooms (Fredricks et al. 2004).

Nolen (2003) suggests that students' perception of classroom learning environment could affect their motivational orientations. Vedder-Weiss and Fortus (2013) argue that students' goal orientations are influenced by the goal emphases of their learning environment. The construct of "motivating science class" could also be explained based on the achievement goal theory in motivation. This theory refers to environmental characteristics that affect goal orientations that could lead to more engagement in science learning (Vedder-Weiss and Fortus 2018). Achievement goal theory suggests that learning environments such as science classrooms and teachers' classroom practices influence students' perceptions of learning environment which in turn influence their goal orientations. According to this, the goal structures of learning environment (i.e., environmental emphases on different goals) consist of students' perceptions of learning environment that could direct them towards effort and improvement (Patrick and Ryan 2008). Vedder-Weiss and Fortus (2018) contend that science teacher is a major agent of goal structure, and his/her classroom practices are related to students' adaptation of certain goal orientations. In this regard, Owen et al. (2008) argue that classroom's affective and motivational climate is a function of the science teacher's activities and class management. A motivating science class is related to activities that science teacher provides for students. In fact, the science teacher plays an important role to motivate students in the science classroom (Owen et al. 2008). Accordingly, the students who perceive the science teacher's activities more interesting and attractive are more motivated to learn science. They also may be more motivated when they consider their science teacher as someone who makes good plans and provides fun activities for them in the science class.

Owen et al. (2008) applied the construct of "motivating science class" to assess the science classroom activities that affect students' motivation. This construct refers to science teacher's arrangement and structure of science class and consists of items related to physical environment of the science classroom, the teacher and the curriculum. These items refer to positive affect and also to teacher-determined lessons such as "we cover interesting topics in science class" or "we do a lot of fun activities in science class" (Owen et al. 2008).

Approaches to Learning Science

Researchers on approaches to learning are concerned with students' accounts of how they would go about their everyday academic studies (Richardson 2015). Approaches to learning refer to the students' methods of task processing that are associated with their motivation regarding the given task (Lin and Tsai 2013). The idea of deep and surface approaches was originally proposed by Biggs (1987) and Marton (1983) to compare meaningful learning with rote learning (Lee et al. 2008). Marton and Säljö (1984) also described deep-level and surface-level processing (Richardson 2015) and proposed two different surface and deep approaches to learning. Dolmans et al. (2016) assert that students have different intentions when approaching a particular task such as studying a text. They argue that students who "try to relate information to prior knowledge, to structure ideas into comprehensible wholes, and to critically evaluate knowledge and conclusions presented in the text" (p. 1088) adopt a deep approach to learning and students who "try to use processing strategies such as rout learning" (p. 1089) adopt a surface approach to learning. In fact, students who apply a surface approach to learning concentrate on memorizing and reproducing information, while those who apply deep approaches concentrate on understanding, analyzing, and relating ideas (Parpala et al. 2013).

Approaches to learning are explained as a combination of intentions (i.e., learning motives) and learning activities (i.e., learning strategies). According to this notion, a surface approach to learning is defined as an intention to reproduce content, rote learning, and memorization, while a deep approach to learning is defined as an intention to understand content, relate ideas, weigh relevant evidence, and critically evaluate knowledge (Dolmans et al. 2016). An approach to learning science embeds the intention and learning processes used to carry out a task in science learning environment (Baeten et al. 2013; Lopez et al. 2013), refers to how students represent learning and is a conjugation between motivational orientation (deep and surface motive) and type of learning strategy (deep and surface strategy). Chin and Brown (2000) argue that deep approaches are associated with intrinsic motivation and interest, while surface approaches are related to learning via extrinsic or instrumental motivation. Research also shows that approaches to learning are related to learning outcomes of students, so that students who adopt a deep instead of surface approach to learning, are more likely to have better outcomes (Duarte 2007; Parpala et al. 2013).

Dolmans et al. (2016) contend that approaches to learning differ from learning styles. While learning styles are viewed as stable individual characteristics, approaches to learning are assumed to be challengeable and influenced by factors in the learning environment and students' perceptions of these factors (Gijbels et al. 2014). Accordingly, the student approach to learning is a learning framework that emphasizes the role of sociocultural and educational contexts in shaping student's motivation and engagement. This framework maintains what motivates students to learn (i.e., learning motive) and how they engage in learning (i.e., learning strategy). Learning motives and learning strategies combine into deep and surface approaches to learning (Liem 2016). According to Lee et al. (2008), students may hold deep motive (e.g., intrinsic interest) on learning science (e.g., "I feel that science topics can be highly interesting once I get into them"), they may use deep strategy (e.g., maximize meaning) to learning science (e.g., "I try to relate what I have learned in science subjects to what I learn in other subjects"), they also may hold surface motive (e.g., fear of failure) on learning science (e.g., "I want to do well in science subjects so I can please my family and the teacher"), and they may use surface strategy (e.g., rote learn) to learning science (e.g., "I see no point in learning science materials that are not likely to be on the examinations").

How the Constructs Are Related

Duarte (2007) contends that approaches to learning are not immune to the learning context. Zeegers (2001) suggests that students' approaches to learning are dependent on contextual factors such as teaching-learning activities, assessment procedures, and institutional values. In this regard, some research studies have investigated the relationship between the factors measuring students' approaches to learning (surface and deep approach) and their perceptions of the teaching-learning environment. Parpala et al. (2013) concluded that positive perceptions of the teaching-learning environment are positively related to deep approaches to learning and negatively related to the surface approach to learning. Baeten et al. (2016), in their research on relationships between student-centered learning environments and their approaches to learning, concluded that students adopting a deep approach preferred cooperative learning, while students adopting a surface approach preferred passive learning. Struyven et al. (2006) investigated the hypothesis that student-activating learning environments are expected to deepen the approach to learning and diminish the scores on surface approaches to learning. Surprisingly, they concluded that the direction of change was opposite to the premise that student-activating instruction deepens student learning. Dart et al. (1999) investigated the relationships between high school students' perceptions of the classroom learning environment and their approaches to learning. The results of this study showed that deep approaches to learning were significantly related to classroom learning environments. In a research on the relations between learning environment and approaches to learning, Yuen-Yee and Watkins (1994) concluded that secondary school students who perceived their classroom to be relatively competitive and as encouraging rote learning tend to adopt a deeper approach to learning.

Although there are several studies on the relationship between classroom learning environment and approaches to learning, the knowledge on the relations between family models and approaches to learning (surface and deep approach) is narrow, which is due to the limited number of studies that have explored these associations. For example, the U.S. Department of Education (2005) suggests that parents who view and talk about science can influence how their children approach learning science. Cano and Cardelle-Elawar (2008) also concluded that attitudes of parents and siblings towards science are associated with students' approaches to learning science. Moreover, the research of Roman et al. (2008) revealed that there is an association between family support and students' deep approach to learning. Although to our knowledge, no research study has addressed the relationship between peer models and approaches to learning science, the research of Owen et al. (2008) showed a positive association between motivating science class and peer models.

The Iranian Science Education Context

Science education is one of the 11 areas of learning in the national curriculum document of Iran (The Islamic Republic of Iran Ministry of Education 2012). In this document, science is defined as the human efforts for understanding the world and the realities of universe. It is considered as a testable knowledge that changes with new evidence and reasons which are necessary for students' scientific development. The Iranian national curriculum considers the improvement of scientific-technological literacy as the base of all science education activities. In this document, according to the Islamic educational foundations, a deep understanding of creation and discovering the secrets of the universe are considered as the other important bases of science education. Also, the family is considered as an important learning environment that should be in effective interaction with the school. It is also identified as the main partner of school for planning and implementing the curriculum (The Islamic Republic of Iran Ministry of Education 2012).

Iran has a 6-3-3 education system. Although most children start school before the age of six, compulsory schooling begins with a 6-year period of elementary education. Science education also begins at grade 1. Most of students enter a compulsory secondary education to continue their education. This period is divided into two parts of lower and upper secondary education (Kuusisto et al. 2016). The lower secondary school includes grades 7, 8, and 9. In this level of education, science education courses include subjects on empirical sciences such as life science, physical science, earth science and health (Mullis et al. 2016) which are taught in the form of inclusive science textbooks. In the 3-year period of upper secondary school that includes grades 10, 11, and 12, based on students' major, science subjects are taught in the form of separate courses such as physics, chemistry, biology, and geology with a different specialist teacher for each subject.

Science teacher education in Iran is comprised of pre-service and in-service training programs. The former includes two separate institutions for science teacher education: public universities and teacher training universities that provide professional programs for elementary and secondary science teachers (Jamshidi Avanaki and Sadeghi 2014). The pre-service training programs are followed by in-service training programs that promote science teachers' professional development especially when they become involved in a new science curriculum. These programs focus on developing science teachers' pedagogical content knowledge, content knowledge, and their teaching skills.

In the recent years, in line with the implementation of new Iranian national curriculum, the content of science textbooks has changed and become more practical and empirical. Also, Iranian science curriculum planners have tried to develop the textbooks with an interdisciplinary approach and to link them to the real life of students. Science is taught in classrooms that are common for all subjects but schools also have science laboratories where practical activities and experiments are carried out. In some cases, science teachers use science materials in science classrooms to facilitate learning and to make it more motivating. Teachers may employ information and communication technology (ICT) such as computers and smart boards in science teaching (Mullis et al. 2016). In general, teachers are encouraged to employ student-based methods in science classrooms and to foster questioning, inquiring, and participation in students (The Islamic Republic of Iran Ministry of Education 2012). The results of the TIMSS (Trends in International Mathematics and Science Study) studies show that in the recent years, Iranian students' average science performance has improved (Kiamanesh 2013), yet achieving a better performance in science education requires increasing the practical and empirical activities and getting away from traditional and teacher-based methods (Minaei 2013).

The Current Study

Previous research shows that no study has simultaneously examined the relationship between motivating science class, family models, peer models, deep approach, and surface approach in an integrated single study. Accordingly, the current study aimed to use structural equation modeling (SEM) to explore variables' relationship. Based on the discussed theoretical framework and research, the hypothesized paths between variables are formulated in a model (see

Fig. 1). The model hypothesizes that motivating science class predicts peer models, which in turn predicts deep approach and surface approach. The model also proposes that motivating science class and family models, as exogenous variables, directly predict the deep approach and surface approach. Accordingly, deep approach would be positively predicted by motivating science class, family models, and peer models. Additionally, according to the proposed model, surface approach would be negatively predicted by motivating science class, family models, and peer models. In addition to the direct effects, the model also shows mediated relations between variables. Accordingly, peer models would mediate the effects of motivating science class on deep approach and surface approach. According to Owen et al. (2008), since there is no justified causal relationship between motivating science class and family models as beginning points, these two latent variables are simply allowed to be correlated and are linked with curved, double-headed arrow in the final structural equation model.

Methodology

Participants and Procedures

Participants were 316 students from 20 eighth and ninth grade classrooms in two school districts in Kerman City in south east of Iran during the 2016–2017 school year. Ten rural secondary schools were selected randomly based on the information provided by the Education Department of Kerman City that comprised almost 2000 eighth and ninth grade students. After that, according to this provided information, a list of students in grade 8 and 9 who were enrolled in a compulsory science subject was identified from these selected schools, and the instruments were administered randomly to them. Participation was voluntary, and the students were told about the purposes of the research, length of participation, and that refusal to participate would not result in any consequences or any loss of benefits. Questionnaires were anonymous, and students were assured that their identities would remain confidential. From the total of 308 valid questionnaires that were finally collected (after eliminating eight incomplete questionnaires), 201 questionnaires were filled out by female respondents (65.3%) and 107 questionnaires were completed by male respondents (34.7%). Of these, 164 respondents (53.2%) were eighth graders and 114 respondents (46.8%) were ninth graders. They aged from 13 to 14 years old.

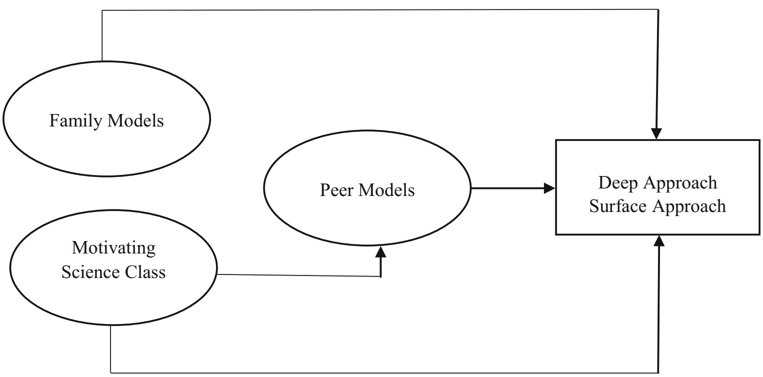

Fig. 1 The hypothesized model of structural relations between research variables

Instruments

The study required scales that captured science learning environment and approaches to learning science. Accordingly, motivating science class, family, and peer models were assessed using several subscales of a previously established measure, Simpson-Troost Attitude Questionnaire-Revised (STAQ-R) (Owen et al. 2008) which is related to science learning environment (two unrelated subscales named "self-directed effort" and "science is fun for me" were excluded). To measure the approaches to learning science, the Approaches to Learning Science (ALS) questionnaire (Lee et al. 2008) was applied. Lee et al. (2008) developed ALS to investigate Taiwanese high school students' approaches to learning science (including deep and surface approaches). Finally, by combining these two scales into a single measure, the current study's questionnaire consisted of five subscales including "motivating science class," "family models," "peer models," "deep approach," and "surface approach" that included from 4 to 14 (a total of 38) items and was presented in a Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire was translated to Persian before administration to the participants. The translation verification procedure included two stages of translation and back-translation of questionnaire items by two independent translators. At the first stage, the English questionnaire was translated to Persian. At the second stage, the Persian version of the questionnaire was retranslated back to English. Analysis of the back-translation showed that the essential meaning of the items had not changed. This procedure verified that the meanings of items of the English questionnaire were retained in the Persian version. A copy of the English questionnaire appears in Appendix 1.

According to Owen et al. (2008), the classic coefficient of Cronbach's alpha for each subscales ranged from .70 (for "family models" and "peer models") to .79 (for "motivating science class"). Owen et al. (2008) also reported construct validity (H) for each subscale ranging from .71 (for "family models" and "peer models") to .79 (for "motivating science class"). The overall alpha for ALS was also reported .89, according to Lee et al. (2008).

Data Analysis

In this study, to investigate the influence of motivating science class, family, and peer models on student's approaches to learning science, both a measurement model and a structural model were used. The measurement model provides information on construct validity based on the links between observed and latent variables. In the first step, a confirmatory factor analysis (CFA) was used to test and to confirm fit of measurement model using LISREL 8.8 software (Jöreskog and Sörbom 2006). Also, by using data from the measurement model, other indices of reliability such as the composite reliability (CR) and the average variance extracted (AVE) were calculated (Hair et al. 2006). In the second step, structural equation modeling was performed to examine the relationships between the motivating science classroom, family, and peer models and student's approaches to learning science. In fact, in this step, the hypothesized model was tested to check if it would fit the data.

In both steps of the measurement model and structural model, the goodness-of-fit was assessed with the following indices: the indices of χ^2, χ^2/df (recommended value of the fit < 5), Root Mean of Square Error of Approximation (RMSEA) (cutoff value of the fit < .08), Comparative Fit Index (CFI) (adequate value > .90) (Hu and Bentler 2009), and the Non-Normed Fit Index (NNFI) (adequate value > .90) (Bentler and Bonett 1980).

Result of Research

Preliminary Analysis

Table 1 shows the bivariate correlations between variables and descriptive statistics. As evident from Table 1, there were significant correlations between motivating science class, family models, peer models, and deep approach. The family models were significantly correlated with peer models and deep approach. There was also a significant correlation between peer models and deep approach. The bivariate correlations in Table 1 also suggest that the surface approach was significantly correlated with the deep approach (negatively).

Table 1 also shows the mean scores and the standard deviations of the variables. Accordingly, students attained the highest scores on the motivating science class ($M = 4.17$), and their scores on the surface approach (an average of 3.34 per item) were relatively lower than those on other variables. Also, the students' mean scores of family models, peer models, and deep approach were 3.70, 3.96, and 4.00, respectively.

Table 1 also presents skewness and kurtosis of each variable. Accordingly, all of the variables are approximately normal and kurtosis indices confirm the univariate normality assumption. Also, as correlations between independent variables were lower than 0.6, the possibility of multicollinearity between the variables was excluded (Grewal et al. 2004).

Also, the autocorrelation among the items within the variables was explored using Durbin-Watson' test (DW). The results revealed that all values were in the acceptable range (1.5 to 2.5), which indicates that autocorrelation among the items within the variables is not likely to be present (Tabachnick and Fidell 2000).

A MANOVA test was performed to investigate the differences between the two groups of eighth and ninth graders in the measured variables. The findings showed that the mean differences by grade were not statistically significant (Wilks' $\Lambda = .946$; F (5, 302) = 2.031; $P = 061$; $\eta^2 = .054$).

CFA Analysis

A confirmatory factor analysis using the LISREL 8.8 software was performed to evaluate the 5-factor model. By using a loading criterion of .30 as cutoff value of factor score item, all loadings for data were found to be upper than this boundary point except for items DA3 ("I work hard at studying science because I find the material interesting"), DA13 ("I try to

Table 1 Correlation matrix, means, standard deviations, skewness, and kurtosis ($n = 308$)

Variable	1	2	3	4	5
1. Motivating science class	–				
2. Family models	.33**	–			
3. Peer models	.38**	.31**	–		
4. Deep approach	.55**	.54**	.36**	–	
5. Surface approach	− .03	− .09	− .01	− .15*	–
Mean	4.17	3.70	3.96	4.00	3.34
SD	.60	.85	.79	.65	.79
Skewness	− .77	− .59	− .91	− .49	− .15
Kurtosis	.46	.32	.29	.19	− .70

$^*P < 0.05$; $^{**}P < 0.01$

understand the meaning of the contents I have read in science textbooks"), SA4 ("I want to get a good achievement in science subject so that I can get a better job in the future"), and SA7 ("As long as I feel I am doing well enough to pass the examination, I devote as little time as I can to studying science subjects. There are many more interesting things to do with my time") which were eliminated from the study. After analyzing the refined set of items using LISREL, the standardized factor loadings ranged from .30 (PM3) to .87 (SA5) all being statistically significant ($P < .001$) (see Table 2). The CFA model included five latent variables and 34 items, and all of the constructs fitted the data well ($\chi^2 = 1106.26$, df = 517, $\chi^2/\text{df} = 2.13$, RMSEA = .06, CFI = .94, NNFI = .94, $P < .001$).

As shown in Table 2, the reliability coefficient and composite reliability values were higher than the cutoff point of .70. Also, according to Table 2, all of the AVE values were .5 or higher that were adequate (Fornell and Larcker 1981).

Table 2 Reliability coefficients of the latent variables and standardized factor loadings of the items ($n = 308$)

Variable	Item	Factor loading	t	R^2	Cronbach's alpha	Composite reliability	AVE
Motivating science class	MSC1	.48	8.28	.23	.75	.77	.61
	MSC2	.40	6.75	.16			
	MSC3	.74	13.88	.54			
	MSC4	.65	11.92	.43			
	MSC5	.78	15.05	.61			
	MSC6	.53	9.12	.28			
Family models	FM1	.60	10.27	.36	.73	.74	.65
	FM2	.66	11.67	.44			
	FM3	.77	14.03	.60			
	FM4	.55	9.30	.30			
Peer models	PM1	.50	8.67	.25	.75	.76	.69
	PM2	.84	16.24	.71			
	PM3	.87	16.75	.75			
	PM4	.44	7.54	.19			
Deep approach	DA1	.68	13.06	.46	.84	.87	.61
	DA2	.53	9.63	.28			
	DA4	.73	14.39	.53			
	DA5	.70	13.60	.49			
	DA6	.58	10.67	.34			
	DA7	.64	12.04	.41			
	DA8	.32	5.46	.10			
	DA9	.63	11.90	.40			
	DA10	.60	11.02	.35			
	DA11	.69	13.23	.47			
	DA12	.74	14.76	.55			
	DA14	.34	5.82	.11			
Surface approach	SA1	.71	13.14	.51	.77	.76	.55
	SA2	.81	15.53	.65			
	SA3	.70	12.93	.49			
	SA5	.30	4.85	.08			
	SA6	.45	7.59	.20			
	SA8	.40	6.62	.16			
	SA9	.43	7.20	.18			
	SA10	.45	7.60	.20			

$P < .001$

Full SEM Analysis

In order to test the hypothesized conceptual model shown in Fig. 1, a structural equation modeling with ML-method was used. The model revealed fit indices indicating an acceptable goodness-of-fit to the data ($\chi^2 = 1118.15$, df = 518, χ^2/df = 2.15, RMSEA = .061, CFI = .94, NNFI = .94, $P < .001$). Figure 2 and Table 3 present the results including direct and indirect structural paths and the coefficients of the full SEM analysis. Accordingly, Fig. 2 shows the completed standard coefficient (regression weights). The statistically significant relations are shown by solid lines, and dashed lines represent non-significant paths. According to Fig. 2 and Table 3, motivating science class was observed to have significant direct effects on peer models ($\beta = .41$, $t = 6.01$, $P < .01$), and deep approach ($\beta = .50$, $t = 7.21$, $P < .01$). Furthermore, family models were found to have a direct effect on deep approach ($\beta = .44$, $t = 6.92$, $P < .01$) and surface approach (negatively) ($\beta = -.21$, $t = -2.52$, $P < .05$).

The findings of the SEM analysis showed that motivating science class appeared to be positively associated with peer models and deep approach. It means that a 1-unit standard

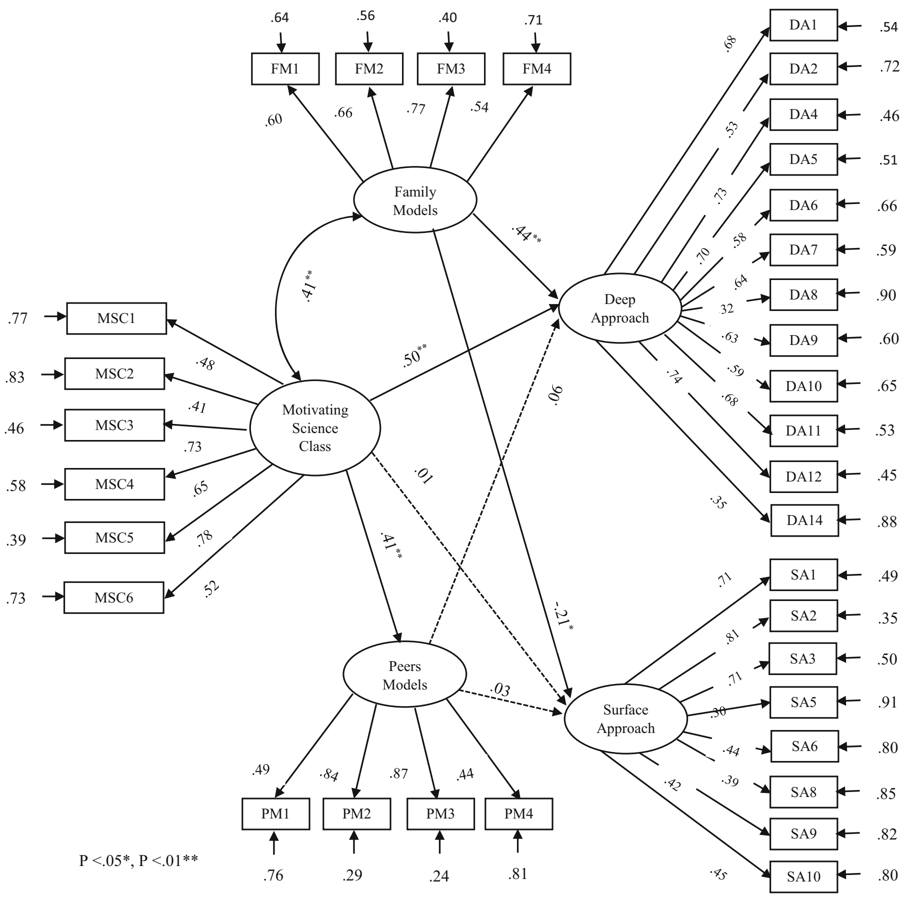

Fig. 2 The final structural equation model (SEM) between classroom environment, family models, peer models, and approaches to learning science ($\chi^2 = 1118.15$, df = 518, χ^2 /df = 2.15, RMSEA = .061, $P = .001$). Dashed structural paths were not statistically significant ($P > .05$)

deviation increase in motivating science class will increase .41-unit standard deviation in peer models and .50-unit standard deviation in deep approach. Moreover, the results also revealed that family models positively predict deep approach. In fact, a 1-unit standard deviation increase in family models will increase .44-standard deviation in deep approach. On the other hand, family models negatively predicted surface approach. According to this finding, a 1-unit standard deviation increase in family models will decrease .21-unit standard deviation in surface approach. According to the results of SEM analysis, none of the indirect effects are statistically significant.

Discussion

As a new contribution to the area of science learning, based on the social cognitive theory of learning (Bandura 1986) and educational productivity model (Walberg 1984), this research investigated how motivating science class, family models, and peer models could affect and predict students' approaches to learning science. Accordingly, drawing upon Owen et al. (2008) and Lee et al. (2008), this study places a specific focus on the joint influences of environmental variables on lower secondary students' approaches to learning science. The students responded to a questionnaire about their attitudes towards science class, their families and peers' attitudes towards science (family models and peer models), and their approaches to learning science. CFA ensured the construct validity of the questionnaire.

This study examined a hypothesized model of structural relations between research variables. The structural relationships between the variables were explored by adopting a SEM approach (Kline 2011). The goodness-of-fit for the hypothesized model was adequate. Some of the findings from this study support the results of previous studies on the relationship between environmental variables and approaches to learning science (Baeten et al. 2010, 2016; Cano and Cardelle-Elawar 2008; Owen et al. 2008; Parpala et al. 2010, 2013; Roman et al. 2008; Smith and Mathias 2010) and provide following contributions to the literature on research in science teaching and learning in the secondary setting.

According to the fitted model, the major finding of this study was that motivating science class and family models have moderate associations with students' deep approach to learning science. That is, students' deep approach to learning science was affected by their perceptions that science class is motivating and by their families' role in affecting their attitudes and beliefs towards science. Accordingly, science class as the most important environmental variable has the strongest impact on students' deep approach. In addition, family models have a modest negative association with students' surface approach. This implies that the students whose parents and siblings, as models, have more positive attitudes towards science, adopt less surface approaches to learning science.

Table 3 Significant direct effects on peer models, deep approach, and surface approach

Direct effects	β	t values	SE
Motivating science class → peer models	.41	6.01**	.07
Motivating science class → deep approach	.50	7.21**	.07
Family models → deep approach	.44	6.92**	.07
Family models → surface approach	− .21	− 2.52*	.08

$P < .05$*; $P < .01$**

In contrast with the family models, the results did not show a significant association between peer models and students' deep and surface approaches to learning science. According to this finding, peer models were not a powerful predictor of students' approaches to learning science.

Moreover, the present study also revealed that motivating science class has a moderate association with peer models. Hence, a greater motivating science class can affect peers to influence student's perceptions about science (Owen et al. 2008). Although the impact of science teacher is crucial to increase students' emotional excitement that can change their attitudes towards science (Bandura 1986), the present study concluded that science classroom variables, such as the role of science teacher, are also predictor of attitudes towards science in peers. This result is congruent with Owen et al. (2008), who found that a motivating science class has moderate associations with peer models.

According to the results of the present study, students who considered science classroom as motivating, interesting, activating, attractive, and fun adopted a more deep approach to learning science. This finding is in line with the results of the similar research (Baeten et al. 2010, 2016; Parpala et al. 2010, 2013; Smith and Mathias 2010), which studied effects of classroom as one of the most important science learning environments on students' approaches to learning science. But this finding is opposite to the results of Struyven et al. (2006) and Gijbels et al. (2008) who found that students use more surface approaches in activating and motivating learning environments. Furthermore, the results did not show any significant association between motivating science class and surface approach to learning science. Accordingly, students who perceived science class as motivating and fun seemed not to use surface approach. Nevertheless, some other research on relationship between science class environment and students' approaches to learning science confirms that students' positive perception of learning environments is negatively related to applying a surface approach (Baeten et al. 2010, 2016; Parpala et al. 2010, 2013; Smith and Mathias 2010).

This study further concluded that families who have more positive attitudes towards science and are somewhat engaged in science may influence students to adopt deeper and less surface approaches to learning science. This finding is in line with the results of Roman et al. (2008) who argued that family support increases students' deep processing strategies of their learning approaches. This is also congruent with Cano and Cardelle-Elawar (2008) who found family's intellectual climate has a moderate association with students' deep learning strategy. In contrast with motivating science class, and consistent with Cano and Cardelle-Elawar (2008), the results of the present study show that students' tendency to adopt surface approach to science learning can be influenced by attitudes of parents and siblings towards science.

The results also suggest that motivating science class has a greater impact on deep approaches to learning science than factors related to the family and peers. This finding seems to be congruent with Owen et al. (2008), who concluded that a motivating and fun science class has a much greater influence on students affect and effort than on parents, siblings, and peers.

Implications of the Results

The findings of this study have implications for both research and practice in science teaching and learning and also for families. This study's results reveal the importance of motivating science classroom and family in students' approaches to learning science. Both of these variables may affect students to adopt a deeper approach to learning science. Interestingly, similar to the motivating science class, family models have moderate associations with students' deep approach. This result highlights the important role of family's attitudes towards science and their engagement with science in students' approaches to learning science. An implication of this result may be that in addition to the important role of schools and science teachers to make science and its teaching more interesting and engaging (Owen et al. 2008), parents and siblings should show positive attitudes towards science and be engaged with science at home. It is important to provide parents with programs to change their attitudes towards science and to encourage them to be more engaged with science, for example, by watching scientific programs on TV or collaborative participation in students' scientific and technological inquiry at home (Hall and Schaverien 2001; Ho 2010). In relation to the effect of learning environment variables on students' approaches to learning science, the findings of the present study show that family models may be more important than motivating science class, because it also negatively predicts students' surface approaches to learning science. Accordingly, encouraging families to be more engaged with science and to show more interest in science can influence students to adopt less surface approaches to learning science.

Also, it is important to encourage science teachers to make science classroom more motivating, since a more motivating science class could affect students to adopt deeper approach to learning science. Science teachers' classroom practices as a major factor affect students' perceptions of classroom learning environment, which in turn influence their goal orientations. Science teachers through providing the students with an interactive curriculum and instructional practices (Swarat et al. 2012) as well as with positive science learning experiences could promote students' interest and motivation (Vedder-Weiss and Fortus 2013). Research shows that motivating and demotivating behaviors of science teachers could change the students' motivational beliefs and perceptions (Gorham and Christophel 1992; Wang and Liou 2017). Accordingly, positive teacher behaviors lead to increasing students' motivation in learning science and vice versa. As the literature suggests, one of the ways to make science class more motivating is changing the nature and orientation of science learning activities to discovery/enquiry-oriented, open-ended, and collaborative learning activities (Hofstein and Kempa 1985; Saab et al. 2009; Schütte and Köller 2015). In this regard, some items with the greatest loading on the motivating science class subscale provide implications for science teachers to set up more motivating activities in science classrooms. These items are "I consider our science classroom attractive and comfortable," "We cover interesting topics in science class," and "We do a lot of fun activities in science class." According to these items, in order to create a more motivating science class, the focus of teachers should be on providing a more comfortable, attractive, and fun learning environment and providing more interesting topics in science teaching.

Further Research and Limitations

This study determined the structural relations between motivating science class, family models, peer models, and students' approaches to learning science. Nevertheless, examining the relations between predictor variables (motivating science class, family models, and peer models) and subscales of deep and surface approaches to learning science (deep motive, deep strategy, surface motive, and surface strategy) (Kember et al. 2004; Lee et al. 2008) is recommended and deserves further attention in future research.

In addition, exploring the relationship between antecedent variables and a third learning approach, labeled strategic or achieving approach to learning science (Tait and Entwistle 1996; Zhu et al. 2008), is also necessary to indicate other effects of predictor variables on students' approaches to learning science.

Moreover, the data reported here did not show that peer models predict students' approaches to learning science. However, this should be explored in other cultures and with different student populations to better demonstrate the role of peer models on students' approaches to learning science.

Furthermore, future research in this area is required to explore the effect of predictor variables on students' approaches to learning science through longitudinal approaches and experimental research designs that may yield additional insights into the structural relations between exogenous and endogenous variables of the present study. Future research could also focus on the effects of motivating science class, family, and peer models on motivational constructs in science learning and also academic achievement in school science.

Using only self-report data is the first limitation of this study. Although self-reported measures are closer to the individuals' reality (Roman et al. 2008), as recommended by Vedder-Weiss and Fortus (2013), triangulating students' report with teachers' and parents' reports is required to increase validity of the results. Also, since the present study is one of the first attempts to investigate the relations between some of the science learning environment constructs and students' approaches to learning science through a SEM model, science educators should view the results with caution.

Finally, findings of the present study came from an educational context of Iran. Therefore, science education researchers should be careful to generalize the findings of this investigation to other cultures and areas.

Appendix 1

Table 4 Questionnaire items on constructs of science learning environments and approaches to learning science

Item	
Motivating science class	
MSC1	We learn about important things in science class
MSC2	Our science classroom contains a lot of interesting equipment
MSC3	We cover interesting topics in science class
MSC4	We do a lot of fun activities in science class
MSC5	I consider our science classroom attractive and comfortable
MSC6	My science teacher makes good plans for us
Family models	
FM1	My family watches science programs on TV
FM2	My mother likes science
FM3	My father likes science
FM4	My brothers and sisters like science
Peer models	
PM1	My friends like science
PM2	My best friend likes science
PM3	My best friend in this class likes science
PM4	Most of my friends do well in science
Deep approach	
DA1	I find that at times studying science makes me feel really happy and satisfied
DA2	I feel that science topics can be highly interesting once I get into them
DA4	I always greatly look forward to go to science class
DA5	I spend a lot of my free time finding out more about interesting topics which were discussed in science class

Table 4 (continued)

Item	
DA6	I come to science class with questions in my mind that I want to be answered
DA7	I find that I continually go over my science class work in my mind even whenever I am not in science class
DA8	I like to work on science topics by myself so that I can form my own conclusions and feel satisfied
DA9	I try to relate what I have learned in science subjects to what I learn in other subjects
DA10	I like constructing theories to fit odd things together when I am learning science topics
DA11	I try to find the relationship between the contents of what I have learned in science subjects
DA12	I try to relate new material to what I already know about the topic when I am studying science
DA14	I can ask myself possibly to understand the subject matter I have learned in science class
Surface approach	
SA1	I am discouraged by a poor mark on science tests and worry about how I will do on the next text
SA2	Even when I have studied hard for a science text, I worry that I may not be able to do well on it
SA3	I worry that my performance in science class may not satisfy my teacher's expectations
SA5	I want to do well in science subjects so I can please my family and the teacher
SA6	I see no point in learning science materials that are not likely to be on the examinations
SA8	I generally will restrict my study to what is specially set as I think it is unnecessary to do anything extra in learning science topic
SA9	I find that studying each topic in depth is not helpful or necessary when I am learning science. There are too many examinations to pass and too many subjects to be learned
SA10	I find the best way to pass science examinations is to try to remember the answers to likely questions

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