HƏNDƏSİ ANLAYIŞLARIN BAŞA DÜŞÜLMƏSİNDƏ PSİXOLOJİ VƏ MƏDƏNİ AMİLLƏR: AZƏRBAYCAN KONTEKSTİNDƏ YANAŞMA

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ANNOTASİYA

Bu tədqiqat Azərbaycanda kənd, qəsəbə və şəhər məktəblərindən seçilmiş 150 şagirdin (10-12 yaş) həndəsi anlayışları mənimsəməsinə psixoloji (riyaziyyatla bağlı narahatlıq, öz imkanlarına inam) və mədəni amillərin təsirini araşdırır. Məqalədə sorğular, sinif müşahidələri və həndəsə üzrə bilik testi kimi qarışıq metodlardan istifadə edilib. Təhlillər göstərir ki, şəhər şagirdləri (85%) kənd (60%) və qəsəbə (70%) şagirdləri ilə müqayisədə daha yüksək nəticə göstərib. Riyaziyyat narahatlığı kənd məktəblərində ən yüksək (orta 4,1/5), şəhər məktəblərində ən aşağı (2,2/5) olub; öz imkanlarına inam isə əks nümunə göstərib. Rəqəmsal resurslara çıxış imkanı nəticələrlə güclü korrelyasiya (r=0,68) göstərib. Mədəni elementlər (xalça naxışları, memarlıq) isə dərslərdə nadir hallarda inteqrasiya olunur, baxmayaraq ki, onlar həndəsi anlayışların mənimsənilməsini dəstəkləmək potensialına malikdir. Araşdırmalar göstərir ki, Azərbaycanda həndəsə təhsilinin yaxşılaşdırılması üçün həm psixoloji dəstək, həm mədəni əsaslı pedaqogika, həm də texnologiyaya bərabər çıxış vacibdir.

Açar sözlər: Həndəsə təhsili, riyaziyyat narahatlığı, öz imkanlarına inam, mədəni amillər, Azərbaycan, rəqəmsal resurslar, xalça naxışları, fəza təfəkkürü.

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PSYCHOLOGICAL AND CULTURAL FACTORS IN UNDERSTANDING GEOMETRIC CONCEPTS: AN APPROACH IN THE AZERBAIJANI CONTEXT

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ABSTRACT

This study examines the effects of psychological factors (mathematics anxiety and self-efficacy beliefs) and cultural factors on the understanding of geometric concepts among 150 students aged 10–12 attending rural, town, and urban schools in Azerbaijan. A mixed-method research design was employed, using validated survey instruments, classroom observations, and a geometry achievement test. The results indicate that students from urban schools achieved significantly higher scores (85%) than their peers from town (70%) and rural (60%) schools. Mathematics anxiety was highest in rural schools (mean = 4.1/5) and lowest in urban schools (mean = 2.2/5), whereas self-efficacy beliefs showed the opposite pattern. Access to digital resources was strongly positively correlated with students' achievement (r = 0.68). However, cultural elements, such as traditional carpet patterns and architecture, were rarely integrated into classroom instruction, despite their considerable potential to enhance students' conceptual understanding of geometry. The findings suggest that strengthening psychological support, adopting culturally responsive pedagogical approaches, and ensuring equitable access to digital technologies are essential for improving geometry education in Azerbaijan.

Keywords: Geometry education, mathematics anxiety, self-efficacy beliefs, cultural factors, Azerbaijan, digital resources, traditional carpet patterns, spatial reasoning.

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INTRODUCTION

Learning geometric concepts is a complex process influenced by cognitive, psychological, and cultural factors. Research has consistently shown that students' understanding of geometry is not determined solely by intelligence but also by motivation, anxiety, and socio cultural background (Ashcraft, 2002; Vygotsky, 1978). Psychological factors such as math anxiety – a feeling of tension that interferes with mathematical performance – and self-efficacy – the belief in one's ability to succeed – are strong predictors of mathematics achievement (Bandura, 1997; Luttenberger et al., 2018). Students with high math anxiety tend to avoid geometry problems, while those with high self-efficacy persist longer and achieve higher scores (Schunk, 2010; Justicia Galiano et al., 2017).

Piaget's theory of cognitive development indicates that children enter the formal operational stage around age 11–12, enabling abstract reasoning necessary for geometry (Piaget & Inhelder, 1967). However, reaching this stage does not guarantee success; cultural context mediates how abstract concepts are internalized. Vygotsky's sociocultural theory emphasizes that learning occurs through interaction with meaningful cultural tools (Vygotsky, 1978). Studies from non Western contexts show that integrating indigenous patterns and artifacts into mathematics lessons improves engagement and understanding (Nunes, 1993; Presmeg, 2006). For example, Leung (2001) found that group oriented educational models in Asian societies promote collaborative learning, which reduces anxiety and enhances geometry comprehension.

In Azerbaijan, geometry teaching traditionally follows a proof based, teacher centered approach inherited from the Soviet system. While this method develops logical thinking, it often neglects students' emotional states and rarely connects geometry to familiar cultural artifacts – such as symmetrical patterns in Azerbaijani carpets, tile ornaments in medieval architecture, or geometric motifs in folk art. Preliminary observations by the authors (2023–2024) suggest that math anxiety is widespread, digital resources are inequitably distributed (rural schools have minimal access), and cultural elements are almost never used in lessons. However, no systematic study has investigated the combined role of psychological and cultural factors in geometry education across different school settings in Azerbaijan. Therefore, this study addresses the following research questions: (1) How do math anxiety, self efficacy, and geometry achievement differ among students in rural, town, and urban Azerbaijani schools? (2) What is the relationship between psychological factors (anxiety, self efficacy) and geometry achievement? (3) To what extent are cultural elements (e.g., carpet patterns, architecture) currently integrated into geometry lessons, and how do students respond to such elements? (4) How does access to digital resources influence geometry learning outcomes?

METHOD

A total of 150 students aged 10–12 (grades 5 and 6) participated in the study. They were selected from three public schools in Azerbaijan: one rural school (mountainous region, n=50), one town school (small district center, n=50), and one urban school (Baku city, n=50). Schools were purposively chosen to represent different levels of access to digital resources and cultural exposure. All participants had completed at least one year of formal geometry instruction. Parental consent was obtained, and participation was voluntary.

Five instruments were used. The Mathematics Anxiety Scale (MAS) consisted of 6 items adapted from Ashcraft (2002) and Hembree (1990), rated on a 5 point Likert scale (1=strongly disagree to 5=strongly agree). A sample item is "I feel stressed during geometry classes." Cronbach's α was 0.87. The Self Efficacy Scale for Geometry (SESG) included 6 items adapted from Bandura (1997) and Schunk (2010), also on a 5 point scale. A sample item is "I believe I can solve geometry problems on my own." Its Cronbach's α was 0.84. The Geometry Achievement Test (GAT) comprised 20 multiple choice and 5 open ended questions on symmetry, angles, area, volume, and spatial visualization. It was developed by the authors and validated by two mathematics education experts (content validity index = 0.91); the maximum score was 100. A Classroom Observation Protocol was used for structured observations lasting three 40 minute lessons per school, recording use of digital tools, mention of cultural examples (carpets, architecture), student engagement, and teacher feedback. Additionally, semi structured interviews were conducted with one mathematics teacher per school to understand current practices and barriers.

Data collection took place in February–March 2025. Surveys were administered in classrooms during regular hours (20 minutes). The achievement test followed (40 minutes). Observations were conducted by both authors independently; inter rater reliability was 0.89. Teacher interviews lasted 15–20 minutes each and were recorded with permission.

Quantitative data were analyzed using SPSS version 26. Descriptive statistics (means, standard deviations) were calculated for each school. Independent samples t tests compared rural vs. urban, and town vs. urban. Pearson correlations examined relationships among anxiety, self efficacy, and achievement. Qualitative data from observations and interviews were analyzed thematically using open coding; themes were reviewed by both authors to ensure reliability.

RESULTS

Table 1 presents the descriptive statistics for geometry achievement, math anxiety, and self efficacy by school type.

Independent t tests revealed significant differences between rural and urban students for achievement ($t(98)=15.2$, $p<0.001$), anxiety ($t(98)=12.4$, $p<0.001$), and self efficacy ($t(98)=11.9$, $p<0.001$). Town students scored significantly lower than urban students on all measures ($p<0.01$) and higher than rural students ($p<0.05$). Figure 1 presents a detailed visual comparison of these achievement scores across the three school categories.

Correlation analysis across all 150 students showed a strong negative relationship between math anxiety and achievement ($r = -0.72$, $p<0.001$) and a strong positive relationship between self efficacy and achievement ($r = +0.69$, $p<0.001$). Anxiety and self efficacy were moderately negatively correlated ($r = -0.58$, $p<0.001$). To further explore this dynamic, Figure 2 contrasts the precise mean scores of math anxiety against self-efficacy dimensions across the sample.

Access to digital resources (rated by observers on a 0–3 scale: 0=none, 3=high) was strongly correlated with achievement ($r = 0.68$, $p<0.001$). Rural schools had a mean access score of 0.2 (only a blackboard and chalk), town schools 1.5 (occasional projector use), and urban schools 2.8 (regular use of dynamic geometry software and online materials). The strength and direction of the relationship between this technological infrastructure and learning outcomes are mapped via the regression line in Figure 3.

Observations revealed that in the rural school, no lesson included any reference to carpets, architecture, or traditional art. When researchers showed rural students a photo of a traditional Azerbaijani carpet during post test interviews, 42 out of 50 students spontaneously identified

Table 1 Mean scores (and standard deviations) for achievement, anxiety, and self efficacy

School Type	N	Achievement (%)	Math Anxiety (1-5)	Self Efficacy (1-5)
Rural	50	60.2 (8.5)	4.1 (0.7)	2.5 (0.8)
Town	50	70.1 (7.9)	3.3 (0.8)	3.4 (0.7)
Urban	50	84.7 (6.2)	2.2 (0.6)	4.3 (0.6)

Figure 1 Geometry achievement levels (%) according to school locations (Rural, Town, and Urban).

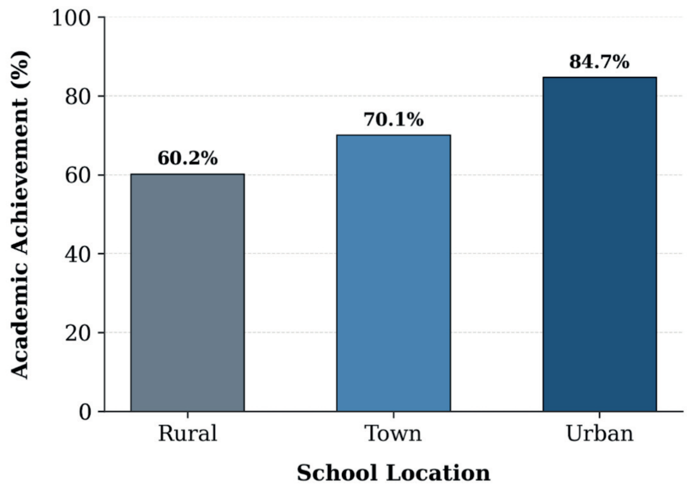
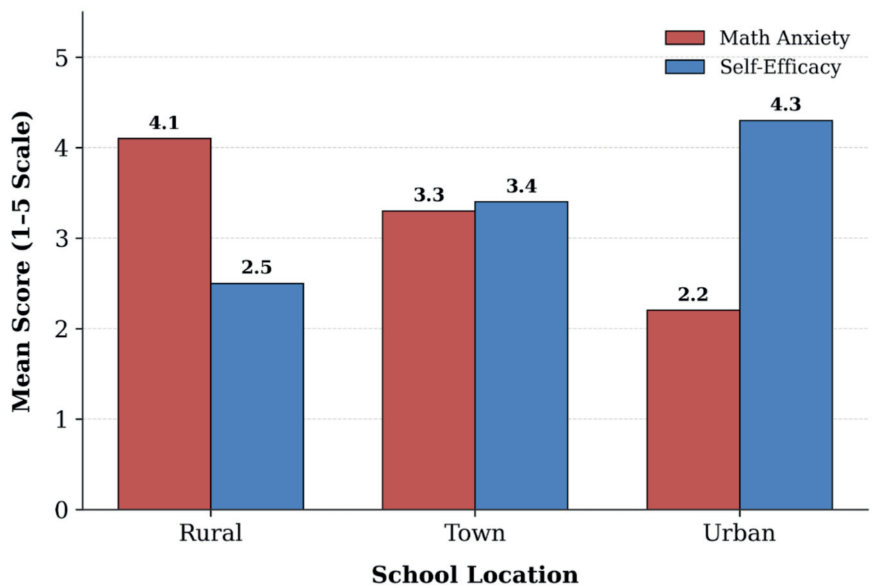


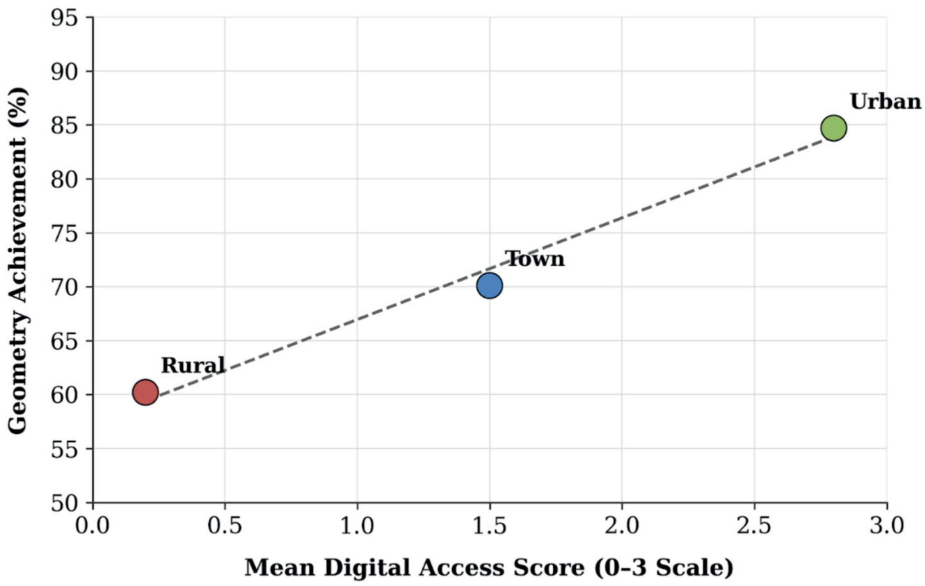
Figure 2 Comparison of math anxiety and self-efficacy mean scores by school type



symmetry and repeating patterns, and 38 could explain periodicity. This indicates high potential for cultural bridging, but it is not used. In the town school, one teacher briefly showed a picture of a mosque ornament for 2 minutes; students appeared more attentive during that segment. In the urban school, no cultural examples were used at all; instead, the teacher relied on GeoGebra for visualizations.

All three teachers interviewed agreed that math anxiety is a problem, but only the urban teacher had explicit strategies to reduce it (group work, positive reinforcement). The rural teacher stated: “We have beautiful carpets at home, but I never thought to use them to teach symmetry.” None of the teachers had received training on integrating cultural elements into geometry lessons. The town teacher mentioned: “The curriculum is overloaded; I have no time to prepare cultural examples.”

Figure 3 Correlation between mean digital access score (0–3 scale) and geometry achievement (%) with linear regression trend (r = 0.68).



After the achievement test, students were shown three images (carpet, architectural tile, traditional embroidery) and asked to describe geometric features. Urban students gave more technical descriptions (e.g., "rotation," "translation") due to prior digital exposure; rural students gave accurate intuitive descriptions (e.g., "the pattern repeats," "it turns around") but lacked formal vocabulary. This suggests that cultural artifacts can serve as effective cognitive scaffolds, regardless of digital access.

DISCUSSION

This study provides the first systematic evidence in Azerbaijan on how psychological and cultural factors influence geometry learning among 10–12 year olds in different school settings. The results confirm that math anxiety and self efficacy are strong predictors of geometry achievement, consistent with international findings (Ashcraft, 2002; Luttenberger et al., 2018). Rural students exhibited the highest anxiety (4.1/5) and lowest self efficacy (2.5/5), corresponding to their low achievement (60%). Urban students, with better digital resources and more varied teaching methods, showed the opposite pattern (achievement 85%, anxiety 2.2, self efficacy 4.3). The correlation between digital access and achievement (r=0.68) underscores the digital divide as a major barrier in rural areas – a finding that mirrors studies from other developing regions (Olkun, 2003; Hodgson, 2004).

However, the most striking result is the disconnect between cultural potential and actual practice. Although Azerbaijani culture is rich in geometric patterns (carpets, architecture, textiles), these elements are virtually absent from geometry lessons. Yet when students were exposed to such images, they quickly recognized symmetry, periodicity, and transformations – even without formal instruction. This aligns with Vygotsky's (1978) concept of the "zone of proximal development": cultural tools can mediate learning when introduced by a teacher. Bruner (1966) also argued that learning becomes more effective when connected to the learner's cultural background. The present study extends these theories by showing that in a post Soviet educational context, teachers lack both training and time to implement culturally grounded pedagogy, representing a missed opportunity.

Unlike previous research that treated cultural factors as a secondary variable (e.g., Nunes, 1993; Leung, 2001), this study explicitly measured the absence of cultural integration and demonstrated its potential through exploratory probes. The fact that rural students – who have lower digital access – could still articulate geometric properties of carpets suggests that cultural artifacts could be a low cost, high impact intervention. However, this requires curriculum redesign and teacher professional development. Another important finding is the interaction between psychological factors and school location. Rural students' higher anxiety may stem not only from limited resources but also from exam pressure, lower parental support in mathematics, and lack of exposure to varied teaching methods. The urban school's use of collaborative learning (group problem solving) likely reduced anxiety, as recommended by Leung (2001). Thus, psychological and cultural factors are not independent: a supportive environment that includes both digital tools and culturally relevant materials can simultaneously raise self efficacy and lower anxiety.

LIMITATIONS

This study has several limitations. First, the sample is limited to three schools and 150 students, so findings cannot be generalized to all of Azerbaijan. Second, the cross sectional design does not allow causal inferences. Third, the exploratory presentation of cultural images after the test was not a controlled intervention; future research should use a pre test/post test experimental design with a culturally enriched curriculum. Fourth, self report scales may be subject to social desirability bias. Finally, the study did not measure parental attitudes or home environment, which could influence both anxiety and cultural exposure.

CONCLUSION

This research demonstrates that math anxiety, self efficacy, and access to digital resources significantly affect geometry achievement among Azerbaijani students, with rural learners at a distinct disadvantage. More importantly, it reveals that cultural elements – particularly geometric patterns in carpets and architecture – are almost never used in geometry teaching, despite their clear potential to make abstract concepts tangible and engaging. Addressing the rural urban gap requires a three pronged approach: (1) equitable provision of digital tools and internet access; (2) teacher training on reducing math anxiety (e.g., collaborative learning, positive feedback); and (3) curriculum integration of local cultural artifacts as low cost, high relevance teaching materials. Future research should develop and test a culturally enriched geometry module in a controlled trial, and examine long term effects on both achievement and math anxiety. By simultaneously addressing psychological and cultural dimensions, Azerbaijan can transform geometry education into a more inclusive, motivating, and effective experience for all students.

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