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Predictive analysis of instruction in science to students' declining interest in science-An analysis of gifted students of sixth - and seventh-grade in Taiwan

Chia-Yen Hsieh
Yang Ming Elementary School

e-mail: banduna@gmail.com

Abstract - *Students' interest in science declines substantially in the transition from elementary to secondary education. Using students' ratings of their instruction on the topic of oxidation-reduction reaction, we examined if changes in instructional practices accounted for differences in situational interest in science imagination instruction and enduring individual interest in science imagination between elementary and secondary school classrooms. Multilevel regression analyses were conducted for a sample of 162 sixth - and 161 seventh-grade gifted classrooms. The use of student experiments, the elicitation of student explanations, and lack of clarity accounted to varying degrees for dis-parities in science interest between grade levels. The impact of instructional practices on individual interest was mediated by situational interest.*

Keywords – *science instruction, situational interest, individual interest, multilevel regression.*

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1. Introduction

It is proved with abundant evidence that a decline of students' academic interest in the transition from elementary to secondary education, which is particularly pro-found in the case of science education (e.g., Krapp & Prenzel, 2011; Osborne, Si-mon, & Collins, 2003). The reasons for this decline are manifold. For instance, a shift from mastery to performance orientation occurs in the course of formal educa-tion, which alienates especially low-achieving students from school (Vedder-Weiss & Fortus, 2013). Jocz, Zhai, & Tan (2014) suggested that self-efficacy and leisure-time science activities but gender, were significantly associated with an increased interest in school science. Mujtaba, & Reiss (2014) thought that the self-concept was an important factor for declining interest in science. Besides, self-regulation is the full mediates the relationship of interest to achievement (Lee, Lee, & Bong, 2014). Schiefele, & Schaffner (2015) found teachers' instructional efficiency plays an important role on students' motivation to science. Furthermore, Pamuk, Sungur, & Oztekin (2016) considered that teachers' self-efficacy and sophisticated epistemological beliefs were crucially linked to students' science achievement. Also, students' success experience and participation have an influence on their interest to science (Meghan, 2016).

Aside from the cross-sectional study mentioned above, longitudinal study also found some reasons for the impact on students' self-concept and interest to sci-ence, such as big-fish-little-pond effect (e.g., Chen, Lin, & Pan, 2016; Dai, & Rinn, 2008; Marsh, & Hau, 2003; Sung, Huang, Kuo, & Tseng, 2012). Moreover, many studies have shown that gender-based differences exist in students' interest to sci-ence, meaning that girls give up on science more easily than boys (e.g. Cai, Lou, Shi, Liu, & Yang, 2016; Miller, Eagly, & Linn, 2015; Nosek, Smyth, Lindner, Devos, Ayala, Bar-Anan, et al, 2009). Yu, Weng, & Chang (2018) conducted a meta-analysis on 72 editorials, theses, and dissertations in Taiwan and the result is supportive.

With the above mentioned, many studies discovered that the interest to science gets to a peak when the subjects are in pre-schools or elementary schools, and that there is rarely gender-based difference. However, the height of their interest to sci-ence drops after they get into secondary schools (or adolescence), and gender-based differences start to show. And the reasons about this had been discussed, such as self-efficacy, self-concept, self-adaption, teachers' instructional efficiency, students' participation, and experience of success, etc. Nonetheless, few researchers have paid attention to instruction to science, so the main goal of this study is to discuss about the influence that the instruction to science has on the interest to science.

Nonetheless, in the elementary education, a holistic approach is usually used, with teachers instructing a single classroom in all or almost all subjects. On the contrary, secondary education introduces a departmental organization of instruction, with teachers possibly feeling more responsible for their specific subject than for a certain group of students (Appleton, 2017; Bellaby, 2017; Eccles & Roeser, 2011). Also, Ko, Hallinger, & Walker (2015) have suggested that in the secondary educa-tion of Hong Kong, the variations in the sociocultural organization of subject de-partments could lead to different learning outcome of students.

Barrington & Hendricks (1998) focused on third-, seventh-, and eleventh grade gifted students' attitudes toward science and scientific knowledge. They found that there were significant differences between grades on attitudes toward teachers and science curriculums. The third grades express the most favorable attitude, the eleventh grades show a bit less, and the seventh grades clearly have the least good attitude. Although Barrington & Hendricks (1998) focused on gifted students, this study were consistent with those in research of general students. It suggests that gifted students' interest in science declines substantially in transition from elementary to secondary education like general students. Swiatek & Lupkowski-Shoplik (2000) found that attitudes toward several academic areas (such as science) be-come more negative with age in 2,089 gifted students through 3rd to 6th-grade.

Farenga & Joyce (1998) examined science-related attitudes and science course selection of young high-ability students. They found "Enjoyment of Science Les-sons", "Leisure Interest in Science", and "Career Interest in Science" are important factors when the gifted students choose science courses. Joyce & Farenga (1999) developed a regression model to predict number of physical science courses selected of 111 gifted students. They found "gender", "Test of Science Related Attitudes" subscale, "informal physical science related experience" and "interest in science", are predicted 42% of the variance related to number of physical science courses selected, which means interest in science is a very important factor influencing gifted students to choose to study science courses.

There are many researches proving that instruction in science can influence the interest of gifted students in science (e.g. Estes & Dettloff, 2008; Nam, Lee, & Lee, 2004; Trna, 2014). Phillips & Lindsay (2006) investigated the factors which had influenced the role of motivation in science in high levels of achievement of a sample of fifteen gifted students. The results confirmed the influences of teaching and learning provision (such as science curriculums for gifted students), of support and of social and emotional factors on the students' motivation in science.

From the above, it is concluded that gifted students' interest in science declines substantially in transition from elementary to secondary education like general stu-dents, and that instruction in science can influence the interest of gifted students in science. Hence, researchers should focus more on the prediction of science instruction to science interest of gifted students.

About forty years ago, recovering from the impact of World War II, many Asian countries, including Taiwan, had started to develop national movements of science. Human power of light and heavy industry was highly needed in Taiwan, but almost all the technology was imported from abroad. Local skilled human resource was insufficient. Taiwan had no choice but to improve its human resource in science and technology. Therefore, Taiwan started to establish gifted education in 1979. On top of that, Taiwan started science gifted education in 2009, establishing a science class in senior high school as the crib of science elite education. Until 2018, many hearings about the science lessons in the 12-year basic education curricula have been held, in order to nourish science talents from all fields. Therefore, we can find the government of Taiwan more and more attention the gifted education in science.

Although this study focused on the prediction of science instruction to science interest of gifted student, it is particularly difficult to control teaching approaches. In that the curricula is elementary education and secondary education are different, so it is impossible to control how the teachers would teach. Besides, there are other confounding variables, such as age, environment, and the classroom atmosphere. Nevertheless, a science teaching approach is a crucial variable. It is proven in many studies that a science teaching approach can be controlled by teachers or other educational practitioners to improve the outcome of science learning (Jack & Lin, 2014; Turner, Christensen, Kackar-Cam, Trucano, & Fulmer, 2014).

Last but not the least, another confounding variable is that I can't guarantee that the gifted students from the elementary school will continue to study in a gifted classroom of junior high school. Thus, in order to switch the confounding variable "classroom type" to a control variable, the researcher divided the subjects into the gifted junior high school students from gifted elementary classrooms and non- gifted junior high school students from gifted elementary classrooms.

The Formation of Science Interest

Researchers in the field of interest commonly divided interests into situational and individual or personal interest (e.g., Anni, Kalle, & Jari, 2016; Krapp, 2002; Renninger & Hidi, 2011; Schiefele, 2009). Hidi (2000) put forward situa-tional interest is a temporary psychological state characterized by positive emo-tions, heightened attention, improved cognitive function, and perseverance. Also, Csikszentmihalyi (1975) thought that heightened situational interest could be seen as a "flow" state between oneself and activities.

Hidi and Renninger (2006) suggested that situational interest has a positive cor-relation to student's academic performance. Shen, Chen & Guan (2007) found that those students who have heightened situational interests make more efforts on their study. Besides, it is vital to situational interests whether or not the students have an aim for their lives. On the other hand, Ryan & Deci (2009) discovered that a situational interest might be related to an inner motivation. Genrally, in some specific field, the building of inner motivation had an enormous conceptual overlap with individual interest to this field (Gottfried, Fleming, & Gottfried, 2001).

Renninger, Ewen, & Lasher (2002) thought that individual interest can be con-strued as a stable disposition to occupy oneself with a specific topic or object of interest. Palmer, Dixon, & Archer (2016) believed that individual interest is a rela-tively long-term preference for a particular subject or activity. Moreover, Hidi & Renninger (2006) claimed that individual interest can boost students' concentration, cognition, memory, motivation, and level of study, etc. Shen, Chen & Guan (2007) also thought that individual interest could effectively enhance students' skills of acquiring knowledge.

Krapp (2002) claimed that the functioning process of situational and individual interest can be seen as the following three phases: (a) teachers arouse students situational interests with external activities, (b) teachers continuously maintain situational interests during acquisition, (c) students develop long-term individual inter-ests. Furthermore, Hidi, & Renninger (2006) suggested a four-phase model of deepening learners' academic interest, which is (a) triggered situational interest, (b) maintained situational interest, (c) less-developed (or emerging) individual interest, and (d) well-developed individual interest. Therefore, from the above two studies, we know that academic interest plays an important role in student's academic performance.

To sum up, situational interest can be temporary or continuous, while individual interest can be a long-term preference. However, situational interest might be relatively unstable to individual interest. According to Csikszentmihalyi's point of view, students might find some subject very interesting due to their experience of "flow" from solving problems or higher-order thinking, but lose interest in this sub-ject the next time when "flow" doesn't continue. Thus, many researchers (e.g., Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Krapp, 2002; Renninger & Hidi, 2011; Schiefele, 2001) thought that individual interest and situational interest are correlated but different concepts.

Due to that individual interests are more long-lasting, the students who have strong individual interests might have better chances to survive those boring science programs. However, situational interests are triggered by external factors, those which arouse students' positive affective reaction and more attention (Renninger & Bachrach, 2015). On the other way around, if one student has only sci-ence situational interest, it might take more time and steps to convert it into indivinterest. Based on this point of view, Ainley, Hidi, & Berndorff (2002) claimed that topic-specific interest is the precursor of domain-specific individual interest. Also, Bathgate & Schunn (2016) demonstrate that the intensity of science interest is separable from topic breadth by using surveys from a sample of 600 middle school students.

While it might be relatively easy to trigger interest by isolated stimuli, keeping students' interest for a period of time appears to be educationally more challenging and rewarding (Ainley, 2012; Krapp, 2002). Aside from setting the stage for successful learning process, the maintenance of situational interest can be regarded as an instructional goal in its own right. It is supported by Renninger & Hidi (2011) that the repeated experience of situational interest during learning process should allow some students to form an enduring individual interest in their academic field. And Rotgans & Schmidt (2017) also stated that repeated arousal of situational interest can lead to increase of individual interest.

Science Teaching and Students' Interest

The main stream of contemporary science teaching is to regard students as active constructors of conceptual understanding rather than passive memorizers of established scientific facts. Teachers are expected to be promoters and supporters of student concept development, rather than disseminators of factual knowledge (Duschl, Schweingruber, & Shouse, 2007). Kampourakis (2016) suggested that the conceptualization of "general aspects" is a pragmatic and effective means to intro-ducing students to nature of science.

In this study, successful science teaching includes the thorough consideration and proper handling of students' science conceptions (Duit & Treagust, 2012), supporting students' participation in scientific discourse and argumentation (Kloser, 2014), and engaging students in inquiry-focused science activities (Windschitl, Thompson, Braaten, & Stroupe 2012). It has been reported that embedding effective science instruction in the exploration of everyday contexts is particularly re-warding to enhance students' active involvement in science learning (Rivera Maulucci, Brown, Grey, & Sullivan, 2014; Wallin, Adawi, & Gold, 2017). In con-trast, prevalent teacher-centered science instruction appears to be the antithesis of effective science teaching, it is prone to leave students uninvolved and to remain unclear (Weiss, Banilower, McMahon, & Smith 2001). In the light of the similarity of the concepts of interest and intrinsic motivation, the fulfillment of the basic needs for competence, autonomy, and social relatedness appears as an essential prerequisite for experiencing episodes of situational interest and finally developing enduring individual interest in a given field (Krapp, 2005). Kiemer, Gröschner, Pehmer, & Seidel (2015) claimed that changes in students' situational motivation can predict changes in individual interest, and that greater the individual interest changes, the more their perceived autonomy, competence, and internal learning motivation would be. Accordingly, instructional practices which fulfill basic needs appear capable of fostering students' interest (Jack & Lin, 2014; Turner et al., 2014).

Considering the mentioned characteristics of contemporary conceptualizations of effective science teaching, the researchers identified three instructional practices as potentially effective for satisfying students' basic needs and, thus, fostering students' interest in science: a) the elicitation of student explanations, b) the use of student experiments, and c) the provision of clarity. On top of that, beyond the fulfillment of basic needs, meaningfulness and personal relevance have been identified as important precursors of situational interest (Jack & Lin, 2014). Therefore, the researchers listed reference to everyday contexts as a fourth instructional prac-tice potentially relevant for enhancing students' interest in science.

Students are known to bring numerous conceptions about natural phenomena to the science classroom (Duit & Treagust, 2012). For many topics, successful handling of these conceptions is essential for inducing the construction of advanced conceptual understanding (Orchard, & Winch, 2015). In particular, such successful handling requires teachers to elicit student conceptions and explanations in order to integrate them into the course of instruction, teachers have to be more open for students' views on the natural phenomena under consideration (Kloser, 2014). So the researchers agreed that the instructional practice of eliciting student explana-tions is suitable to support students' autonomy.

Moreover, students are likely to experience competence when they discover new insights on their own through carefully induced cognitive conflict or properly se-lected analogies (Jack & Lin, 2014; Kang, Scharmann, Kang, & Noh, 2010). Similarly, student experiments and firsthand activities provide students with the opportunity to experience autonomy and competence. Besides, due to their potential for collaborative learning, student experiments have the capacity to satisfy learners' need for social relatedness. Thus, it is conventionally expected that student experiments foster interest in science (Hofstein & Lunetta, 2004). Shernoff, Csikszent-mihalyi, Schneider, & Shernoff (2003) suggest that the increase of engagement, such as focusing on learning activities that support students' autonomy and provide an appropriate level of challenge for students' skills, could help students increase their interest and enjoyment.

However, for Taiwanese teachers, it is not easy to combine firsthand activities with curriculum goal in that firsthand activities are time-consuming. It happens to agree with Qualter and Harlen (2014) that combining firsthand activities with cur-riculum objectives is not a very simple matter. Therefore, the use of firsthand activity is one of the crucial science teaching methods.

In addition, the provision of clear instruction allows students to become cognitively engaged in learning situations (Mottet, Garza, Beebe, Houser, Jurrells, & Furler, 2008). Titsworth, Mazer, Goodboy, Bolkan, & Myers (2015) used two me-ta-analyses to find out the relationship between teacher's clarity and student's learning. The results suggested that teacher's clarity has some effects for student affective learning and cognitive learning. In other words, unclear instruction leads to a severe barrier to students' construction of understanding. Froiland & Worrell (2016) supported this assumption with the statement that clarity of goal has been shown to be associated with intrinsic learning motivation in practical learning situations, but not with long-term development of individual interest.

Lastly, in the domain of science, the combination of the learning materials and students' life experiences has some potential to foster students' interest in that con-tent (Jack & Lin, 2014). For instance, on a field trip, the experiential learning at formal and informal field trip venues would increase students' interest, knowledge and motivation. (Behrendt, & Franklin, 2014). Besides, the informing of parents about the importance of science for daily life and various careers also has been shown to indirectly increase adolescents' interest in school science (Harackiewicz, Rozek, Hulleman, & Hyde, 2012 ; Garriott, Flores, Prabhakar, Mazzotta, Liskov, & Shapiro, 2014). Accordingly, instructional approaches presenting science content in personal relevance and everyday contexts can be expected to increase learners' in-terest in science (Houseal, Abd-El-Khalick, & Destefano, 2014).

In sum, connecting with daily situations, providing clarity, elicitation of student explanations, and using student experiments to form a set of instructional practices that have spurred students' interest in science instruction.

Regarding to science instruction in Taiwan, it is more popular to use effective teaching strategies in elementary than in secondary education. Teachers give at least instructional practices referring to daily situations, eliciting student' explanation to some situation, and let students conduct experiments (Hsieh, 2016). There-fore, these practices are promising candidates for uncovering an impact of changing instruction on the decline of students' interest in science in the transition from elementary to secondary science education.

The Cultural and Institutional Context of the Present Study

In the past two decades, the cross-cultural validity of these motivational theories has been explored and studied (e.g., Caleon, Wui, Tan, Chiam, Soon, & King, 2015).Contemporary theories of motivation have been developed originally in the cultural context of western societies (Pintrich, 2003); this observation also applies to the person-object theory of interest and to the self-determination theory (Kiemer, Gröschner, Pehmer, & Seidel, 2015; Krapp, 2005). For instance, Hau & Ho (2010) thought that in Eastern Asian (China) cultures, academic achievement does not depend on students' interest. It is considered that Chinese students typically do not regard intelligence as fixable but trainable through learning, which en-ables them to take a persistent rather than helpless approach to schoolwork, and subsequently perform well. In

Taiwan, people have similar culture as China, and they believe that daily science study time could be a confounding variable in this study, so the researchers added the option of " How much time do you study science every day?" in the questionnaire. In Chinese culture, great academic achievements have been traditionally regarded as the passport to social success and reputation, and a way to enhance the family's social status (Hau & Ho, 2010). Both Chinese and Taiwanese students take a good academic achievement rather than subject interest as their main study goals. In other works, interest in science may not be the main reason for their scientific success.

Many studies about interest theory are designed with western literature, which ignores the potential cultural differences. Against this background, Ainley and Ainley (2011) found that knowledge, affection, and value combined in the structure of students' interest in science might vary in line with historical and cultural traditions. They found that the associations between science knowledge and interest in science would influence the interconnections between knowledge, affection, and value, which need to be understood in relation to students' broader historical and cultural context. Nevertheless, in a cross-cultural perspective of student characteristics, both Taiwan and China constitute examples of societies that combine relatively high science achievement with low interest in science. In international comparison, Taiwan's education system features an early transition from elementary to secondary education. Gifted students are asked to decide on the different class types of secondary education after sixth grade. Some gifted students choose to study in a gifted class, some choose a general class. In accordance with Hou (2010), due to the big-fish-little-pond effect, many students who choose to go to a gifted class experience a severe depression of their academic self-concepts after the transition from elementary school to the secondary education. So the researchers want to know if students who get high scores in science in elementary school can still get high scores when they go to secondary school.

Moreover, in Taiwan the transition from elementary to secondary education is accompanied by a reorganization of school subjects. In elementary education, science include natural knowledge, technology, chemistry, physic, and so on. In re-cent years, a new type of science teaching in Taiwan has been introduced, which is termed School-based curriculum. In this curriculum, each school puts different school subjects together to design its own science courses, science teaching is embedded alongside history, geography, and social sciences instruction.

Generally, elementary science program is relatively easy for students in that School-based curriculum usually lists a broad range of relevant contents and thematic priorities, and that the hard natural sciences occupy only a comparatively small portion of this range. In contrast, in Taiwan secondary education, the academic disciplines of biology, chemistry, and physics are represented in school sub-jects of their own. These subjects are taught by teachers with a subject-specific method, especially in the gifted classes. That is to say, in the transition from elementary to secondary education, Taiwanese students experience both a differentiation of school subjects and an intense subject reorganization.

In sum, all of the above studies indicate that students' declining science interest in middle school is not only attributed to psychological factors like shifts of motivational values, decrease of self-efficacy, and doubts about the utility of schooling in general, but also to students' different cultural backgrounds and the different curriculum designs between elementary and secondary education.

Research Questions

In order to elucidate the contribution of instructional practices to the decline of students' interest in science during the transition from elementary to secondary education, three specific research questions were raised for the present study:

- Research Question 1: Are actual instructional practices related to situational interest in science instruction, and do they account, at least partially, for disparities in situational interest between elementary and secondary education?
- Research Question 2: Are actual instructional practices associated with individual interest in science, and do they explain the disparities in individual interest between elementary and secondary education?
- Research Question 3: Do actual instructional practices have impacts on individual interest influenced by situational interest?

Specifically, with respect to the first and second research questions, the researchers wonder if the four following science teaching methods can effectively predict the difference of students' situational interest and individual interest in elementary and secondary education, which are a) the elicitation of student explanations, b) the use of student experiments, c) the provision of clarity, and d) reference to everyday context.

However, although the researchers hypothesized that the instructional practice of providing clarity would be relevant to situational interest, it was still uncertain if it would also be associated with individual interest. Additionally, as the person-object theory of interest predicts that repeated episodes of situational interest might eventually evoke an enduring individual interest in a specific field, the re-searchers assumed that instructional practices would be related more closely to situational interest than to individual interest. Thus, with respect to the third research question, the impact actual instructional practices have on individual interest is influenced by situational interest (discussion of mediation).

2. Method

Participants

The researchers compared 162 sixth graders (Elementary school students, 82 girls and 80 boys) from ten classrooms and 161 seventh graders (Secondary education students, 78 girls and 83 boys) from seven classrooms, and average class size in the sixth and seventh grade was 22.21 and 24.97 students, respectively. Among these participant classes of secondary schools, four classes with a total of 93 students were from the gifted classrooms. The other three classes with a total of 68 students were from the general classrooms. In Taiwan, 40% of sixth grade gifted students don't continue attending gifted classrooms when they move to the seventh grade, which is the proportion of investigation in this study. The sampling was cluster sampling. Initially, we had planned to recruit 15 classes from elementary schools, 15 classes from the secondary schools. The elementary schools secondary schools are in the same administrative area in Kaohsiung city in Taiwan. But at last there were only ten elementary schools and seven secondary schools on their voluntary participation. After a brief description of the purpose of the study, science teachers or heads of schools decided to participate.

In elementary schools, our investigations were embedded in the school sub-ject School-based curriculum, while in secondary schools, our examinations were embedded in only chemistry. Students' average age was 10.79 years in elementary schools and 12.01 years in secondary schools. Within the total 323 sample par-ents—a response rate of 71.45%—completed a questionnaire on family socioeco-nomic status.

Design

Participating teachers were instructed to provide their classes with a series of six 45-minute lessons on the topic of oxidation-reduction reaction. Moreover, the instructions specified that teachers were expected to address the factors that have the capacity to accelerate or decelerate processes of oxidation reaction like the temperature of the environment, the air, the temperature of the water, and so on. The instructions highlighted explicitly that the outlined thematic aspects represented minimum mandatory content to be covered, that the science achievement test for the students would address this mandatory content, and that teachers were free to cover additional relevant content in the series of three lessons. On average, a period of 10.12 days (SD = 5.79 days) passed between the first and final lesson. The first lesson was videotaped. For each lesson, teachers provided a title and a one-sentence description of learning goals in a short protocol. We did not observe systemic deficiencies in covering the obligatory thematic content across school types.

Students were tested for science achievement and reported on situational interest, individual interest, and their perception of science instruction both before and after the investigation. These pre-instructional assessments took place three days before the first lesson, and the post-instructional assessment five days after the final lesson. In addition, the questionnaire about the perception of instruction was also administered immediately after the videotaped lesson. All the assessments were completed in regular class time.

In order to properly account for nesting of students in classrooms, we took a multilevel approach to data analysis (Snijders & Bosker, 2012). Particularly, stu-dents' perceptions of science instruction were considered as predominantly reflec-tive constructs, that is, instruction occurring on the class level was assumed to cause students' ratings of instruction on the individual level. Thus, students' ag-gregate ratings were used as latent indicators of instructional practices on the class level, while students' individual deviations from aggregate ratings simultaneously were taken into consideration on the individual level. Teachers in elementary and secondary schools provided lessons on the same topic. Therefore, the design ex-plicitly entailed the possibility to disentangle effects of instructional practices from effects of specific topics taught.

The first set of multilevel analyses was devoted to the question if the impact of instructional practices on situational interest could account for disparities in situa-tional interest between elementary and secondary schools. For this purpose, a base-line model containing school types and other relevant predictors was constructed and compared to models including additional indicators of specific instructional practices. The change of the size and statistical significance of regression weights for school type resulting from the incorporation of instructional practices among the predictors of situational interest was considered as an evidence with respect to the aforementioned research question.

In a second set of analyses, this procedure was repeated with the more distal learning outcome of individual interest as the dependent variable. Students' ratings of science instruction on the third measurement occasion, that is, after the entire se-ries of lessons, were used as indicators of instructional practices. Apart from that, measures of pre-instructional individual interest and pre-instructional achievement were included as covariates in the analyses.

For the different measures, between 6.0% and 7.3% of the data was missing. Missing data was treated in a model-based approach, using full information maxi-mum likelihood estimation. All analyses were conducted with the software pack-age Mplus.

Measures

Employing the response categories not at all, a little, almost, and exactly, the items of all measures (with the achievement test as an exception) made use of a 4-point Likert scale. Scores ranging from 0 to 3 were assigned to these categories for sub-sequent statistical analyses. We had constructed the student questionnaire on per-ception of science instruction in order to capture aspects of science teaching poten-tially fostering students' engagement in science learning.

For all measures, Cronbach's alpha was used as an indicator of internal con-sistency on the individual level. Moreover, aggregated students' perceptions of sci-ence instruction were used latently as measures of actual instructional practices in participating classrooms.

Thus, for traditional measures, conventional intra-class correlations, ICC(1), the average number of students per class Spearman-Brown adjusted intra-class correla-tions, ICC(2) (Bliese, 2000), and the mean of the average absolute devia-tion ADM(J) (Burke, Finkelstein, & Dusig, 1999) were retrieved as criteria for in-strument quality on the class level. That is, to underscore feasibility of aggregated student ratings as indicators of instructional practices. The ICC(2) can be interpret-ed straightforwardly as a reliability coefficient, whereas the ADM(J) is a measure of interrater agreement for students in a given classroom, which represents stu-dents' average deviation from the respective class mean in terms of the metric of the original scale. It has been suggested that in case of four response categories values of .67 or below for the ADM(J) point toward substantial interrater agree-ment (Burke, Finkelstein, & Dusig, 1999).

Everyday Contexts

The student questionnaire on perception of science instruction contained six items assessing the extent to which content was connected to everyday situations during science lessons. In particular, items asked if content was applied to everyday situa-tions (e.g., "Our science teacher remind us time and again to explain what we know from everyday life.") and if students noticed connections of lesson content to everyday life (e.g., "I observed it in the experiment, I also discovered it in my daily life."). On the individual level, Cronbach's alpha equaled .88. Computation of the ICC(1) and of the ICC(2) yielded values of .21 and .79, respectively. Aver-age interrater agreement in terms of ADM(J) was .83.

Missing Clarity

Six negatively worded items in the student questionnaire were used to measure the perception of science instruction. This lack of clarity concerned both unclear teach-er communication (e.g., "Often our science teacher explains things with foreign or deep words, which we do not understand.") as well as a missing goal orientation in lesson structure (e.g., "In the science class, consider too many questions at the same time."). Cronbach's alpha on the individual level was .68. Calculation of the ICC(1) yielded .19. The ICC(2) equaled .86. Average interrater agreement in terms of ADM(J) amounted to .71.

Student Explanations

Six items were designed to uncover what role student-generated explanations played in science lessons. In particular, items were assessed if students had time and opportunity to offer explanations of their own (e.g., "Our science teacher al-ways gives us a lot of opportunities to try, and to find an explanation."), if teachers were supportive of incomplete explanations (e.g., "Our science teacher will listen carefully to our explanation, and be interested in our wrong explanations."), and if teachers prompted students to generate justifications for their assertions (e.g., "Our science teacher prompts us time and again to justify our hypotheses."). Individual-level Cronbach's alpha was .81. Calculation of the ICC(1) and of the ICC(2) yield-ed values of .21 and .83, respectively. Average interrater agreement in terms of ADM(J) equaled .70.

Student Experiments

Students rated the occurrence and cognitive quality of student experiments in their science lessons on a scale containing six items. Three of these items were con-cerned with the sheer amount of experiments (e.g., "We could do a lot of experi-ments in our science class."). The remaining four items included the use of experi-ments to elicit cognitive conflicts (e.g., "We could often observe something that surprised us in our science class.") as well as subjective evaluations of learning pro-gress due to experiments (e.g., "After conducting experiments in science class, I did understand the topic better."). Individual-level Cronbach's alpha was .88. The ICC(1) had a value of .22, whereas the ICC(2) amounted to .90. The value of ADM(J), that is, average interrater agreement, was .69.

Student Achievement Test

To assess students' gains in knowledge across the series of lessons, we made an achievement test covering the topic of oxidation-reduction reaction. We developed both items that addressed relevant factual knowledge and ones that probed for conceptual understanding of oxidation-reduction reaction. An pre-test of 65 items was pre-piloted in semi-structured interviews with small groups of students. Through the pre-test, the Cronbach's alpha is .93, and the test-retest reliability (5 days, n = 29) was.927. Eventually, 24 multiple-choice and multiple-select items with up to six response alternatives nested under a common item stem were select-ed for the final version of the achievement test used in the present study.

Among those items, 11 were about the knowledge of scientifically appropriate terminology and of conditions promoting oxidation reaction.To capture students' conceptual understanding, the other 13 items were asked about the recognition of correct explanations for specific phenomena of oxidation-reduction reaction with distractor response alternatives containing common student misconceptions.

Eventually, application of the scoring scheme resulted in 21 dichotomous and 12 multiple scored items; for the latter, maxima ranged from two to three raw points. Using Winsteps 3.75, we calibrated the achievement test according to the partial credit model. Students' pre- and post-instructional responses were scaled concur-rently. For model identification, the distribution of item difficulties was fixed at zero. Weighted likelihood estimates of person ability were used in subsequent sta-tistical analyses. Separation reliability of these estimates was .89.

Situational Interest in Science Instruction

The scale measuring students' interest in science instruction consisted of six items. Students were asked to think of the entire sequence of lessons on oxidation-reduction reaction before answering these items. Some of the items were feeling-related (e.g., "Science class was very funny.") and value-related aspects (e.g., "Sci-ence class was my favorite classes.") of situational interest as well as the experience of flow (e.g., “During science class I did not realize how time went by.”). The wording of items was inspired by a questionnaire by Kao (2012). Internal consisten-cy in terms of Cronbach’s alpha was .92 for the assessment of situational interest after instruction, and the test-retest reliability (5 days, n = 29) was.922.

Individual Interest in Science

Assessment of students’ individual interest in science was presented on six items. Students were instructed to consider topics other than oxidation-reduction reaction before answering these items, such as “acid-base reactions”. In resemblance of the scale for situational interest, items were concerned with feeling-related (e.g., “To occupy myself with these topics is a lot of fun.”) and value-related aspects (e.g., “I am eager to get to know more about this topics.”) of individual interest. Moreover, the experience of flow (e.g., “When I am occupied with these topics, I forget eve-rything around me.”) and behavioral indicators of interest (e.g., “At home I often read about these topics.”) were covered. The wording of items inspired by a ques-tionnaire by Kao (2012). Measurement of individual interest prior to instruction yielded a Cronbach’s alpha of .85. Cronbach’s alpha for the measurement of indi-vidual interest after instruction was .89.

For the credibility of the final mediation analyses, it was of crucial importance that our scales for students’ situational and individual interest were actually meas-ured out with discernible constructs. Thus, to probe the discriminant validity of the scales, we submitted students’ post-instructional reports of situational and individ-ual interest to confirmatory factor analyses. The analyses treated manifest items as categorical indicators of latent constructs and took the clustering of students’ re-sponses into consideration. First, researchers tested a two-factor model featuring a freely estimated correlation between the latent constructs of situational and indi-vidual interest. According to common conventions (Browne & Cudeck, 1993; Hu & Benteler, 1999), this model displayed good fit to the data, $\chi2(43) = 434.19$, $p < .001$, AGFI=.911, RMSEA=.050, SRMR=.0311, NNFI=.976, CFI=.978. The model returned a statistically significant latent correlation between situational and individual interest, $r = .79$, $p < .001$. Likewise, the corresponding correlation of students’ manifestly aggregated responses was statistically signifi-cant, $r=.68$, $p<.001$. Second, researchers explored a two-factor model restricting the latent correlation between situational and individual interest to equal one; that is, the model assumed that the two scales for students’ situational and individual interest were assessed as the same construct. This model exhibited poor fit to the data, $\chi2(43) = 2,232.95$, $p < .001$, AGFI=.900, RMSEA=.185, SRMR=.136, NNFI=.898, CFI=.906. So, unsurprisingly, corrected for weighted least square es-timation, difference testing revealed that the unrestricted model possessed relative-ly better fit than the restricted model, $\chi2(1) = 339.55$, $p < .001$. Apparently, the scales for situational and individual interest measured related yet distinct constructs.

3. Results

Descriptive Results

To obtain a first impression of the data, we calculated descriptive statistics for raw scores for the respective level of primary concern. On the individual level, elementary school students, that is, sixth graders, and secondary school students, that is, seventh graders, clearly diverged with respect to the interest measures employed. Students from all school types reported greater situational interest in science instruction than enduring individual interest in science. Moreover, students from the gifted classroom tended to show lower situational and individual interest than students from the general classroom. Additionally, individual interest apparently decreased slightly in the course of instruction on oxidation-reduction reaction. Last but not least, a conventional gender difference, with boys being more interested in science and science instruction than girls, was presented in the school types of secondary education only (see Table 1).

In case of the aggregated student ratings of instructional practices on the class level—that is, in case of the indicators of actual instructional practices—notable discrepancies between school types became apparent as well. In general, these discrepancies favored elementary school classrooms. The largest differences, outpacing the corresponding pooled standard deviations, were observed for the instructional practice of student experiments. On the contrary, the smallest differences were detected for the connection of lesson content to everyday contexts. Disparities in missing clarity and in the incorporation of student explanations fell in between. (see Table 2). Brief inspection of the inter-correlations between aggregated ratings of instructional practices revealed that the use of student experiments and the elicitation of student explanations were strongly related to each other, whereas the utilization of everyday contexts and missing clarity were moderately associated to the other features of instruction. Of course, missing clarity was related negatively to the other three instructional practices (see Table 3).

Table 1. Students' Mean Interest and Achievement Scores by School Type and Gender

	Individual Interest (Pre)		Science Achievement (Pre)		Situation Interest (Post)		Individual Interest (Post)	
School type	M	SD	M	SD	M	SD	M	SD
Elementary school[a]	1.74	0.74	056	0.52	2.15	0.85	1.61	0.88
Boys	1.76	0.75	0.61	0.52	2.08	0.87	1.58	0.92
Girls	1.71	0.76	0.50	0.50	2.21	0.78	1.65	0.83
Secondary school[b]								
Gifted classroom	1.26	0.78	0.96	0.64	1.49	0.86	1.05	0.86
Boys	1.46	0.77	1.06	0.68	1.62	0.89	1.26	0.92
Girls	1.08	0.76	0.86	0.55	1.37	0.80	0.86	0.4
General classroom	1.29	0.80	0.37	0.52	1.73	0.88	1.22	0.90
Boys	1.37	0.80	0.41	0.53	1.80	0.86	1.33	0.90
Girls	1.17	0.79	0.33	0.53	1.63	0.89	1.06	0.88

a Sixth- grade classrooms
b Seventh- grade classrooms

Table 2. Mean Class-Level Aggregated Ratings of Instructional Practices and Mean Class-Level Aggregated Science Achievement by School Type

	Everyday Contexts (Post)		Missing Clarity(Post)		Student Explanations (Post)		Student Experiments (Post)		Science Achievement (Post)	
School type	M	SD	M	SD	M	SD	M	SD	M	SD
Elementa ry school[a]	1.78	0.36	0.85	0.34	2.37	0.24	2.37	0.28	0.58	0.22
Secondar y school[b]										
Gifted classroom	1.70	0.39	0.98	0.33	2.17	0.38	1.81	0.44	0.36	0.22
General classroom	1.64	0.29	1.13	0.28	2.10	0.30	1.98	0.32	0.97	0.31

a Sixth- grade classrooms
b Seventh- grade classrooms

Table 3. Class-Level Inter-correlations of Ratings of Instructional Practices

Practice	1	2	3	4
1.Everyday Contexts	—	-.39	.71	.61
2. Missing Clarity	-.45	—	-.74	-.57
3.Student Explanations	.78	-.81	—	.82
4.Student Experiments	.63	-.61	.83	—

Note. Values above the diagonal represent correlations between manifest class means; values below the diagonal represent correlations between latent class means

In summary, the descriptive results disclosed advantages in favor of elementary school classrooms, with respect to both students' interest and students' ratings of instruction, making it plausible that a contribution of differing instructional practices to discrepancies in interest in the transition from elementary to secondary education. Furthermore, with respect to students' interest, in face of a general superiority of elementary school students' interest, students from the elementary school reported higher post-instructional situational and individual interest than students from the secondary school. As disparities in interest between boys and girls were apparent predominately in seventh grade, additionally there was a hint at an interaction between genders and grades.

Multilevel Models for Situational Interest

For the investigation of students' situational interest in science instruction as the dependent variable, we first set up a baseline model containing relevant predictors beyond students' ratings of instructional practices of science instruction. On the individual level, this baseline model included pre-instructional science achievement in that we assumed that relevant prior knowledge potentially fosters the formation of situational interest during science lessons (Alexander, Jetton, & Kulikowich, 1995). Moreover, we incorporated pre-instructional individual interest in science as an individual-level predictor in order to control possible contributions of the actualization of individual interest to the generation of situational interest. This focused our examination on the learning sequence on oxidation-reduction reaction. In addition to the obligatory random intercept, a random slope for gender allowing the effect of gender to vary between classrooms was included in the baseline model and regressed on school type. In other words, we introduced a cross-level interaction for gender to simulate a plausibly age-dependent effect of gender. In this model formulation, the mean of the random slope for gender represented the average effect of gender on situational interest.

The manifest class mean in pre-instructional achievement was incorporated as a covariate on the class level in order to account for a possible big-fish-little-pond effect on situational interest (Trautwein, Lüdtke, Marsh, Köller, & Baumert, 2006). Accordingly, composition in terms of achievement was treated as a formative construct, that is, the aggregation of individual students' achievement was construed to generate the qualitatively different feature of achievement composition on the class level (see Lüdtke, Marsh, Robitzsch, Trautwein, Asparouhov, & Muthén, 2008). Finally, the baseline model included school type as a dummy-coded predictor on the class level, with elementary school as the reference category. Continuous measures were Fisher z-standardized prior to multilevel analyses. This resulted in grand-mean centering of continuous measures on a standardized scale. Gender was entered as a dummy-coded variable into the analyses (0 = girls, 1 = boys). Moreover, as an analogue to explained variance in standard ordinary least squares regression, we calculated the modeled proportion of variance for each level of the estimated multilevel models according to the approach proposed by Snijders and Bosker (1994, 2012). Specifically, modeled variance on the individual level was defined as the proportional reduction in mean square prediction error for predicting individual values relative to the corresponding empty model, and modeled variance on the class level was defined as the proportional reduction in mean square prediction error for predicting group averages relative to the corresponding empty model.

The intraclass correlation for situational interest in the baseline model was .23, which means, around one-fifth of the variance in students' reports on situational interest could be attributed to differences between classrooms. After estimating the baseline model, we gradually added instructional practices seriatim, forming a distinctive model for each instructional practice (see Table 4). Specifically, ratings of instructional practices were aggregated latently on the class level and used as indicators of actual instruction. Meanwhile, the deviations of given ratings from the respective class means were incorporated as predictors on the individual level and construed as indicators of the subjective portion in individual students' perceptions of instruction (see Lüdtke et al., 2008).

Apart from achievement composition, all predictors of the baseline model significantly affected situational interest. In particular, school type exerted a large influence on situational interest; both students from the gifted classroom of secondary education, $B = -.68$, $SE = .11$, $p < .001$, and from the general classroom of secondary education, B = −.46, SE = .12, p < .001, displayed significantly lower situational interest in science instruction than elementary school students. As elementary school constituted the reference category for school type, the mean of the random slope for gender, B = −.20, SE = .08, p < .01, indicated that in elementary school, boys were reported less post-instructional situational interest than girls. Moreover, there were considerable cross-level interactions between gender and school type, for gender×gifted classroom, B = .34, SE = .11, p < .01, and for gender×general classroom, B = .30, SE = .11, p < .01, highlighting that the net effect of gender reversed in secondary school classrooms; in secondary education, boys showed higher situational interest than girls. However, the random slope for gender was not related to any of the instructional practices. For sake of brevity, the corresponding analyses are not presented here. Rather, the role of the random slope was confined to controlling the age-dependent effect of gender.

Extending the baseline model, aggregated ratings of the prevalence of everyday contexts in science instruction substantially influenced situational interest, B = .59, SE = .12, p < .001. However, compared to the baseline model, the effects of school type were almost unaffected, both in gifted classroom, B = −.65, SE = .10, p < .001, and in general classroom, B = −.43, SE = .11, p < .001. In contrast, the inclusion of the instructional feature of missing clarity as a school type covariate, B = −.55, SE = .10, p < .001, entailed a considerable change of the effect on gifted classroom, B = −.47, SE = .10, p < .001, and of the effect on general classroom, B = −.33, SE = .11, p < .01. On the class level, the instructional practice of eliciting student explanations exhibited a substantial effect on situational interest, B = .56, SE = .10, p < .001, and, relative to the baseline model, reduced the effects on gifted classroom, B = −.50, SE = .11, p < .001, and general classroom, B = −.29, SE= .11, p < .01. Similarly, the aggregated ratings of the use of student experiments had a great impact on situational interest, B = .64, SE = .09, p < .001, representing the effects of school type impressively smaller than in the baseline model, on gifted classroom, B = −.21, SE = .10, p = .04 and for general classroom, B = −.20, SE = .11, p = .07.

On the individual level of the analyses, the obtained effects of the subjective portions of perceptions of instructional practices on situational interest resembled mainly the pattern of results found on the class level although regression coefficients were consistently smaller. In essence, the outlined sequence of multilevel analyses demonstrated that the inclusion of aggregated ratings for the use of student experiments, the elicitation of student explanations, and missing clarity—the latter for gifted classroom exclusively—diminished the importance of school type as a predictor of situational interest. Disparities in instructional practices elucidated differences in situational interest between school types.

Multilevel Models for Individual Interest

We estimated the sequence of models outlined previously for individual interest as the dependent variable as well (see Table 5). With respect to the effects of the aggregated ratings of instructional practices, the results resembled those obtained for situational interest as the dependent variable. In particular, the baseline model contained a considerable impact of school type; students' individual interest both in gifted classroom, B = −.47, SE = .10, p < .001, and in general classroom, B = −.36, SE = .10, p < .001, fell statistically significantly below students' individual interest in elementary school.

The mean of the random slope for gender, B = −.09, SE= .04, p = .09, indicated no significant discrepancy in elementary school students' individual interest in gender. In addition, there were substantial interactions between gender and class type, for gifted classroom, B = .35, SE = .11, p < .001, and for general classroom, B = .27, SE = .11, p < .01. Again, the random slope for gender was not related systematically to any of the aggregated ratings of instruction.

Although the class-level covariate for the incorporation of everyday contexts in science instruction was clearly associated with individual interest, B = .45, SE = .10, p < .001, in comparison to the baseline model, the corresponding effects for school type remained basically unchanged , both for gifted classroom, B = −.43, SE = .07, p < .001, and for general classroom, B = −.35, SE = .09, p < .001.When taking the instructional feature of missing clarity into consideration, B = −.18, SE = .08, p = .02, we observed a moderate diminishment of the effect of class type for gifted classroom, B = −.40, SE = .10, p < .001, but not for general classroom, B = −.33, SE = .10, p < .001. The inclusion of students' aggregated ratings of the elicitation of student explanations in science instruction, B = .22, SE = .08, p < .01, entailed a moderate reduction of the effect of class type for a s gifted classroom, B = −.40, SE = .10, p < .001, and for general classroom, B = −.32, SE = .10, p < .01. Finally, after incorporation of the instructional feature of student experiments on the class level, B = .25, SE = .05, p < .001, we found a considerable decrease of the effect of class type, both for gifted classroom, B = −.28, SE = .11, p < .01, and for general classroom, B = −.26, SE = .10, p < .01.

On the individual level, the subjective portions of ratings of instructional practices exerted significant influences on individual interest as well. In case of the instructional practices of eliciting student explanations and using student experiments, these individual-level effects were as large as the corresponding class-level effects. (Note that all effects are expressed in terms of the individual-level Fisher z-standardization) . Likewise, the reduction of effects of class type by inclusion of instructional practices was also smaller than in the models for situational interest.

Testing for Mediation

After establishing that instructional practices exerted statistically significant influences on both situational and individual interest, we explored if effects of instructional practices on individual interest were mediated by situational interest. Our examinations featured instructional practices as independent variables located on the class level, situational interest as the mediator situated on the individual level, and individual interest as the dependent variable located on the individual level (see Fig.1). Therefore, we followed the approach outlined by Zhang, Zyphur, and Preacher (2009) for testing this form of multilevel mediation. Specifically, we entered situational interest as a predictor into those models outlined previously for individual interest as the dependent variable. Thereby, individual-level situational interest was centered within classes, and the manifest class mean of students' situational interest was included as an additional predictor on the class level. Overall, four models were estimated, one for each instructional practice. To confirm the existence of a mediation or partial mediation, we monitored if statistical significance of class-level regression coefficients for instructional practices was deleted or at least reduced by inclusion of students' situational interest in the models. The magnitude of indirect effects of aggregated ratings of instructional practices on individual interest was computed by multiplying regression coefficients for instructional practices from the first set of multilevel analyses—that is, the multilevel models for situational interest as the dependent variable—with corresponding regression coefficients for class mean situational interest as the predictor for students' individual interest. Therefore, only variation in situational interest between classrooms contributed to the calculation of the indirect effects of instructional practices on students' individual interest. Standard errors for the indirect effects were based on the estimate of unbiased variance (Goodman, 1960).

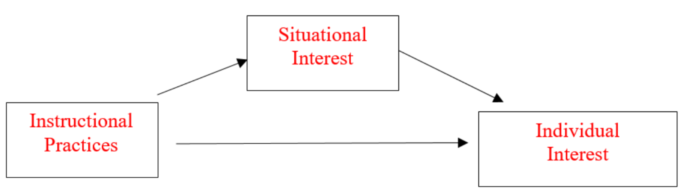

Figure 1. Model of test for instructional practices on individual interest were mediated by situational interest

After incorporation of class mean situational interest, $B = .39$, $SE = .07$, $p < .001$, the class-level effect of referring to everyday contexts was reduced yet still significant, $B = .30$, $SE = .10$, $p < .05$. The size of the respective indirect effect amounted to .19, constituting a statistically significant partial mediation, $z = 3.39$, $p < .001$. After entering the class mean of situational interest into the respective analysis, $B = .50$, $SE = .07$, $p < .001$, the instructional feature of missing clarity exerted a positive and statistically significant influence on individual interest on the class level, $B = .17$, $SE = .06$, $p = .03$. Also, the indirect effect of missing clarity on individual interest amounted to −.39. This indirect effect proved to be statistically significant, $z = -6.14$, $p < .001$. In case of eliciting student explanations, the incorporation of class-mean situational interest, $B = .49$, $SE = .09$, $p < .001$, yielded a marginally significant regression weight for eliciting student explanations on the class level, $B = -.17$, $SE = .06$, $p = .03$. The size of the indirect effect was .37, indicating a significant partially mediation, $z = 5.31$, $p < .001$. Finally, for the instructional practice of student experiments, the inclusion of class mean situational interest, $B = .47$, $SE = .05$, $p < .001$, rendered the class-level effect of using student experiments insignificant, $B = -.07$, $SE = .07$, $p = .31$. The corresponding indirect effect equaled .35, forming a full mediation, $z = 5.99$, $p < .001$.

So, the full mediation was present for the instructional practices of using student experiments; in case of the instructional practice of referring to everyday contexts, and student explanations we observed only a partial mediation. With respect to the instructional feature of missing clarity, finally, we detected an inconsistent mediation: While there was a negative indirect effect of missing clarity via situational interest on students' individual interest, the direct of effect of missing clarity on students' individual interest was positive. Apparently, besides the hypothesized indirect influence of missing clarity on individual interest, situational interest functioned as a suppressor for the direct relation between missing clarity and students' individual interest (see Holmbeck, 2002; MacKinnon, Krull, & Lockwood, 2000).

4. Discussion

Our analyses disclosed disparities in students' situational and individual interest in science between elementary and secondary education. For students' post-instructional interest, these disparities were remarkably larger for the gifted classroom than for the general classroom. This finding occurs with previous research on the development of students' interest in school subject in the course of Taiwan secondary education (Wang, Wang, & Liu, 2015). Obviously, in case of the processes occurring in the series of three lessons on oxidation-reduction reaction, the general classroom students functioned as a protective slot for students' interest in science in secondary education. In addition, analysis of descriptive statistics for students' individual interest showed that the outlined pattern of post-instructional disparities was embedded in the context of a mild decrease of students' individual interest over the course of the lessons.

The instructional practices of eliciting student explanations and using student experiments were predictive of students' interest and accounted for a considerable portion of the differences in students' interest between elementary and secondary schools. In this context, the associations between these two instructional practices and situational interest outstripped the corresponding associations with individual interest. Surely, in the transition from elementary to secondary education, this corroborated the validity of our correlational evidence in favour of a contribution of the instructional practices of eliciting student explanations and using student experiments to the decrease of students' interest in science.

To the casual eye, the results brought light to that the instructional feature of missing clarity were similar to the results obtained for the instructional practice of eliciting student explanations: Missing clarity viewed as a portion of the disparities in students' interest between elementary and secondary education, and its association with students' situational interest was closer than its association with students' individual interest. However, in contrast to this, we found an inconsistent mediation of the effects of missing clarity via situational interest on individual interest. Aside from mediating, an expected negative indirect effect of missing clarity on individual interest, situational interest performed also as a suppressor for the positive direct relation between missing clarity and individual interest. Apparently, there are at least two mechanisms with opposing directionality that underlie the relation between the instructional feature of missing clarity and students' individual interest (MacKinnon, Krull, & Lockwood, 2000).

Last, the pattern of results retrieved for the instructional practice of reference to everyday contexts was quite contrasting. In particular, differences in situational and individual interest between elementary and secondary education couldn't be explained by the reference to everyday contexts. Besides, the effect of referring to everyday contexts on individual interest was particularly large and only partly mediated by situational interest. This cast doubt on the validity of students' ratings of the connection of learning content to everyday contexts. The judgment of reference to everyday contexts afforded the students to transcend the immediate confines of the lessons on in the process of rating in comparison to the ratings of the other instructional practices. Moreover, in educational research, the classification of constructs as reflective or formative is tentative (Lüdtke et al., 2008). In fact, constructs are neither entirely reflective, that is, caused in a perfectly unidirectional manner by class-level phenomena, nor entirely formative, that is, forming qualitatively new factors on the class level bottom-up from the individual level. Possibly, students' individual interest in science partially influenced their capacity to discover connections between instruction and everyday contexts outside the classroom. This in turn plausibly blurred the rating of the instructional practice of reference to everyday contexts more intensely than it blurred the judgment of the other instructional practices.

5. Conclusions

In our cascade of statistical analyses, the instructional practices of eliciting student explanations and using student experiments, on the one hand, and the instructional features of missing clarity and referring to everyday contexts, on the other hand, behaved quite differently. For missing clarity, we detected an inconsistent mediation of effects on individual interest via situational interest. And for referring to everyday contexts, we found a surprisingly strong association with students' individual interest. What are the potential reasons for the differential behavior of the instructional practices? Apparently, as mentioned previously, the operation of a unitary mechanism can't describe the relation between missing clarity and students' interest accurately. The ratings of the occurrence of everyday contexts in instruction appear to suffer from validity issues. The conformity of the instructional practices of eliciting student explanations and using student experiments to our predictions, however, lends further credibility to the appropriateness of contemporary conceptualizations of successful science teaching aiming at fostering students' active learning and engagement (Duschl, Schweingruber, & Shouse, 2007; Kloser, 2014; Windschitl, Thompson, Braaten, & Stroupe, 2012).

Only one set of potential determinants of interest development among many relevant factors was represented by instructional practices. Therefore, it sometimes has been argued that their actual influence is irrelevant or inconsequential in comparison to other factors. However, even after controlling for additional determinants such as gender and achievement composition, instructional practices were comparatively strong predictors of students' situational and individual interest. Accounting partly for differences in interest between elementary and secondary education, especially domain-specific elements of teaching, such as incorporating student explanations in lessons and devising student experiments, appear to constitute central determinants of the development of interest in science in the transition from elementary to secondary education in Taiwan. Apparently, a more constructive approach to science instruction could perform as a protective factor against an undue decline of students' interest in science.

Due to the natural limitations of a cross-sectional study, the current analyses cannot yield conclusive evidence regarding the development of individual students' interest in science. Further contributing to this issue of study design, the measures of instructional practices and interest were employed briefly after the sequence of lessons on oxidation-reduction reaction. When measurement occasions for instruction and interest were separated for one year, previous research has not found any relation between instructional features and individual interest (Kunter, Baumert, & Köller, 2007; Seidel, Rimmele, & Prenzel, 2015). Future analyses of data from the longitudinal part Study, which followed the sixth graders of the current analyses with annual measurement occasions up to the seventh grade, will substantiate and qualify the results reported here.

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Table 4. Parameter Estimates of Multilevel Models for Situational Interest as Dependent Variable

	Model1A		Model2A		Model3A		Model4A		Model5A	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Individual-level variables										
Intercept	.32***	.07	.28***	.06	.20***	.06	.20***	.06	.09	.05
Individual Interest(pre)	.33***	.03	.25***	.03	.32***	.04	.29***	.04	.24***	.03
Achievement(pre)	.06**	.03	.05*	.04	.02	.03	.03	.03	.05**	.03
Gender	-.20**	.08	-.16**	.07	-.13*	.06	-.13*	.06	-.11*	.06
Everyday Contexts			.30***	.03						
Missing Clarity					-.26***	.03				
Student Explanations							.35***	.05		
Student Experiments									.44***	.03
R1 square	.26		.35		.35		.38		.43	
Class-level variables										
Gifted classroom	-.68***	.11	-.65***	.10	-.47***	.10	-.50***	.11	-.21*	.10
General classroom	-.46***	.12	-.43***	.11	-.33**	.11	-.29**	.11	-.20	.11
Gender ×Gifted classroom	.34**	.11	.30**	.10	.28**	.10	.28**	.09	.23**	.08
Gender ×General classroom	.30**	.11	.29**	.12	.29**	.10	.31**	.10	.29**	.10
Class mean achievement(pre)	-0.7	.08	-.11	.10	-.21*	.10	-.10	.07	-.11	.09
Everyday Contexts			.59***	.12						
Missing Clarity					-.55***	.10				
Student Explanations							.56***	.10		
Student Experiments									.64***	.09
R2 square	.51		.62		.67		.67		.71	
Variance components										
Within-class variance	.62***	.03	.56***	.03	.58***	.03	.55***	.03	.50***	.03
Intercept variance	.12***	.03	.09***	.03	.08***	.03	.08***	.02	.07***	.02
Slopevariance(gender)	.07**	.03	.05**	.03	.05**	.03	.03	.01	.04**	.03

Note. Modeled variance was calculated according to the approach outlined by Snijders and Bosker (1994, 2012).
*p < .05. **p < .01. ***p < .001.

Table 5. Parameter Estimates of Multilevel Models for Individual Interest as Dependent Variable

	Model1B		Model2 B		Model3 B		Model4 B		Model5 B	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Individual-level variables										
Intercept	.25***	.10	.21***	.08	.25***	.07	.18***	.08	.09	.09
Individual Interest(pre)	.50***	.03	.43***	.05	.49***	.04	.48***	.05	.45***	.03
Achievement(pre)	.04	.03	.03	.03	.03	.03	.01	.02	.04	.03
Gender	-.09	.04	-.07	.06	-.09	.07	-.05	.05	-.04	.04
Everyday Contexts			.26***	.04						
Missing Clarity					-.10***	.04				
Student Explanations							.23***	.05		
Student Experiments									.25***	.05
R1 square	.36		.43		.37		.39		.41	
Class-level variables										
Gifted classroom	-.47***	.10	-.43***	.07	-.40***	.10	-.40***	.10	-.28***	.11
General classroom	-.36***	.10	-.35***	.09	-.33***	.10	-.32***	.10	-.26***	.10
Gender ×Gifted classroom	.35***	.11	.32***	.10	.33***	.11	.31***	.10	.29***	.11
Gender ×General classroom	.27**	.11	.26**	.09	.27**	.09	.27**	.09	.26**	.10
Class mean achievement(pre)	-.09	.06	-.09	.06	-.13	.08	-.10	.08	-.10	.08
Everyday Contexts			.45***	.10						
Missing Clarity					-.18*	.08				
Student Explanations							.22**	.08		
Student Experiments									.25***	.05
R2 square	.68		.76		.73		.71		.73	
Variance components										
Within-class variance	.60***	.01	.53***	.02	.60***	.02	.58***	.01	.55***	.01
Intercept variance	.04***	.01	.02***	.01	.05***	.02	.04***	.02	.05***	.01
Slopevariance(gender)	.04*	.01	.03*	.02	.05*	.02	.04*	.01	.05*	.02

Note. Modeled variance was calculated according to the approach outlined by Snijders and Bosker (1994, 2012).
*p < .05. **p < .01. ***p < .001