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Bridging the Gap: Aligning High School and University Mathematics Curricula in Albania

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Abstract: This paper evaluates the discrepancy in mathematics education between high school and higher education within STEM disciplines in Albania, focusing on the issues caused by curriculum gaps. It addresses the educational challenges hindering students' transition from high school to university and underscores the importance of aligning educational content across levels to enhance student preparedness for advanced studies. This study builds on analyses of educational transitions, emphasizing the impact of curricular disparities on student preparedness for higher education. It explores the shift towards application-focused content in high school mathematics textbooks at the expense of foundational scientific concepts. The research involved a comparative analysis of Albania's high-school and university mathematics textbooks, concentrating on content alignment and pedagogical strategies relative to real-world applications and rigorous academic requirements. Findings reveal a significant gap between the mathematical competencies developed at the high school level and those required in higher education, leading to increased academic pressures and forcing university professors to fill pre-existing knowledge gaps. These insights are vital for curriculum developers and educators, advocating for integrated curricula that improve educational continuity and student outcomes. This paper contributes to the educational discourse by promoting curriculum reforms that prepare students for the demands of higher STEM education, aiming to enhance the quality and competitiveness of Albanian STEM education internationally.

Keywords: curricular discrepancies; educational transition; STEM challenges; math textbooks

1. Introduction

An educated individual, proficient in all dimensions of knowledge, is the archetype of the future—equipped with the essential skills and competencies to tackle forthcoming challenges. This individual possesses a comprehensive understanding across various fields and dimensions of education, oriented towards future needs rather than the demands of contemporary society. The acquisition of knowledge and development of skills are grounded in the necessity for young people to take responsibility for their lives, engage as active citizens, and integrate successfully into the labor market.

Globally, there is a notable trend in sciences, particularly mathematics, to shift from their abstract (theoretical) nature towards a more practical orientation. This shift is driven by demands from daily life

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and the labor market. Consequently, educational institutions are now tasked with shaping individuals who are practical: capable of addressing everyday situations, making optimal decisions from various alternatives, understanding and managing diverse phenomena, and planning their lives effectively.

In Albania, educational texts, especially in mathematics, have aligned with this global trend. Over the past decade, textbooks across primary, lower secondary, and upper secondary education have been entirely revised, drawing from models used by Oxford, Cambridge, and other renowned institutions.

Mathematics textbooks have been significantly transformed, shedding their abstract nature in favor of practical applications relevant to everyday life and other scientific disciplines. The difficulty level has been adjusted to reduce anxiety and prejudice among students towards mathematics. While topics such as statistics and probability have been introduced, there has been a reduction in the coverage of functions, equations, inequalities, limits, derivatives, and integrals.

This reconceptualization of mathematics education offers numerous benefits in creating practical individuals and enhancing young people's awareness of mathematics' importance. However, after many years, this approach has also revealed certain challenges and problems inherent in this conceptual framework.

"Mathematics is the queen and servant of all sciences" — E. T. Bell. This expression can be broken down as follows:

1. Across all sciences and in everyday life, numerous problems arise that demand solutions. Mathematics addresses these problems by creating abstract symbols, formulating statements and theorems, and ultimately validating these through proof. This function of mathematics as the "queen" underscores its central role, as most problems across disciplines turn to it for resolution;

2. After establishing these solutions, mathematics integrates them along with algorithms and theorems into the fabric of each science, making them applicable as needed. This illustrates its role as a "servant" to all sciences.

From this perspective, the abstract nature of mathematics is indispensable. While it can be enriched with real-life situations and applications from other sciences, it cannot be stripped of its abstract core without losing its essence.

There has always been a significant difference in the content and rigor of mathematics textbooks between high school and university education. This is due to the fact that students who continue their education and attend university typically have a higher degree of maturity and mental capacity, and they often possess a special inclination toward scientific subjects.

However, the new high school curriculum in recent years has created a substantial gap and discontinuity between these two stages. The current high school school mathematics textbooks aim to prepare students for practical everyday situations. While this approach forms practical individuals, it has created a significant problem for the intellectual development of the country. The focus on real-life applications has led to the replacement of fundamental scientific and abstract mathematics topics with more applied topics.

Meanwhile, university-level mathematics in natural sciences remains aligned with global standards and cannot lower its academic requirements. Consequently, the gap between high school and university mathematics has widened, leading to unfair competition between Albanian and foreign students and diminishing the scientific and intellectual caliber of our students.

University mathematics professors are unable to bridge the knowledge gaps left by high school education, resulting in an overwhelming burden for first-year students. This often leads to frustration and discouragement, prompting some students to change their major or lower their academic expectations, accepting mediocre grades. One of the most severe consequences is the abandonment of studies, with students mistakenly believing that the problem lies within themselves.

This study was initiated to explore several critical questions regarding the impact of changes in mathematics curricula. Specifically, we are interested in addressing the following questions:

- What are the effects of changing mathematics textbooks on the development of logical reasoning in young people who have an inclination towards scientific fields?
- How do the changes in mathematics textbooks affect the quality of students who aspire to pursue scientific disciplines?
- What challenges do mathematics professors face in these scientific branches?

1.2. Methodology

1. Comparative Analysis of High School Textbooks: New and previous high school mathematics textbooks were analyzed to compare the amount of practical applications and abstract theoretical concepts they contain. Specific attention was given to the concepts of limits, derivatives, and integrals, which have significant applications in everyday life and other sciences;

2. Teacher Questionnaire: A questionnaire was developed and distributed to mathematics teachers to gather their insights on the positive and negative aspects of the revised textbooks in light of the changes implemented;

3. University Syllabi Analysis: The mathematics syllabi of scientific branches at various universities were studied, focusing on how they address the three aforementioned elements/topics;

4. Professor Questionnaire: Another questionnaire was created for mathematics professors at different universities to assess their perceptions of students' understanding and assimilation of mathematics in these scientific branches.

2. Comparative Analysis of High School Textbooks

In Albania, high school textbooks, including those for mathematics, have undergone three significant changes in the past 20 years. However, this study focuses on two specific periods:

1. Current Mathematics Textbooks: The new textbooks currently in use;

2. Previous Mathematics Textbooks: The textbooks used before the most recent changes.

In the previous curriculum, mathematics textbooks were structured into two distinct levels:

- Basic Mathematics;
- Advanced Mathematics (optional).

Both levels were taught over the three years of high school. Advanced mathematics was optional and began in the tenth grade, while basic mathematics was covered throughout all three years. For this study, we focused on the concepts of limits, derivatives, and integrals due to their extensive applications, which align with the practical orientation of the new textbooks. In the previous curriculum, these concepts were covered over two consecutive years (11^{th} and 12^{th} grades) in both the basic and advanced texts.

The detailed comparison of the coverage of these topics in the textbooks from both periods is as follows:

Table 1. Basic Mathematics Topics

Grade 11			Grade 12			Total
Limit	Derivative	Integral	Limit	Derivative	Integral	
22	-	-	7	32	17	78

Table 2. Advanced Mathematics Topics

Grade 11			Grade 12			**Total**
Limit	Derivative	Integral	Limit	Derivative	Integral	
5	-	-	1	6	3	**15**

In the previous curriculum, high school mathematics textbooks covered a total of 93 topics on the key concepts of limits, derivatives, and integrals. Specifically, the basic mathematics textbooks included 78 topics on these concepts, while the advanced mathematics textbooks covered 15 topics. Analysis of matura exam results from those years shows that approximately 70% of graduates correctly solved exercises on limits and derivatives, whereas only 40-50% managed to correctly solve exercises on integrals. This suggests that students generally found the concepts of limits and derivatives easier to understand, while they perceived integrals as more difficult.

In the new textbooks, the number of topics related to the key concepts of limits, derivatives, and integrals has been reduced to make room for the inclusion of everyday life mathematics applications. Additionally, these three concepts are now covered only in one school year, specifically the 12^{th} grade. The extent of their coverage in the new curriculum is as follows:

Table 3. New Curriculum Grade 12

Basic Mathematics			Advanced Mathematics			**Total**
Limit	Derivative	Integral	Limit	Derivative	Integral	
-	5	4	-	7	6	**22**

As observed from the table, the new curriculum includes only 22 topics on the key concepts of limits, derivatives, and integrals, compared to the 93 topics in the previous curriculum. A test conducted on 200 students from various high schools for our study revealed that only 20% of students answered derivative exercises correctly. Furthermore, only 9% could correctly apply the derivative as a rate of change, despite the exercises being of a basic level. These findings suggest that the reduction in topics and the lack of theoretical treatment are significant factors contributing to these results.

3. Teacher Questionnaire Results

A sample of 100 high school mathematics teachers was randomly selected and surveyed about the innovations and challenges introduced by the new mathematics textbooks, which have increased the focus on applications while reducing the theoretical content. The questionnaire covered various topics, but only those related to this study were considered.

The years of work experience among the teachers who participated in the questionnaire are as follows:

Table 4. Years of Experience

5 – 10 years	10 - 20 years	Over 20 years
30%	55%	15%

Nearly 70% of the teachers surveyed have more than 10 years of experience, enabling them to effectively compare the old and new textbooks. Consequently, only the responses from teachers with more than 10 years of experience were considered in the analysis of the following questions.

Regarding the question on the estimated impact of the lack of limit topics on the explanation of the derivative, the results were as follows:

Table 5. Impact Percentage

Not at all	A little	Enough	A lot
0%	9%	48%	36%

As can be seen from the responses, nearly 84% of the teachers believe that the absence of "limit" topics in the new mathematics textbooks has significantly impacted the explanation of the derivative. An interesting element extracted from the questionnaires pertains to the results of these two questions:

1. Is teaching the derivative in the new textbooks easier or more difficult for teachers?

Table 6. Q1 Results

Yes	No
79%	21%

2. How do your students perceive the concept of the derivative?

Table 7. Q2 Results

Easy	Hard
39%	61%

According to the teachers, nearly 80% find that the new textbooks, with their limited topics and reduced hours devoted to the derivative, make it easier to teach this concept. This is because the new textbooks cover only one rule (the power rule for x^n) and three applications of this rule. However, there is a contradiction in how students perceive this concept. According to 61% of the teachers, students find the derivative difficult. This suggests that the reduction and simplification of mathematics topics do not necessarily lead to better understanding and perception of mathematical concepts; in fact, they can have the opposite effect, as seen in this case. This conclusion is further supported by the test results mentioned earlier.

When asked about the impact of the reduced number of topics on limits, derivatives, and integrals in the new textbooks on students who plan to pursue scientific fields, the responses were as follows:

Table 8. Impact on Students Pursuing Scientific Branches

Negative	Positive
97%	3%

The conclusion is reinforced that the absence or reduction of certain theoretical concepts will exacerbate the gap between high school and university education. This will place students in a difficult position regarding the assimilation of mathematical concepts at the university level and will hinder professors in effectively teaching these concepts.

4. University Mathematics Syllabi Analysis

The reduction of theoretical topics in the new curriculum, replaced largely by applications in daily life and other sciences, has widened the gap between high school and university, particularly in scientific branches.

Positive Aspects of the New Textbooks:

1. They demonstrate to young people the practical utility of mathematics in everyday life;

2. They cultivate a practical and resourceful youth capable of solving everyday problems;

3. They make mathematics a more attractive subject;

4. They introduce students to numerous applications across various sciences;

5. They prepare students for decision-making on various life problems.

4.1. Challenges and Issues

However, along with these positive aspects, several problems arise. The new textbooks lack definitions, theorems, mathematical properties, proofs, and other abstract aspects of mathematics. While these abstract elements can indeed create anxiety and insecurity among students, they also foster logical development and confidence, especially in students inclined toward scientific subjects. At the end of high school, these students will pursue scientific disciplines at universities, and among them will emerge scientists who solve future challenges, teachers who educate the next generation, engineers who create remarkable works, architects who design groundbreaking projects, programmers who innovate and enhance business operations, and managers and financiers who stabilize economies and manage crises.

Therefore, the balance between theoretical and practical topics needs to be carefully considered, incorporating real-life applications. Below, we illustrate the significant gap between high school and university mathematics education by examining three crucial mathematical concepts: limits, derivatives, and integrals, and their representation in the syllabi of various domestic and international universities.

Table 9. University Mathematics Courses

	Computer Science UAMD - Durrës	Mechatronic Engineering UBT - Tirana	Faculty of Business Tirana	Management & Technology TU - Munich	Business, Economics, Social Sciences Marquette - US
Limit	27%	20%	7%	15%	4%
Derivative	27%	27%	27%	15%	29%
Integral	20%	33%	20%	15%	12%
Total	**74%**	**80%**	**54%**	**45%**	**45%**

As observed from the table, in the first year of various university programs, the concepts of limits, derivatives, and integrals together constitute between 45% to 80% of the curriculum. In Natural Sciences faculties (Albania), these concepts account for nearly 100% of the entire subjects such as Analysis 1. These topics are introduced with the expectation that incoming students possess sufficient knowledge from high school. However, as seen in the new high school textbooks, the limit concept is not addressed at all, while derivatives and integrals are covered in only 4 to 6 topics. This discrepancy is a major factor contributing to the widening gap between high school and university education. This increasing gap has several significant consequences:

1. Decreased Interest in Scientific Fields: Graduates lose interest in scientific disciplines due to their inability to handle the heavy academic load at the beginning of their university studies. This leads to dissatisfaction, uncertainty about their abilities, and a perception of personal failure, despite their initial interest in these fields. The root cause of this failure is not their lack of ability or inclination but the absence of scientific elements in high school mathematics texts, which provide only minimal knowledge through practical mathematics topics. Students often misinterpret this as a personal shortcoming, resulting in dissatisfaction with the field and the professors. Consequently, many students either leave these fields or avoid choosing them altogether, which negatively impacts the development of intellectual talent in the nation. According to studies conducted on university enrollment in Albania (INSTAT - EDUCATION) for the academic year 2023-2024, the total number of university students has decreased by 43%. Over the past five years, there has been a 10% decrease, largely attributed to the emigration of young people. Notably, the number of students in scientific fields has decreased by 61% over the same period. This significant decline cannot be solely attributed to youth emigration; a major contributing factor is the substantial gap in scientific subjects between high school and university, which deters young people from choosing scientific disciplines;

2. Challenges for Science Professors: University professors, particularly in mathematics, face significant challenges as students struggle to keep up with their courses. To address this issue, professors are employing various strategies:

a) Preparatory Courses: Some universities, such as the Faculty of Natural Sciences in Tirana, offer preparatory courses to bridge the gaps in students' mathematical knowledge. While this is a positive step, it presents problems: the condensed timeframe for teaching mathematical concepts that would normally require much longer to assimilate, and the additional burden on professors who essentially assume the role of high school teachers;

b) Reduced Academic Rigor: Professors are lowering the difficulty level of their courses by removing advanced scientific topics and dedicating more time to remedial mathematics, thereby compensating for the deficiencies in high school education.

These conclusions are supported by data collected from a questionnaire completed by 40 mathematics professors across various universities in Albania.

5. Professor Questionnaire Results

Based on the results from questionnaires distributed to high school mathematics teachers, highlighting their complaints about the new textbooks' focus on everyday life applications, a subsequent questionnaire with open questions was developed for 40 mathematics professors across various university branches. The open-ended questions aimed to uncover the professors' concerns regarding the academic readiness of incoming students and the challenges faced during lectures.

The professors identified two main issues:

1. A decline in the number of young people enrolling in scientific fields;

2. A notably low academic level among those who do enroll in these fields.

Several factors contributing to these issues were identified:

1. Emigration of young people for work or studies abroad;

2. The new mathematics textbooks are more practical and less focused on logical and theoretical aspects, which are crucial for pursuing scientific degrees;

3. Significant educational gaps resulting from online learning during the pandemic.

The professors expressed a major concern about the intellectual decline in Albania, which could eventually lead to a shortage of specialists in numerous fields, including economics, engineering, and the sciences.

6. Conclusions

1. The shift of mathematics textbooks towards practicality and real-life applications has made the subject more engaging and enjoyable for young people. However, this approach diminishes the development of logical reasoning and proof skills, as well as the acquisition of the fundamental knowledge necessary for pursuing scientific fields in universities.

2. The absence of theoretical content in the new mathematics textbooks has exacerbated the gap between high school education and scientific disciplines at the university level.

3. This widening gap has resulted in a domino effect, leading to a decline in the number of students enrolling in scientific fields and, consequently, a decrease in graduates in these areas.

4. Furthermore, this gap necessitates university professors to revisit high school material to address the deficiencies in knowledge that students bring from their high school education.

7. Recommendations

1. In highghschool, Advanced Mathematics should be introduced in the 10th grade, encompassing the theoretical, abstract, logical, and proof-based aspects of the subject. This course should be optional and designed for students with a strong inclination towards scientific subjects who aspire to pursue scientific fields in the future.

2. Within high schools, distinct scientific and social classes should be established, each focusing on the relevant mathematics curriculum, allowing students to choose which class to attend based on their interests and future aspirations.

3. Moreover, there should be high schools with distinct profiles: scientific and social. This practice, observed in countries like Italy, would enable students to select their preferred school profile. Each profile would have corresponding mathematics textbooks tailored to the specific focus of the curriculum.

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