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Research Insights
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THE EFFECT OF SEVENTH GRADE STUDENTS' STATE CURIOSITY AND ANXIETY ABOUT REFRACTION OF LIGHT AND LENSES ON ACADEMIC SUCCESS

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Abstract. This study examined seventh-grade students' academic achievement on the subject of refraction of light and lenses, as well as their state curiosity and anxiety levels. The study was conducted with 310 students from eight middle schools in the Palu and Kovancılar districts of Elazig province. The Science State Curiosity and Anxiety Scale (SSCAS) and the Refraction of Light and Lenses Academic Achievement Test (RLLAAT), developed by the researchers, were used as data collection tools. The study employed a relational screening model, a quantitative research method. The relationships between students' curiosity and anxiety levels and academic achievement were assessed using descriptive statistics, correlation analysis, regression analysis, and repeated-measures ANOVA. Findings indicated that as the learning process progressed, students' curiosity levels increased, while their anxiety levels decreased. A positive relationship was found between curiosity and academic achievement, while a negative relationship was found between anxiety and academic achievement. The regression analysis revealed that curiosity had a positive effect on academic achievement, while anxiety had a negative effect. No significant difference was found based on gender; only a difference was found in the anxiety level during the science problem encounter phase, favoring girls.

Keywords: physics education; science education; state science curiosity; state science anxiety

Introduction

Curiosity is defined as an individual's desire to learn and make sense of the unknown (Litman, 2005). It is the starting point of learning in human develop-

ment. Children tend to learn by observing their environment, asking questions, and exploring (Lindholm, 2018). In this respect, curiosity is both a cognitive and emotional process. It activates intrinsic motivations for learning (Loewenstein, 1994). Supporting curiosity in education contributes to students' development of analytical thinking and problem-solving skills (Peterson, 2020; Wade & Kidd, 2019). The presence of curiosity in the learning process increases students' motivation. It also helps them learn concepts more permanently and use scientific process skills more effectively (Gruber et al., 2019; Jirout & Klahr, 2012; Lombardi et al., 2021). Some researchers have focused on perceptual and epistemic curiosity. Perceptual curiosity refers to interest in sensory stimuli, while epistemic curiosity refers to the search for information (McNary, 2024). Some studies have focused on social curiosity and scientific curiosity (Renner, 2006). Epistemic curiosity is especially important in the context of learning. Epistemic curiosity strengthens students' desire to fill knowledge gaps and encourages them to engage in active learning. (Litman & Spielberger, 2003). Curiosity can manifest in individuals in both permanent and temporary forms. Trait curiosity is an innate and enduring disposition related to personality (Grossnickle, 2016; Karwowski, 2012). State curiosity, on the other hand, is a temporary state of interest that emerges at a specific moment and under specific conditions (Lee et al., 2003). Examining state curiosity in the educational context seems more useful for understanding students' real-time emotions during the learning process (Amorim Neto et al., 2022). State curiosity increases students' short-term motivation. It encourages active participation in learning and contributes to the development of higher-order thinking skills (Kang & Kim, 2021; Wade & Kidd, 2019).

Anxiety is a negative emotional state that arises when an individual perceives threat or stress. It is often accompanied by feelings of restlessness, tension, and apprehension. Anxiety can distract students and impair their memory during the learning process (Owens et al., 2012). Trait anxiety reflects an individual's general disposition. State anxiety, on the other hand, is a temporary emotional response experienced at a specific moment (Deacy et al., 2016). When students experience intense state anxiety during learning, their achievement decreases. This is because high anxiety reduces attention and makes it difficult for students to understand the material (Barroso et al., 2021). However, moderate anxiety can contribute to students being more attentive and motivated (Deacy et al., 2016).

When curiosity and anxiety are considered together, opposing effects occur in the educational process. While curiosity supports learning, intense anxiety can hinder it. Therefore, researchers emphasize examining state curiosity and anxiety together (Jaber & Hammer, 2016; Kang & Kim, 2022). State curiosity increases students' attention and enables their active participation in scientific processes. State anxiety, on the other hand, weakens students' motivation and reduces their achievement. Indeed, research shows that as students' curiosity levels increase,

their academic success increases. Research also shows that as anxiety levels increase, student achievement decreases. (Hardy et al., 2017; Rotgans & Schmidt, 2017; Schiefele & Krapp, 1996).

Research shows that curiosity and anxiety change dynamically throughout the learning process. Students' anxiety increases when they encounter a new problem. As the process progresses, anxiety decreases and curiosity increases (Kang & Kim, 2022; Wade & Kidd, 2019). Gruber and co-workers (2019) stated that curiosity strengthens memory, while Fastrich et al. (2018) stated that curiosity supports short- and long-term learning. On the other hand, many studies have emphasized that high levels of anxiety undermine students' self-confidence, negatively affect their cognitive processes, and reduce their academic achievement (Hembree, 1988; Hooda & Saini, 2017; Pascoe et al., 2019; Pekrun, 2006). Therefore, it is important to organize educational environments in a way that increases students' curiosity and reduces their anxiety (Henschel, 2021; Spektor-Levy et al., 2013). While teachers' giving students the opportunity to ask questions, explore and experiment will increase curiosity, avoiding oppressive approaches will reduce anxiety (Taheri et al., 2024; Zainal & Newman, 2023).

Different scales have been developed to measure state curiosity and anxiety. The State Epistemic Curiosity Scale, The Melbourne Curiosity Inventory, The State-Trait Curiosity Inventory, The State-Trait Anxiety Inventory, and the Cognitive Conflict Levels Test are the most well-known among these (Lee et al., 2003; Litman & Spielberger, 2003; Naylor, 1981). However, these scales have limitations in the context of science education. To more accurately measure students' moment-to-moment emotions in science classes, Kang, Yoo, and Kim (2020) developed the "Science State Curiosity and Anxiety Scale (SSCAS)". This scale makes a significant contribution to the literature because it can separately measure students' curiosity and anxiety levels during the stages of encountering a science problem, checking their answers, and learning concepts.

Refraction of light and lenses are among the physics topics that students struggle to grasp. Research on this topic shows that students often perceive light refraction as simply a change in direction. Research also shows that students often overlook fundamental factors such as changes in speed and the density of the medium (Galili & Hazan, 2000). The literature indicates that students hold various misconceptions about refraction of light and lenses (Kaltakci-Gurel, Eryilmaz & McDermott, 2017). Such studies demonstrate the importance of teaching refraction of light and lenses in the context of science education. However, the majority of research in this area focuses on students' cognitive achievements and misconceptions. Therefore, more research is needed that examines the affective dimensions of refraction of light and lenses.

This study aimed to investigate the effects of 7th-grade students' state curiosity and anxiety about refraction and lenses on their academic achievement. There are no studies in the literature examining the impact of students' state curiosity

and anxiety about refraction and lenses on their academic achievement using the SSCAS developed by Kang et al. (2020). This research contributes to the literature in three ways. 1) The SSCAS is a recently developed scale. This study was the first to measure state curiosity and state anxiety about refraction and lenses, a challenging topic for students. 2) Existing research in the literature has focused primarily on measuring general curiosity and general anxiety levels at a single stage. However, the current study examined state curiosity and state anxiety about refraction and lenses across three stages of the learning process (encountering the problem, checking the answer, and learning the concept), thus identifying changes in affective factors in more detail than previous studies. 3) Most studies in the literature have employed participants from different grade levels. The current study focused solely on 7th grade. This eliminated any affective differences that might arise from grade levels, ensuring that the findings reflect true age-specific affective changes. These three characteristics distinguish this study from the existing literature and strengthen its originality.

Theoretical Model

The current research is based on a theoretical model that suggests that state curiosity and state anxiety change throughout the learning process and also affect students' academic achievement. According to this theoretical model developed by Kang, Yoo, and Kim (2020), when students first encounter a science problem, their state anxiety increases, and at the same time, they begin to develop curiosity. According to the model, curiosity will increase and anxiety will decrease as the learning process progresses (Kang & Kim, 2022; Wade & Kidd, 2019). Some cognitive theories in the literature suggest that state curiosity facilitates students' learning by increasing individuals' intrinsic motivation and desire to explore, thereby contributing to increased academic achievement (Ainley, 2019; Loewenstein, 1994). These theories argue that state anxiety makes it difficult for students to focus on a given task, negatively affects students' information processing, and thus leads to a decrease in students' academic achievement (Owens et al., 2012; Pekrun, 2006). In conclusion, the theoretical model on which the current study is based has an approach that accepts the following: a) State curiosity positively impacts students' academic achievement because it increases intrinsic motivation and stimulates greater cognitive effort. b) State anxiety negatively impacts students' academic achievement because it negatively impacts students' cognitive effort and makes it difficult for them to focus. c) State curiosity and state anxiety differ in the stages of encountering a science problem, checking answers, and learning concepts. d) These momentary changes in affective behaviors affect academic performance in science education. This model forms the basis for the research questions of the current study.

Research Questions

The main research question of the study is as follows: What effect do 7th-grade students' state curiosity and anxiety about refraction and lenses have on their aca-

demic achievement? The study also sought to answer the following sub-research questions:

– Is there a significant relationship between students' state curiosity levels about refraction and lenses and their academic achievement? This research question was prepared because of the assumption that curiosity increases intrinsic motivation and supports learning.

– Is there a significant relationship between students' state anxiety levels about refraction and lenses and their academic achievement? This question was prepared because of the assumption that anxiety negatively affects cognitive processes.

– Do students' state curiosity and anxiety levels differ based on gender? This question was prepared because some previous studies indicated that affective characteristics differ according to gender.

– How do students' state curiosity and anxiety levels about refraction of light and lenses change at different stages of the learning process (encountering the problem, checking the answer, learning the topic)? This question was prepared because it is assumed that state curiosity and state anxiety are at different levels when encountering a science problem, checking answers, and learning concepts.

Some studies in the literature report that situational curiosity and anxiety may vary by gender (Aprilia et al., 2009; Henschel, 2021). Therefore, the gender variable was also examined as a comparison factor in the current study.

Method

This study used the correlational screening model, a quantitative research approach. The correlational screening model is a research design that aims to reveal the level and direction of the relationship between two or more variables (Aybek & Aslan, 2017). This model is quite useful in examining existing relationships between variables. However, this model identifies correlations without establishing cause-and-effect relationships. For the reasons mentioned, although regression analyses were conducted, the findings from this study do not explain cause-and-effect relationships.

Population and Sample

The population of the study consisted of 7th-grade students attending public schools in the Palu and Kovancılar districts of Elazig province. The study sample consisted of 310 seventh-grade students enrolled in eight different middle schools in these districts who volunteered to participate in the study. It has been reported in the literature that students frequently have misconceptions about optical concepts and experience cognitive difficulties with these concepts (Galili & Hazan, 2000; Kaltakci-Gurel et al., 2017). Because the topics of refraction and lenses are first introduced to students in Turkey in the 7th grade, this is the first time students encounter abstract optical concepts. 7th-grade students are in early adolescence. In these early adolescences, momentary emotions such as state curiosity and state

anxiety are likely to be more pronounced. For these reasons, 7th-grade students were chosen as participants in the current study. 47.1% of the participants were male and 52.9% were female. Approval for this study was received from the Firat University Social and Human Sciences Research Ethics Committee (decision date and number: January 20, 2024–21554). All students were informed about the study before participating. Both students and parents signed the voluntary participation form.

Data Collection Tools

Two different instruments were used to collect data in the study: the "Science State Curiosity and Anxiety Scale (SSCAS)" and the "Refraction of Light and Lenses Academic Achievement Test (RLLAAT)". The SSCAS, developed by Kang et al. (2020), was used to determine students' state curiosity and anxiety levels towards science courses. The scale consists of 30 items and includes two main dimensions: state science curiosity and state science anxiety. Each dimension is divided into three sub-dimensions. State science curiosity measures curiosity during the stages of (i) encountering a science problem, (ii) checking answers, and (iii) learning science concepts. State science anxiety measures anxiety during the stages of (i) encountering a science problem, (ii) checking answers, and (iii) learning science concepts. Prior to the study, a pilot study was conducted with 52 seventh-grade students at a middle school in Elazig. This pilot study tested the item clarity, response time, and applicability of the scale. Following the pilot study, minor wording adjustments were made to two items, and the resulting data were used to analyze the validity and reliability of both scales. The Kaiser-Meyer-Olkin (KMO) value for SSCAS was found to be 0.758. The Bartlett Test of Sphericity result was $\chi^2 = 2403.740$, SD = 435, and $p < .001$. Exploratory factor analysis revealed six factors with eigenvalues above 1, explaining 51.88% of the total variance. In reliability analyses, Cronbach's alpha coefficients ranged from 0.613 to 0.708. The majority of the item discrimination indices were found to be above 0.30. These data indicate that the scale has an acceptable level of reliability in both the curiosity and anxiety dimensions. A KMO value above 0.70 indicates that the data are suitable for factor analysis. A value above this value in the current study indicates that the SSCAS is suitable for factor analysis. A significant Bartlett test of sphericity indicates that the data are suitable for factor analysis. The significance of the Bartlett test in the current study indicates that the correlations between the items are suitable for factor analysis. Cronbach's alpha coefficients between 0.60 and 0.70 are considered acceptable levels of internal consistency for newly developed scales or scales adapted to a specific topic. The Cronbach's alpha values obtained for the SSCAS in this range in the current study indicate that the scale has an acceptable level of internal consistency. However, the finding that internal consistency values were relatively low in some subscales was considered a limitation of this study. RLLAAT was developed by the researchers to measure students' academic achievement in the subjects of refraction of light and

lenses. To create this test, firstly 32 questions were prepared in accordance with the 7th grade student outcomes. Three science teachers and one academic reviewed and evaluated these questions for student level, relevance to the topic, and understandability. Following this review, 12 questions deemed inappropriate by the experts were removed. Minor changes or adjustments were made to some questions. After these procedures, the test took its final form of 20 questions. The test consists of different question types. Part A contains six true-false questions. These questions relate to the basic properties of lenses. Part B contains one diagnostic branching tree question. This question helps determine whether students are following correct or incorrect logical patterns. Part C contains four drawing questions. These questions ask students to draw the path of light after passing through lenses. Part D contains one table completion question. The question includes a table. The table contains pictures of some devices (such as magnifying glasses, flashlights, and cameras). Students are asked to indicate the type of lens used in these devices (thin-edged or thick-edged). Part E contains six short-answer questions. These questions relate to the types of lenses in some common devices used in daily life. Part F contains two explanation questions. These questions provide real-life examples, and students are asked to explain the situations in the example by relating them to the topic of lenses. Only questions that could be scored objectively were included in the reliability analysis of the RLLAAT. A total of 12 open-ended questions (questions in sections C, E, and F) were not included in this analysis because they required subjective scoring. Analyses using the remaining questions yielded a Cronbach's alpha of 0.82, demonstrating that the RLLAAT is a reliable instrument. The item analysis results of the RLLAAT also demonstrate the test's suitability. Analyses revealed that the difficulty values of the questions ranged from 0.30 to 0.88, indicating that the test included easy, medium, and difficult items. Analyses also determined that the RLLAAT's discrimination values were adequate. Five questions had very good discrimination, eight had good discrimination, and seven had moderate discrimination. These findings demonstrate that the test is sufficient to identify student achievement differences.

Data Collection

The implementation process was carried out in the same order and under the same conditions in all classes. Data collection was conducted in the classroom. All stages of the data collection process were conducted by the researcher in collaboration with the teacher responsible for the course. Before the implementation began, the process was explained in detail to the students. In the first stage, the first section of the RLLAAT was administered to the participants. Students were given 40 minutes to answer the questions. The 40-minute time limit was determined based on expert opinions. This time was determined to be sufficient in the pilot study. Furthermore, considering the total number of questions (20) and the multiple question types in the test (true-false, branching tree, drawing, table completion, short-answer, and explanatory questions), it was concluded that this time was sufficient.

Immediately after the students completed their answers, the first section of the SSCAS (curiosity and anxiety experienced when encountering a science problem) was administered. Students completed this section in approximately 5 minutes. After this stage, the correct answers from the achievement test were given to the students, and they checked their answers. After the students checked their answers, the second section of the SSCAS (curiosity and anxiety experienced during the process of checking the answers) was administered. Students also completed this section in approximately 5 minutes. After this stage, the teacher responsible for the course explained the topic "Refraction of Light and Lenses" to the students. Immediately following this explanation, the third section of the SSCAS (curiosity and anxiety experienced during the process of learning science concepts) was administered. Students completed this section in approximately 5 minutes.

Results and discussions

Descriptive statistics regarding students' state science curiosity and anxiety levels regarding the topic "Refraction of Light and Lenses" are presented in Table 1.

Table 1. Descriptive statistics of students' state curiosity and anxiety levels

Stage	Curiosity (Mean)	Anxiety (Mean)	Minimum	Maximum
Encountering the science problem	16.38	15.44	9	24
Checking the answers	15.79	14.62	10	25
Learning the science concepts	16.33	13.51	11	25

An examination of Table 1 reveals that when students first encountered a science problem, their average curiosity level was 16.38 and their anxiety level was 15.44. During the answer-checking phase, the curiosity level decreased to 15.79, and the anxiety level decreased to 14.62. During the learning phase, the curiosity level increased to 16.33, while the anxiety level decreased to 13.51. State curiosity and anxiety levels of the students were compared according to gender. The t-test results are presented in Table 2.

Table 2. Comparison of students' state curiosity and anxiety levels by gender

Variable	Stage	Gender	N	Mean	p
Curiosity	Encounter	Male	146	16.20	.842
Curiosity	Encounter	Female	164	16.55	
Anxiety	Encounter	Male	146	15.78	.042*
Anxiety	Encounter	Female	164	14.96	

Curiosity	Check	Male	146	15.62	.671
Curiosity	Check	Female	164	15.95	
Anxiety	Check	Male	146	14.75	.517
Anxiety	Check	Female	164	14.50	
Curiosity	Learning	Male	146	16.28	.389
Curiosity	Learning	Female	164	16.37	
Anxiety	Learning	Male	146	13.72	.411
Anxiety	Learning	Female	164	13.31	
Curiosity	Total	Male	146	48.10	.592
Curiosity	Total	Female	164	48.87	
Anxiety	Total	Male	146	44.25	.275
Anxiety	Total	Female	164	42.77	

Note. p = Significance level, * p < .05. Encounter = Encountering the science problem, Check = Checking the answers, Learning = Learning the science concepts.

An examination of Table 2 reveals no significant overall difference between the curiosity and anxiety levels of male and female students. A significant difference was found in favor of female students only in the anxiety associated with encountering science problems subscale (p < .05). Scores for male and female students were similar for all other subscales. The relationships between students' academic achievement and state curiosity and anxiety levels were examined using Pearson correlation analysis. The findings are presented in Table 3.

Table 3. Correlation between academic achievement and state curiosity and anxiety (Correlation analysis)

Variable	Stage	r	p
Curiosity	Encounter	.214	.000**
Anxiety	Encounter	-.083	.127
Curiosity	Check	.198	.001**
Anxiety	Check	-.102	.072
Curiosity	Learning	.233	.000**
Anxiety	Learning	-.119	.041*
Curiosity	Total	.241	.000**
Anxiety	Total	-.127	.033*

Note. r = Correlation coefficient, p = Significance level. * p < .05, ** p < .01. Encounter = Encountering the science problem, Check = Checking the answers, Learning = Learning the science concepts.

An examination of Table 3 reveals generally positive and significant relationships between academic achievement and state curiosity. Significant positive correlations

were found between encounter curiosity, control curiosity, learning curiosity, and overall curiosity, and achievement. Conversely, negative correlations were found between anxiety levels and academic achievement. While encounter anxiety was not significant, significant negative correlations were found between learning anxiety and overall anxiety and achievement. These findings suggest that curiosity is a factor that supports achievement, while anxiety is a factor that diminishes it. To further examine the effects of curiosity and anxiety on academic achievement, multiple regression analyses were conducted, and the results are presented in Table 4.

Table 4. Regression analysis of academic achievement with curiosity and anxiety

Variable	B	β	p
Curiosity	.28	.35	< .01
Anxiety	-.22	-.29	< .05

Note. B = Regression coefficient, β = Standardized regression coefficient, p = Significance level. * $p < .05$, ** $p < .01$.

An examination of Table 4 reveals that students' curiosity levels have a positive and significant impact on academic achievement. In other words, as students' curiosity increases, their achievement also increases. Conversely, anxiety levels negatively impact academic achievement. As anxiety increases, student achievement decreases. These results clearly demonstrate that curiosity enhances achievement, while anxiety diminishes it. A repeated-measures analysis of variance (RM-ANOVA) was conducted to examine changes in students' curiosity and anxiety levels at different learning stages. The results are presented in Table 5.

Table 5. Students' state curiosity and anxiety levels at different stages (RM-ANOVA results)

Variable	**Stage**	**F**	**p**
Curiosity	Encounter	5.12	< .05
Curiosity	Check	6.03	< .01
Curiosity	Learning	7.24	< .01
Anxiety	Encounter	4.55	< .05
Anxiety	Check	3.92	< .05
Anxiety	Learning	4.21	< .05

Note. Encounter = Encountering the science problem, Check = Checking the answers, Learning = Learning the science concepts.

The RM-ANOVA results presented in Table 5 indicate that curiosity levels increased significantly from the encounter phase to the learning phase, while anxiety levels decreased significantly throughout the process. This finding demonstrates that the learning process directly affects students' emotional experiences.

An examination of the correlation coefficients obtained in the study reveals that some relationships are statistically significant, but this significance is low. Values between 0.10 and 0.29 can be considered weak, while values around 0.30 can be considered moderate. This suggests that the relationships between variables may have limited practical impact. An examination of the magnitudes of the regression coefficients reveals that these magnitudes explain little change in student achievement. This suggests that, even if statistically significant results were obtained, the effects were not large in practical terms.

This study examined the curiosity and anxiety of 7th-grade students regarding the refraction of light and lenses. The study found that students' anxiety levels were high when faced with a new problem. These findings are consistent with the literature. Kang and Kim (2022) found that students were initially more anxious, but their curiosity increased over time. Wade and Kidd (2019) stated that curiosity gradually strengthened during the learning process. This study found a positive correlation between curiosity and achievement. It was observed that as curiosity increased, students' achievement also increased. Curiosity, particularly in the encounter, control, and learning stages, was significantly correlated with success. Similar to this finding of the current study, Gruber et al. (2019) stated that curiosity increases achievement by strengthening memory. Lombardi et al. (2021) also stated that curiosity integrates cognitive and emotional processes and thus plays a role as a factor that increases achievement. Many different studies in the literature also mention the positive relationship between curiosity and student achievement (Hammer, 2016; Hardy et al. 2017; Jaber & Peterson, 2020; Rotgans & Schmidt, 2017; Schiefele & Krapp, 1996; Wade & Kidd, 2019).

The current research found a negative relationship between anxiety and achievement. Learning anxiety and total anxiety are negatively correlated with achievement. In other words, as anxiety increases, achievement decreases. This result is consistent with the literature. Similar to this finding of the current study, Hooda and Saini (2017) found that high anxiety reduces students' self-confidence and makes learning difficult. Pekrun (2006) also stated that anxiety negatively affects academic performance. Another study in the literature concluded that increased anxiety decreases student achievement (Anyan & Hjemdal, 2016; Aprilia & Aminatun, 2022; Barroso et al. 202; Hembree, 1988; Owens et al. 2012; Pascoe et al. 2019). There are also studies in the literature indicating that anxiety is linked to depression and stress, and therefore affects students' achievement (Ozamiz-Etxebarria et al., 2021). According to the results of regression analysis, curiosity in the current study had an enhancing effect on achievement, while anxiety had a depressing effect. Rotgans and Schmidt (2011) found that state curiosity is directly related to success in their study with high school students. This study reached the same conclusion.

The current study found no overall difference between the curiosity and anxiety levels of male and female students based on gender. A significant difference was found only in the anxiety subscale of encountering science problems, favoring female students. This finding is similar to some previous studies. Aprilia et al. (2009) stated that gender may influence anxiety in certain situations but is not a determining factor overall.

According to the RM-ANOVA results, students' curiosity levels increased throughout the process, while their anxiety levels decreased. Students experienced higher anxiety when faced with a new problem. However, as the process progressed, anxiety decreased and was replaced by increased curiosity. This finding is also similar to studies by Kang and Kim (2022) and Wade and Kidd (2019).

A significant contribution of the current study is the separate measurement of curiosity and anxiety at different stages of learning. Previous studies have generally examined curiosity and anxiety as a single dimension. This study, however, measured students' immediate reactions and more clearly revealed the emotional dimension of learning experiences. This contributes to the literature.

Furthermore, the findings are consistent with research showing that curiosity plays a protective role in students' psychological well-being. Zainal and Newman (2023) stated that curiosity plays a preventive role in depression and anxiety. Peng et al (2024) showed that increasing students' self-confidence reduces anxiety. Taheri et al. (2024) found that positive attitudes toward curiosity reduce anxiety and depression. Litman and Spielberger (2003) stated that curiosity is an interactive process with anxiety and affects learning. Grossnickle (2016) emphasized that curiosity is critical for learning motivation. Karwowski (2012) also demonstrated that curiosity is related to creativity. Lee et al. (2003) demonstrated that curiosity is an important factor in student success. Amorim Neto et al. (2022) found that curiosity strengthened students' academic motivation. Renner (2006) stated that curiosity supports learning processes. Deacy et al. (2016) demonstrated the importance of curiosity in the context of science education.

The results also provide important insights into how to design learning environments. Current research suggests that teachers should incorporate practices that foster students' curiosity and provide support to reduce anxiety. Spektor-Levy and colleagues (2013) emphasized that learning environments should be designed to foster curiosity. Henschel (2021) similarly emphasized the importance of curiosity-focused learning environments. Providing students with opportunities to ask questions, explore, and experiment fosters curiosity. Avoiding oppressive attitudes that increase anxiety supports success.

Conclusions

This study examined the effects of 7th-grade students' state curiosity and state anxiety about refraction and lenses on academic achievement. The findings showed that students' curiosity increased while their anxiety decreased during the learning process. Curiosity was found to be positively correlated with academic achievement, while anxiety was negatively correlated with success. It was observed that students' achievement decreased,

particularly when learning anxiety and overall anxiety increased. This suggests that curiosity supports learning, while anxiety can hinder it. No significant difference was found overall based on gender. Only in the dimension of "anxiety regarding encountering a science problem," a significant difference was found in favor of female students. This result demonstrates that curiosity and anxiety are largely independent of gender.

This research demonstrates that state science curiosity and state science anxiety can be examined separately at different stages of the learning process and also that the SSCAS can be effectively applied to a science topic such as refraction of light and lenses. This study contributes to the literature in three ways: 1) The SSCAS was applied for the first time to the subject of refraction and lenses, thus measuring situational curiosity and situational anxiety specifically for a science topic rather than a general science context. 2) Changes in situational curiosity and situational anxiety across three stages of the learning process were examined, providing more detailed information than previous single-stage studies. 3) By focusing solely on 7th-grade students, the emotional responses of a specific class were determined. These characteristics distinguish the current study from previous studies.

This research has limitations. The study was conducted only with 7th-grade students in a specific region. Therefore, its generalizability is limited. The study was conducted only on the refraction of light and lenses topic. Research conducted in different subjects and with different age groups may yield different results. Internal consistency values for some subscales of the SSCAS were relatively low. This is a limitation that should be taken into account when interpreting the results. Another limitation of this study is that it is a correlational study. The findings reveal relationships between variables. Even though regression analyses were conducted, they cannot fully draw causal conclusions. The fact that the study was conducted in the Palu and Kovancılar districts may limit the generalizability of the findings to other regions or countries due to differences in sociocultural characteristics, school structures, and curriculum practices. Curiosity and anxiety are context-sensitive variables. In this study, students' affective states were assessed with only a single measure at each learning stage. This prevents the full capture of natural fluctuations in students' curiosity and anxiety levels. Future research could address this limitation by using longitudinal or mixed-method data collection approaches. The data are based on students' own responses. Future research can use experimental methods, and similar studies can be replicated in different cultural contexts. Future research could be conducted in different regions and with larger samples. Longitudinal studies could examine changes in curiosity and anxiety over time. The use of qualitative methods can reveal students' subjective experiences in more detail. Furthermore, the experimental application of teaching strategies that increase curiosity and reduce anxiety would contribute to the strengthening of the findings.

The results also provide important clues for organizing teaching environments. Teachers providing students with opportunities to ask questions, explore, and experiment can

increase curiosity. Using concrete materials and examples related to daily life can stimulate students' interest. Avoiding oppressive and punitive attitudes can support success by reducing anxiety. The findings of the current study are particularly valuable for science education, given that students are known to struggle with understanding the concepts of refraction and lenses. By identifying how state curiosity and state anxiety change across learning stages, this research offers practical guidance for designing more supportive and engaging instruction on these topics.

The findings of this study have led to concrete suggestions for classroom practice. Students have been shown to experience higher anxiety when faced with a new problem. Therefore, preparing students for the topic with low-stakes, leading questions at the beginning of the lesson can reduce anxiety. Given that curiosity increases throughout the learning process, asking students to predict how light will behave after passing through a lens can foster curiosity. Using short reflection questions after each step can reduce students' anxiety stemming from uncertainty. Furthermore, incorporating short exploration activities about refraction and lenses into the lesson can increase students' curiosity and encourage active engagement in learning.

In conclusion, this research demonstrates that curiosity and anxiety are important emotional variables in science learning and directly impact students' academic achievement. Encouraging students' curiosity and maintaining a healthy level of anxiety not only increases their success but also contributes to the development of positive attitudes toward science classes.

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