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THE PREDICTIVE POWER OF CLASSROOM EMOTIONAL CLIMATE ON HIGH SCHOOL STUDENTS' VAN HIELE LEVELS OF GEOMETRIC THOUGHT

O PODER PREDITIVO DO CLIMA EMOCIONAL DA SALA DE AULA NOS NÍVEIS DE PENSAMENTO GEOMÉTRICO DE VAN HIELE DE ALUNOS DO ENSINO MÉDIO

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Abstract
This study investigates the predictive influence of the classroom emotional climate on high school students' Van Hiele Levels of Geometric Thought, addressing persistent low mathematics achievement in Turkey from an affective viewpoint. Employing a predictive correlational design with 374 students and 33 teachers, the research analyzed how teachers' instructional emotions and students' achievement emotions impact geometric reasoning. The findings revealed that a teacher's pride significantly predicts higher student achievement levels, while teacher anxiety is a negative predictor. Among students, positive emotions experienced after a class correlated with higher Van Hiele levels. Counterintuitively, positive emotions during study sessions and before exams were negative predictors of success. This suggests that the "cognitive struggle" essential for deep geometric learning is not always an emotionally comfortable process. The research concludes that the classroom's affective ecosystem, shaped primarily by the teacher, is a central mechanism in students' cognitive development. It underscores the need to integrate affective goals into mathematics curricula, acknowledging that the path to geometric abstraction is profoundly shaped by the interplay of human emotions.

Keywords: Classroom Emotional Climate. Van Hiele Levels of Geometric Thought. Achievement Emotions. Affective Domain.

Resumo
Este estudo investiga a influência preditiva do clima emocional da sala de aula nos Níveis de Pensamento Geométrico de Van Hiele de alunos do ensino médio, abordando o baixo desempenho persistente em matemática na Turquia sob uma perspectiva afetiva. Empregando um delineamento correlacional preditivo com 374 alunos e 33 professores, a pesquisa analisou como as emoções instrucionais dos professores e as emoções de desempenho dos alunos impactam o raciocínio geométrico. Os resultados revelaram que o orgulho do professor prediz significativamente níveis mais elevados de desempenho dos alunos, enquanto a ansiedade do professor é um preditor negativo. Entre os alunos, as emoções positivas vivenciadas após uma aula correlacionaram-se com níveis mais elevados de Van Hiele. Contraintuitivamente, as emoções positivas durante as sessões de estudo e antes das provas foram preditores negativos de sucesso. Isso sugere que a "luta cognitiva" essencial para a aprendizagem geométrica profunda nem sempre é um processo emocionalmente confortável. A pesquisa conclui que o ecossistema afetivo da sala de aula, moldado principalmente pelo professor, é um mecanismo central no desenvolvimento cognitivo dos alunos. Ressalta a necessidade de integrar objetivos afetivos aos currículos de matemática, reconhecendo que o caminho para a abstração geométrica é profundamente moldado pela interação das emoções humanas.

Palavras-chave: *Clima Emocional em Sala de Aula. Níveis de Pensamento Geométrico de Van Hiele. Emoções de Realização. Domínio Afetivo.*

1 INTRODUCTION

Turkey has a long-standing problem with low student achievement in mathematics. This is clear from the results of national exams. For example, in the Higher Education Institutions Examination (YKS), the average scores for the mathematics tests are consistently low. It is also the section with the most unanswered questions each year (ÖSYM, 2018; ÖSYM, 2019; ÖSYM, 2020; ÖSYM, 2021). The same issue appears in international assessments. Turkey’s mathematics literacy scores in the PISA tests are below the Organisation for Economic Co-operation and Development (OECD) average (MEB, 2015; MEB, 2018). This pattern of underperformance is seen not just in PISA and YKS, but also in other key benchmarks like the TIMSS study and additional exams from ÖSYM and MEB.

To solve a problem this big, we cannot only look at the curriculum. Educational theory states that good teaching must balance three main areas: the cognitive, the affective (or emotional), and the psychomotor. In a difficult subject like mathematics, the emotional side of learning is frequently ignored. This makes the idea of "classroom climate" very important here (Özden, 2005). Özden (2005) describes it as the interaction between the psychological feeling of the classroom and the emotions of the students. This climate has a powerful effect on learning, even though we cannot always see it. Education today changes quickly because of technology and society. For this reason, paying attention to the classroom climate is not an option. It is a fundamental part of providing a high-quality education.

This persistent underperformance underscores the imperative to move beyond the cognitive dimension and investigate the influence of affective factors in mathematics education. Notably, PISA 2018 included questions about students' emotional states for the first time, reporting that a significant portion of students in Turkey experience negative emotions such as fear and sadness (OECD, 2018). The existing literature further indicates that students' anxiety and negative attitudes towards mathematics tend to increase as they advance through educational levels (Baykul, 2005), with many students reporting a fear of both the subject and their teachers (Başar, Ünal, & Yalçın, 2002; Tuncer & Yılmaz, 2016).

These affective barriers are also prominently manifested in geometry, a critical sub-domain of mathematics. Although geometry constitutes a significant portion of both the curriculum and national exams—where it often includes the most discerning questions within the mathematics section—research consistently shows that students struggle to learn the subject and exhibit low performance in this area (Clements & Battissa, 1992). In this context, understanding the impact of the emotional climate, shaped by the feelings of both teachers and students in mathematics classrooms, on geometry achievement emerges as a critical necessity to illuminate a fundamental problem in the field.

1.1 Conceptual and theoretical framework

To understand the role of emotions within educational settings, this work integrates several key theoretical perspectives. Emotions are generally understood as complex phenomena influenced by both evolutionary history and social environments (Ekman, 1992; Izard, 2007; Russell, 2003). One perspective, Basic Emotion Theories, posits that there is a small set of universal, biologically-based emotions (Ekman, 1992; Plutchik, 2001). In contrast, Appraisal Theories argue that emotions are not innate but rather emerge from how we mentally process and interpret our experiences (Scherer, 2001; Moors et al., 2013).

Building on these foundational ideas, our research is primarily guided by Pekrun's (2006) Control-Value Theory of Achievement Emotions. This framework suggests that feelings experienced in academic contexts—like enjoyment, hope, pride, anxiety, or boredom—stem from two main judgments: a student's perceived level of control over a task (control appraisal) and the importance they attach to it (value appraisal). The theory then offers a robust model for how these feelings shape a student’s motivation, learning approach, and eventual academic performance (Pekrun & Perry, 2014). Although emotions in education can be classified in several ways, including as achievement, epistemic, topic, or social emotions (Pekrun & Linnenbrink-Garcia, 2014), this study narrows its focus to achievement emotions because of their direct link to academic activities and results.

The emotional life of a classroom is not confined to the experiences of students. Teachers, with their own motivations, goals, and emotional experiences, also play a central role in shaping this climate; however, research focusing on teacher emotions remains relatively limited (Chang, 2009). The emotions that teachers experience, such as enjoyment, pride, anger, and anxiety, influence their instructional behaviors (Frenzel, 2014) and the relationships they build with students, thereby defining the overall emotional climate of the classroom (Sutton & Wheatley, 2003).

Emotions directly affect how well students do in school. Positive feelings like hope can increase motivation (Pekrun, Elliot, & Maier, 2006). On the other hand, negative feelings like anxiety can hurt performance. This is because they use up a student's mental energy and reduce their interest in learning (Hembree, 1990; Zeidner, 1998). In mathematics, anxiety is a well-known problem. A lot of research shows that when students have high math anxiety, their achievement is lower (Ma, 1999).

This study measures geometry skills using the Van Hiele Theory of Geometric Thought (van de Walle et al., 2019). This theory presents five levels of geometric thinking that students move through in order: (0) Visualization, (1) Analysis, (2) Informal Deduction, (3) Formal Deduction, and (4) Rigor. A key idea in the theory is that students progress through these levels based on their classroom experiences, not just because they get older (Usiskin, 1982). This makes the model a useful way to evaluate how students develop their geometric understanding.

1.2 Purpose and significance of the study

The primary objective of this research is to investigate the geometry achievement of high school students, defined by the Van Hiele Levels of Geometric Thought, in the context of core affective variables that constitute the classroom emotional climate. To this end, the study analyzes the predictive power of several factors on students' Van Hiele Levels: the emotional states experienced by high school mathematics teachers during the instructional process; the achievement emotions of high school students during mathematics lessons, study sessions, and examinations; and students' attitudes towards geometry.

The significance of this study stems from its approach to addressing the persistent issue of low mathematics achievement in Turkey, observed in both national and international examinations, from an affective perspective. While the mathematics education literature has traditionally focused on cognitive processes, this research aims to fill a notable gap by emphasizing the importance of the classroom climate created by the emotions of both students and teachers. By placing the teacher, as well as the student, at the center of the classroom emotional climate, the study acknowledges that teachers are integral components of this affective environment. Examining how teachers, as emotional and social beings, both influence and are influenced by the classroom climate will contribute to a more multidimensional understanding of the subject. The findings are expected to yield significant theoretical and practical implications, particularly for integrating the affective dimension of mathematics more effectively into curricula and for developing strategies to foster positive affective behaviors among students toward mathematics.

1.2.1 Research questions

In line with this primary objective, the article seeks to answer the following research questions:

1. What are the levels of positive and negative emotions—specifically anxiety, pride, enjoyment, anger, hope, and frustration—experienced by high school mathematics teachers during the mathematics instruction process?
2. What are the achievement emotions of high school students in the context of their mathematics lessons, study sessions, and examinations?
3. What are the attitudes of high school students towards geometry?
4. What are the Van Hiele Levels of Geometric Thought (VHLGT) among high school students?
5. Do the instructional emotions of mathematics teachers, the mathematics achievement emotions of high school students, and the geometry attitudes of high school students predict the students' geometry achievement levels (VHLGT)?

2 METHOD

This section provides information regarding the research design, participants, data collection instruments, data collection procedure, and data analysis methods used in the study.

2.1 Research design

This study was designed using a relational survey model, a quantitative research method aimed at examining the relationships and predictive power among variables. More specifically, a predictive correlational research design was employed, which seeks to forecast a particular variable based on a set of other variables. In this design, the objective is to investigate the effect of one or more variables (predictor variables) on another variable (the criterion variable).

In the context of this research, the predictor variables are: the instructional emotions of high school mathematics teachers (anxiety, pride, enjoyment, anger, hope, frustration); the mathematics achievement emotions of high school students (in class, during study, and in exams); and students' attitudes towards geometry. The criterion variable for the study was identified as the high school students' Van Hiele Levels of Geometric Thought (VHLGT).

2.2 Participants

The population of this study consisted of high school students and mathematics teachers at public high schools in the Keşan district of Edirne during the 2020-2021 academic year. The sample was selected using a stratified sampling method, where schools were classified by type (Science High School, Anatolian High School, Vocational High School). From these strata, participants were chosen using a random sampling technique based on voluntary participation.

A total of 33 out of 34 high school mathematics teachers in the research population participated in the study (63.6% female, 34.4% male). The teachers' ages ranged from 28 to 58, with professional experience spanning 5 to 35 years. Of the participating teachers, 67.7% held an undergraduate degree, while 33.3% had completed graduate-level education. Additionally, 374 high school students taught by these teachers were included in the study (49.2% female, 50.0% male). The student sample was distributed across grade levels as follows: 24.3% were in the 9th grade, 24.9% in the 10th grade, 25.1% in the 11th grade, and 25.7% in the 12th grade.

2.3 Data collection instruments

Data were collected using structured scales administered through separate forms for teachers and students.

2.3.1 Instrument for teachers

To measure the emotions of high school mathematics teachers during instruction, the *Teachers' Instructional Emotions Scale*, originally developed by Hong et al. (2016) and adapted into Turkish by Dilekçi and Nartgün (2019), was used. This 4-point Likert-type scale consists of 27 items and measures six core emotions experienced by teachers: anxiety, pride, enjoyment, anger, hope, and frustration. For the present study, the Cronbach's alpha reliability coefficients for the subscales were calculated as 0.64 for anxiety, 0.69 for pride, 0.77 for enjoyment, 0.69 for anger, 0.91 for hope, and 0.81 for frustration.

2.3.2 Instruments for students

The student form comprised three different scales:

Van Hiele Geometry Thinking Levels Test: This test, developed by Usiskin (1982) and adapted into Turkish by Duatepe (2000), was used to determine students' geometry achievement and thinking levels. The test consists of 25 multiple-choice items, with five questions designed to measure each of Van Hiele's five levels of thought (from 0 to 4). For a student to be considered as having reached a specific level, they must answer at least four of the five questions for that level correctly. The reliability coefficient for the test in this study was calculated as 0.65.

Geometry Attitude Scale: This scale, developed by Duatepe and Çilesiz (1999), was used to measure students' attitudes towards geometry. The 5-point Likert-type scale contains 12 items and includes two sub-dimensions: "Motivation" and "Self-Confidence." The total reliability coefficient of the scale for this study was found to be 0.88.

Achievement Emotions Questionnaire-Mathematics (AEQ-M): This instrument, developed by Pekrun et al. (2005) and adapted into Turkish by Çalık and Çapa-Aydın (2019), was used to measure students' achievement emotions in mathematics. The 5-point Likert-type scale assesses students' emotions across three different contexts: class (before, during, after), studying (before, during, after), and exams (before, during, after). The overall reliability coefficient for the scale in this study was calculated as 0.94.

2.4 Data collection procedure

Prior to commencing the research, ethical approval was obtained from the Çanakkale Onsekiz Mart University Graduate Education Institute's Ethics Committee, and necessary permissions were secured from the scale developers. Data were collected during the spring semester of the 2020-2021 academic year via online forms due to the prevailing COVID-19 pandemic conditions. Informed consent forms were obtained from all participants before the administration of the instruments.

2.5 Data analysis

The collected data were analyzed using the IBM SPSS 21 software package. Before analysis, the dataset was checked for missing values, and the assumption of normal distribution was confirmed by examining skewness and kurtosis values. The following analyses were conducted in line with the research questions:

Descriptive Analyses: To answer the first four research questions (teachers' emotional levels, students' achievement emotions, geometry attitude levels, and VHLGT distributions), descriptive statistical methods such as frequency, percentage, arithmetic mean, and standard deviation were used.

Ordinal Logistic Regression Analysis: To test the tenth research question (the predictive power of affective variables on VHLGT), an ordinal logistic regression analysis was performed. This method was chosen because the criterion variable (VHLGT) is ordinal and categorical. In the analysis, teacher emotions, student achievement emotions, and geometry attitudes were included in the model as predictor variables.

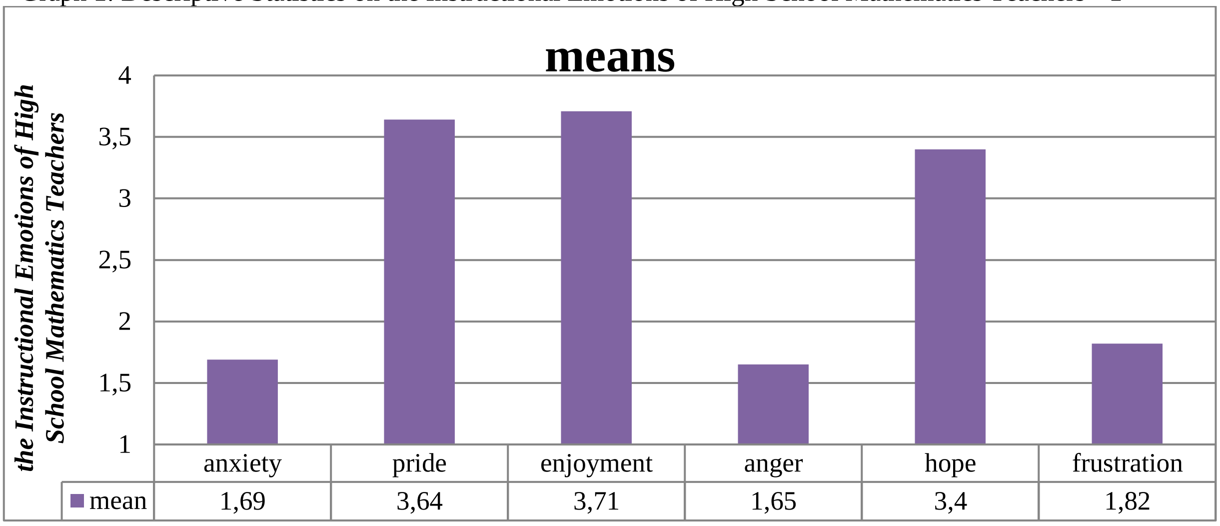
3 FINDINGS

In this section, the findings obtained in line with the sub-objectives of the research are presented, structured according to the corresponding research questions.

3.1 Instructional emotions of high school mathematics teachers

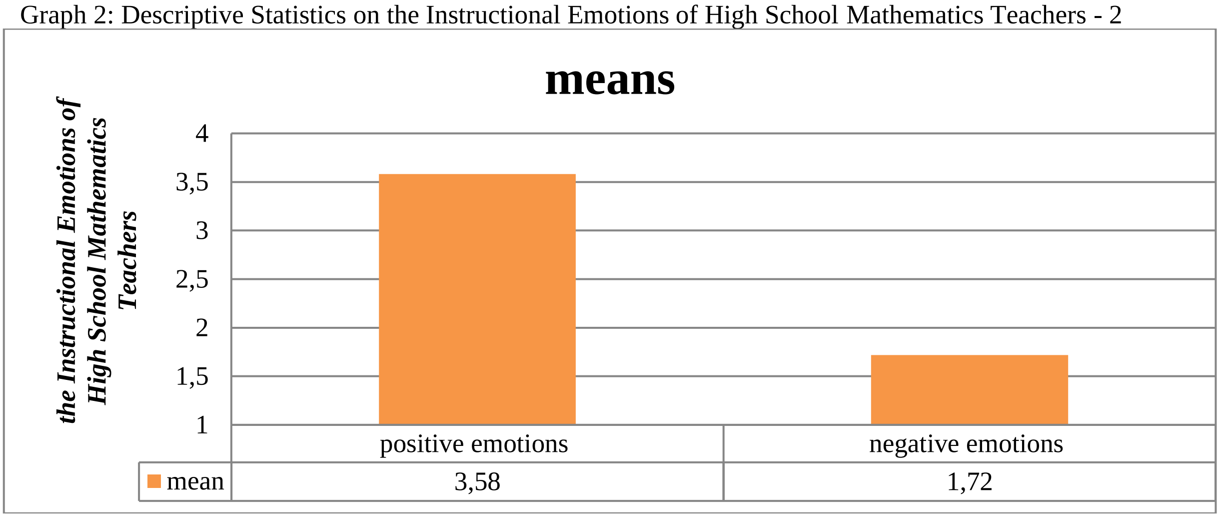
In the context of the first research question, descriptive statistics concerning the emotional states experienced by high school mathematics teachers during the instructional process were examined.

Graph 1: Descriptive Statistics on the Instructional Emotions of High School Mathematics Teachers - 1



Source: Authors

Graph 2: Descriptive Statistics on the Instructional Emotions of High School Mathematics Teachers - 2



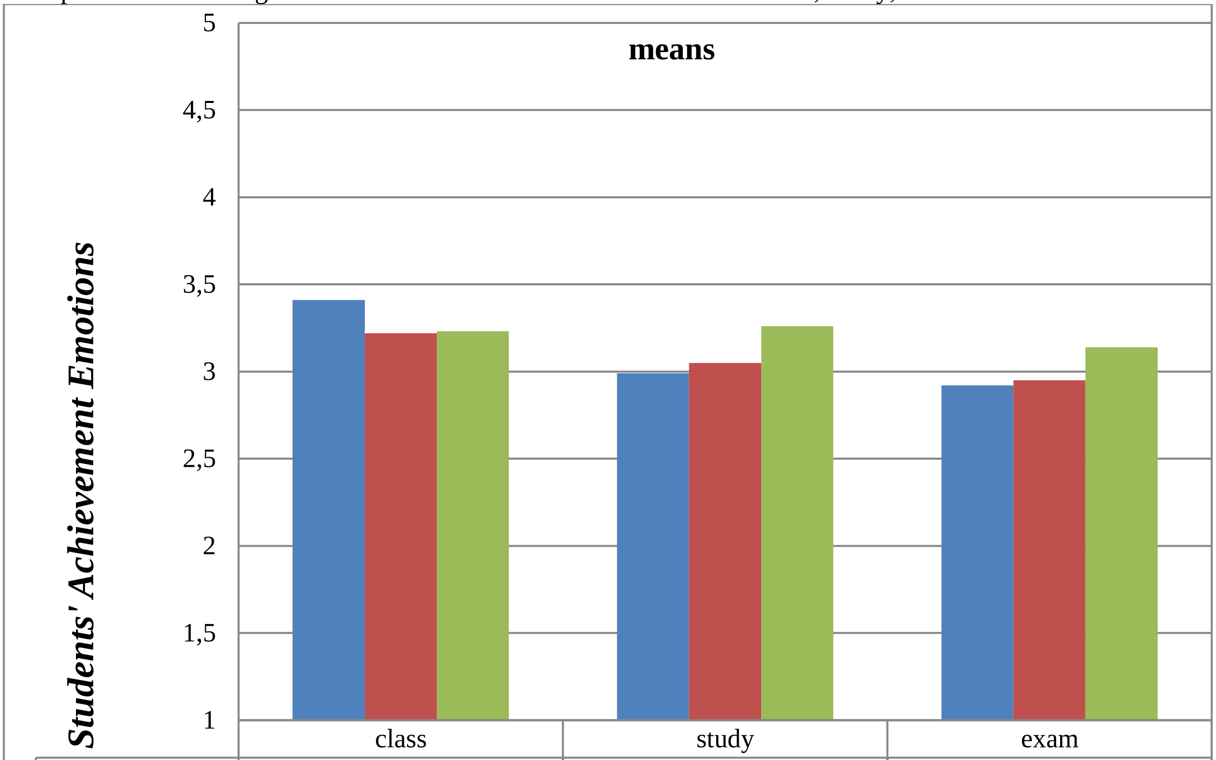
Source: Authors

An examination of the findings in Graph 1 and Graph 2 reveals that the means for positive emotions (pride, enjoyment, hope) among the participating high school mathematics teachers are markedly higher than the means for their negative emotions (anxiety, anger, frustration). The most intensely experienced emotion was "enjoyment" ($\bar{x}$=3.71), followed by "pride" ($\bar{x}$=3.64) and "hope" ($\bar{x}$=3.4), respectively. The least experienced emotion was "anger" ($\bar{x}$=1.65). When positive and negative emotions are treated as distinct categories, the mean for positive emotions ($\bar{x}$=3.58) was found to be high, while the mean for negative emotions ($\bar{x}$=1.72) was low. These results indicate that, from their own perspective, teachers predominantly experience the classroom affective atmosphere as a positive climate.

3.2 Achievement emotions of high school students in mathematics

In line with the second research question, the achievement emotions of high school students related to their mathematics lessons, study sessions, and examinations were analyzed.

Graph 3: Means of High School Students' Achievement Emotions in Class, Study, and Exam Processes



	class	study	exam
before studying	3,41	2,99	2,92
during studying	3,22	3,05	2,95
after studying	3,23	3,26	3,14

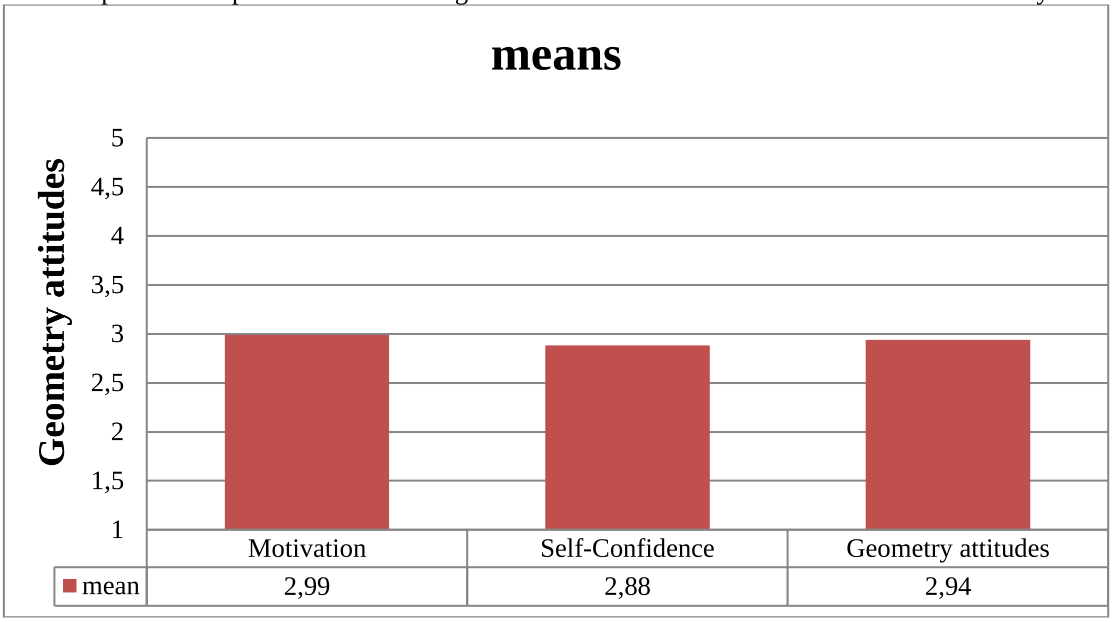
Source: Authors

According to the findings, the overall mathematics achievement emotions of high school students across class, study, and exam contexts are at a moderate level. When analyzed by process, students' achievement emotions related to "class" were highest before the lesson ($\bar{x}$=3.41) but showed a decrease during ($\bar{x}$=3.22) and after the lesson ($\bar{x}$=3.23). In contrast, during the "studying" process, the mean for emotions was lower before studying ($\bar{x}$=2.99) but increased during ($\bar{x}$=3.05) and after studying ($\bar{x}$=3.26). A similar trend was observed in the "exam" process; the emotion mean, which was lowest before the exam ($\bar{x}$=2.92), rose during ($\bar{x}$=2.95) and after the exam ($\bar{x}$=3.14).

3.3 High school students' attitude levels towards geometry

The third research question involved describing the attitude levels of high school students towards geometry.

Graph 4: Descriptive Statistics on High School Students' Attitude Levels Towards Geometry



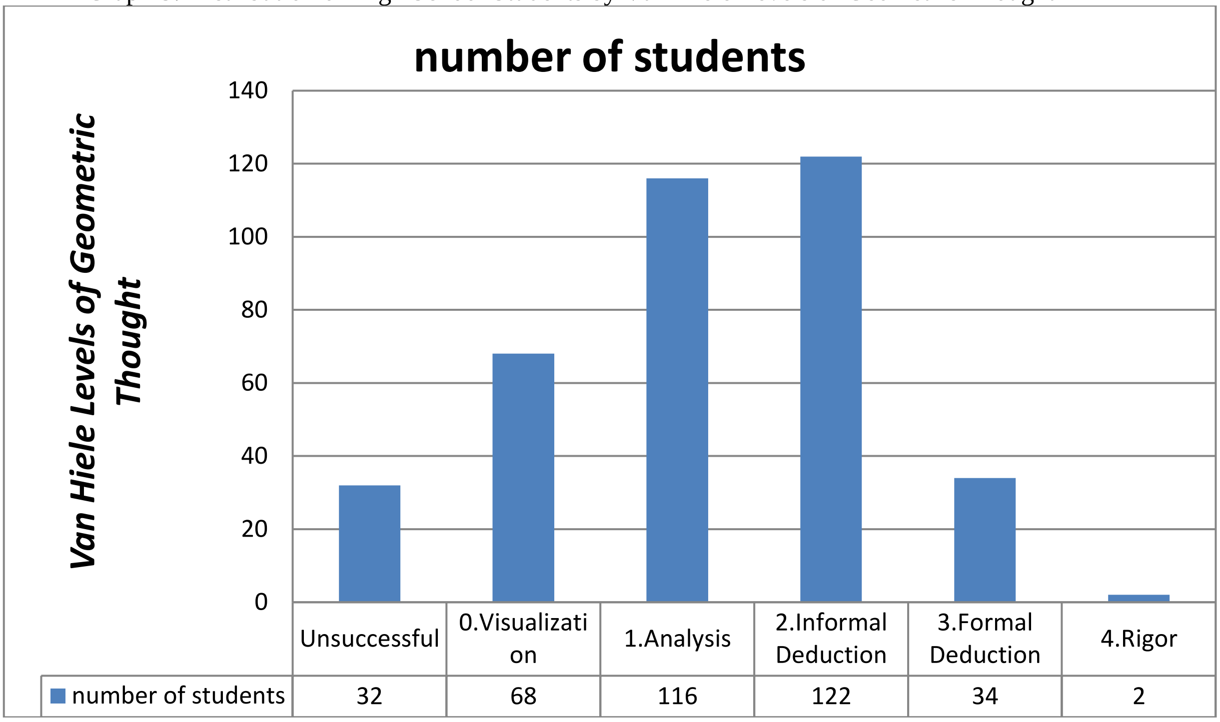
Source: Authors

The overall mean attitude of the participating high school students towards geometry was found to be 2.94, which indicates a moderate level. When the sub-dimensions of the scale were examined, the mean for the "Motivation" dimension was 2.99, while the mean for the "Self-Confidence" dimension was calculated as 2.88. These findings suggest that students' attitudes toward geometry are neither distinctly positive nor negative, clustering around an average level.

3.4 High school students' van hiele levels of geometric thought

The fourth research question aimed to determine the distribution of high school students according to their Van Hiele Levels of Geometric Thought (VHLGT).

Graph 5: Distribution of High School Students by Van Hiele Levels of Geometric Thought



Source: Authors

Analysis of the students' VHLGT distribution shows that a large majority of participants are concentrated at Level 1 "Analysis" (31.01%) and Level 2 "Informal Deduction" (32.62%). The combined percentage of students who were unsuccessful on the test (8.55%) or were at Level 0 "Visualization" (18.18%) is 26.7%. This figure is higher than the total percentage of students at the upper levels representing higher-order thinking skills, namely Level 3 "Formal Deduction" (9.09%) and Level 4 "Rigor" (0.53%), which collectively account for 9.6%. These findings indicate that a significant portion of high school students have not reached the level of geometric thinking expected for understanding the high school geometry curriculum.

3.5 The predictive power of affective variables on Van Hiele levels of geometric thought

For the fifth research question, the predictive power of teacher- and student-related affective variables on students' VHLGT was investigated using ordinal logistic regression analysis.

Table 1: Results of the Ordinal Logistic Regression Analysis on the Effect of Teacher and Student Affective Variables on VHLGT

	Variables	Estimate	Std Error	Wald	df	Sig	LowerBound	UpperBound	Exp_B	Lower	Upper
Criterion variables	[VHLGT = unsuccessful]	-1,938	1,761	1,211	1	,271	-5,391	1,514	,144	,005	4,544
	[VHLGT = Visualization]	-,512	1,758	,085	1	,771	-3,957	2,933	,599	,019	18,789
	[VHLGT = Analysis]	1,022	1,758	,338	1	,561	-2,424	4,468	2,780	,089	87,193
	[VHLGT = Formal Deduction]	3,319	1,766	3,532	1	,060	-,142	6,779	27,622	,867	879,578
Predictor variables	Teacher-enjoyment	-,818	,479	2,918	1	,088	-1,756	,120	,441	,173	1,128
	Teacher- pride	1,575	,331	22,615	1	,000*	,926	2,224	4,831	2,524	9,247
	Teacher-anger	-,157	,220	,506	1	,477	-,588	,275	,855	,555	1,316
	Teacher-hope	-,127	,282	,202	1	,653	-,680	,426	,881	,507	1,531
	Teacher-frustration	-,322	,183	3,091	1	,079	-,680	,037	,725	,507	1,038
	Teacher-anxiety	-,617	,201	9,418	1	,002*	-1,011	-,223	,540	,364	,800
	Student - Geometry attitudes	,160	,166	,927	1	,336	-,166	,486	1,174	,847	1,626
	Student – before lesson	,407	,215	3,566	1	,059	-,015	,829	1,502	,985	2,290
	Student – during lesson	,491	,301	2,653	1	,103	-,100	1,081	1,634	,905	2,949
	Student –after lesson	,341	,147	5,372	1	,020*	,053	,629	1,406	1,054	1,876
	Student – before studying	-,145	,178	,669	1	,414	-,494	,203	,865	,610	1,225
	Student – during studying	-1,361	,363	14,070	1	,000*	-2,073	-,650	,256	,126	,522
	Student –after studying	,074	,156	,225	1	,635	-,232	,380	1,077	,793	1,463
	Student – before exam	-,594	,271	4,829	1	,028*	-1,125	-,064	,552	,325	,938
	Student – during exam	,517	,312	2,755	1	,097	-,094	1,128	1,677	,911	3,089
	Student – after exam	,134	,180	,556	1	,456	-,218	,487	1,144	,804	1,627

Source: Authors

According to the analysis results, among the instructional emotions of high school mathematics teachers, enjoyment, anger, hope, and frustration did not show a significant effect on students' VHLGT. However, the teachers' emotions of pride and anxiety were found to be significant predictors of students' VHLGT. A one-unit increase in mathematics teachers' experience of pride increases the odds of a student being in a higher VHLGT category by a factor of 4.831 [(95% CI, 2.524 to 9.247), Wald $\chi 2(1) = 22.615$, $p < .001$]. Conversely, a one-unit increase in teachers' experience of anxiety decreases the odds of a student being in a higher VHLGT category by a factor of 0.540 [(95% CI, .364 to .800), Wald $\chi 2(1) = 9.418$, $p = .002$].

Students' general attitudes toward geometry did not show a significant effect on VHLGT. However, students' emotional state *after class*, their emotional state *during studying*, and their emotional state *before an exam* did significantly affect VHLGT. (Note: Students' emotional states for "class, study, and exam" are scaled from negative to positive). A one-unit increase in positive emotions *after class* increases the odds of being in a higher VHLGT category by 1.406 [(95% CI, 1.054 to 1.876), Wald $\chi 2(1) = 5.372$, $p = .020$]. In contrast, a one-unit increase in positive emotions *during studying* decreases the odds of being in a higher VHLGT category by a factor of 0.256 [(95% CI, .126 to .522), Wald $\chi 2(1) = 14.070$, $p < .001$]. Similarly, a one-unit increase in positive emotions *before an exam* decreases the odds of being in a higher VHLGT category by 0.552 [(95% CI, .325 to .938), Wald $\chi 2(1) = 4.829$, $p = .028$]. Students' emotional states before class, during class, before studying, after studying, during the exam, and after the exam did not have a significant effect on VHLGT.

4 DISCUSSION

The findings of this research offer significant insights into the complex and multifaceted relationship between the emotional climate in high school mathematics classrooms and students' levels of geometric thought. The discussion is structured around the primary research questions, dialectically examining the aspects of the findings that align with and diverge from the existing literature.

The study's initial finding revealed that high school mathematics teachers experience positive emotions (enjoyment, pride, hope) more intensely than negative emotions (anxiety, anger, frustration) during instruction. This result is consistent with the findings of researchers such as Frenzel and Goetz (2007), Carson (2007), and Becker (2011). This is significant as it suggests that teachers, through their professional experience and classroom management skills, are able to maintain a positive affective stance despite the challenges inherent in teaching. As Frenzel (2014) notes, teachers with a predominantly positive emotional experience have a greater potential to build trusting relationships with students and to use a variety of instructional strategies with greater flexibility. In this respect, the positive affective profile exhibited by teachers can be considered a fundamental component for creating an effective learning environment.

In contrast, the finding that students' achievement emotions in their mathematics lessons, study sessions, and exams remained at a "moderate level" points to a divergence between the positive affective profile of the teachers and that of their students. The tendency for students' emotions to become less positive, particularly as they approach moments of evaluation like classes and exams, confirms the domain- and context-specific nature of academic emotions, as highlighted by Goetz et al. (2006). By its very nature, mathematics has the potential to generate a wide spectrum of emotions, from anger and frustration to joy and elation (Boaler, 2000). This moderate affective experience among students may be a reflection of the abstract nature of mathematics and the pressure of performance-oriented assessment.

One of the most critical findings of the research is that a vast majority of high school students have not reached the geometric thinking skills of Level 3 (Formal Deduction) and above, which are expected for the high school level by the NCTM (2000). The concentration of students at Level 1 (Analysis) and Level 2 (Informal Deduction) aligns with the findings of many previous studies conducted in Turkey (Altun, 2018; Bal, 2014; Gömlekçi, 2021). This suggests a misalignment between the curriculum and the cognitive developmental levels of the students, indicating that they struggle to comprehend topics requiring higher-order skills such as geometric proof and abstract reasoning.

At this juncture, the study's predictive findings help to illuminate the role of the emotional climate in this cognitive gap. It is noteworthy that among teacher emotions, "pride" was a significant positive predictor of students' VHLGT, while "anxiety" was a significant negative predictor. A teacher's feeling of pride is likely a result of successful teaching practice, mastery of the subject matter, and witnessing student understanding; this, in turn, may manifest as more effective and supportive instruction, elevating students' cognitive levels. Conversely, a teacher's anxiety, as implied in Frenzel's (2014) model, may lead to a more rigid, rote-based, and less discovery-oriented teaching practice. Such an instructional style could trap students in the lower Van Hiele levels (visualization and analysis), hindering their transition to higher levels that require them to establish relationships between properties and construct abstract proofs.

The predictive effects of student emotions on VHLGT present a more complex and dialectical picture. The finding that positive emotions "after class" enhance achievement is expected and may indicate that the learned material has been internalized, creating a sense of competence. However, the finding that positive emotions "during studying" and "before an exam" *negatively* predicted VHLGT is one that, while seemingly contradictory at first, becomes meaningful upon closer inspection. This may be indicative of the inherent difficulty and cognitive effort involved in learning geometry, as noted in the work of Van Putten (2008). It is natural for a student striving to develop higher-order geometric thinking skills to experience struggle, frustration, and even anxiety in the process. Therefore, "positive" emotions felt during study sessions might be a sign that the student is not cognitively challenging themselves, engaging instead in superficial and procedural learning. The moments of "struggle" where genuine cognitive leaps occur may not always feel affectively positive. This finding suggests that the impact of affective states on achievement is not linear but is closely intertwined with the cognitive demands of the learning task.

Finally, the fact that students' "attitudes toward geometry" did not significantly predict VHLGT contradicts some studies in the literature (Bal, 2014; Frykholm, 1994). This could suggest that a more general and stable affective construct like attitude may not be as powerful a predictor as the instantaneous and context-specific "achievement emotions" experienced during lessons, studying, and exams. In other words, whether a student generally "likes" or "dislikes" geometry (attitude) may not play as direct a role in the development of their geometric thinking level as the "frustration" felt while solving a specific problem or the "enjoyment" experienced upon understanding a concept (emotion).

In summary, the findings of this research reveal that geometry achievement is not merely a cognitive process but is shaped within a dynamic emotional climate where teacher and student emotions are deeply interwoven. It appears that specific emotions, such as pride and anxiety in teachers, and the momentary feelings students experience at different stages of the learning process, play a key role in the development of a complex cognitive structure like geometric thinking. These results underscore that in geometry instruction, affective goals and emotion regulation are at least as important as cognitive objectives, and that curricula should be redesigned with this holistic perspective in mind.

5 CONCLUSION

This study reveals the process of learning geometry to be much more than a cognitive exercise. It is an experience deeply embedded within a shared emotional world, one in which the teacher often acts as the primary architect of the learning climate. The feelings present in the classroom—particularly a teacher's pride or anxiety—do not remain isolated experiences but instead seem to spread, creating an atmosphere that can either bolster or impede a student's capacity for learning. This finding directly confronts a long-standing assumption in mathematics education: that the subject is a purely rational one. Our work positions the emotional domain not as a peripheral concern, but as a central mechanism in a student's ability to advance toward abstract geometric thinking.

Our research data showed a clear link between these teacher emotions and student outcomes. The presence of teacher pride significantly increased the likelihood of students reaching higher levels of geometric thought, whereas teacher anxiety tended to hold them back. This suggests the teacher's function is less about simply transmitting information and more about managing the room's emotional tenor. A teacher's professional pride, for instance, which may stem from their own sense of competence, appears to foster a space of psychological safety where students feel more willing to explore and risk making mistakes. Conversely, a teacher’s anxiety can saturate that same space with a sense of rigidity. This atmosphere seems to discourage students from attempting to move beyond the foundational levels of the Van Hiele hierarchy, effectively limiting their potential for growth.

Genuine learning is rarely a comfortable process. It is better characterized as a "cognitive struggle," a journey to the edge of one's abilities that almost always involves wrestling with confusion and frustration. This reality presents a difficult paradox for educators: what if a student feeling 'good' or untroubled during a study session is not a sign of progress, but of intellectual stagnation?

Our research confronts this uncomfortable question directly. We unearthed a counter-intuitive pattern where positive feelings reported during the intense work of studying or immediately before an exam were linked to worse outcomes—even as postlesson satisfaction remained a good indicator of success. It seems the mental exertion required to climb to a new level of understanding is simply not meant to feel easy. The final prize, the true sense of achievement, is reserved for those who successfully navigate this demanding terrain. This forces a necessary shift in how we approach mathematics education. The goal can no longer be to cultivate a generic 'positive attitude,' a target that our findings suggest may even be counterproductive during the active learning phase. The real work lies in teaching students to engage with and channel the difficult, momentary feelings that arise from the struggle itself, using them as fuel for cognitive growth. The road to geometric abstraction, it turns out, is paved not just with axioms and proofs, but with the full, often messy, spectrum of human emotion.

NOTES

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Both authors contributed equally to the development of this article.

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