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Analysis of High School STEM Program Impact on Students' University Performance

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Abstract- The rapid progress of information technology has led to significant changes in the economy, professional development, and interactive communication throughout the entire global life of society and the education system has become a promoter of this wave of change. In the school's integrated curriculum, mathematics and natural sciences form the core of preparing students for university studies. Subjects related to these areas are associated with the STEM (Science, Technology, Engineering, and Mathematics) groups. This article examines the high school STEM program's impact on their university performance in the subject of mathematics. The study examines the high school matura test and calculus test outcomes of the same students, divided into STEM and non-STEM groups. The purpose is to compare the outcomes in order to assess the impact of the high school STEM program on students' university performance.

Keywords: STEM, High School, Performance, University, Curricula.

I. INTRODUCTION

The impact of high-quality STEM programs (Science, Technology, Engineering, and Mathematics) education in high school on students' university performance is a key factor in their overall academic journey. High school STEM education builds a crucial foundation for those pursuing STEM fields in higher education. It offers a comprehensive curriculum that not only covers specific knowledge but also develops problem-solving abilities, creativity, and a STEM-oriented mindset. This foundation prepares students to tackle more advanced coursework in university and excel in their chosen disciplines [1].

High school STEM education fosters a mindset of critical thinking, resilience, and innovation. This helps students handle complex challenges in their university studies and future careers. It encourages them to view obstacles as chances to learn and grow. Such preparation is essential for transitioning smoothly into higher education [2].

University STEM programs demand a solid academic base, and high school STEM courses often meet university entry requirements. This alignment helps students transition effortlessly into higher education, where they are better prepared to understand complex concepts and engage deeply in their studies from the start [3].

A strong link exists between high school and university performance. Success in high school is a good predictor of university success. Students who perform well in high school STEM subjects are more likely to continue their success at the university level. A solid high school foundation not only helps with advanced topics but also enhances students' confidence, paving the way for high academic achievements [4].

Effective teaching methods in high school STEM education are vital for engaging students and deepening their understanding of STEM topics. Techniques like project-based and inquiry-based learning promote critical thinking, creativity, and hands-on experience. Good teaching practices also develop teamwork, communication, and problem-solving skills, which are crucial for university STEM programs [5].

STEM education is more than just academic study; it drives individuals toward a promising future and equips them with tools to impact the world. In today's fast-evolving technological landscape, proficiency in STEM is highly valued by both employers and educational institutions [6]-[7]

The demand for strong STEM education is highlighted by the fact that STEM careers are among the fastest-growing and highest-paying. High schools are essential in fostering students' interest, skills, and capabilities in STEM subjects to prepare them for these lucrative fields [8] –[9].

Interacting with successful STEM professionals can significantly boost students' ambitions and confidence. Students who engage with industry experts and gain real-world STEM experiences are more inclined to pursue STEM careers in university. Enthusiastic STEM teachers can spark students' curiosity and guide them towards STEM career paths, shaping their perceptions and providing career insights [10].

High school STEM education imparts more than just technical knowledge; it fosters a mindset of problem-solving, resilience, and innovation. Students with this STEM mindset are better prepared to face complex problems, adapt to changes, and see challenges as learning opportunities [10].

Developing a growth mindset through STEM education enhances not only academic performance but also persistence and adaptability. This mindset helps students break down complex issues, develop hypotheses, and conduct experiments, providing a strong basis for university coursework [11]-[12].

Aligning high school STEM courses with university requirements is crucial for students' readiness for higher education. High school STEM classes introduce key concepts that are relevant to university-level studies [13].

High school academic success is a strong indicator of university achievement. Students who excel in high school STEM subjects tend to carry their success into university STEM programs, benefiting from a solid academic base that boosts their understanding and confidence, leading to high academic success [14]-[15].

STEM education is increasingly recognized in Albania for its role in preparing students for the modern workforce and global economy. The Albanian education system has incorporated STEM subjects into school curricula, starting from an early age, to build a solid foundation in these areas [16].

Efforts are being made to improve teacher training in STEM fields, enhancing the quality of instruction. The first phase of this initiative, completed in the 2021–2022 school year, involved training 30 teachers and featuring over 50 student projects, with the top four being selected. The second phase focuses on training teachers and students aged 12–14 across 60 schools [17]-[18].

The Albanian Ministry of Education has implemented several measures to boost STEM education, including revising curricula to include more STEM subjects, improving teacher training, and investing in school resources [19]-[20]. Albanian universities are also advancing STEM education by offering relevant degree programs and research opportunities [21].

Factors influencing university performance in Albania include:

Type of school: general high school, professional;

School performance: ranking, tradition, history, teachers' commitment, reputation;

Students: personal skills, commitment, background, study time spent, motivation;

Family: economic level, culture, parental commitment, and help;
Curricula and programs: textbooks, teaching methods, independent work;
Class and homework: projects and assignments,
Programs: STEM program, advanced studies, olimpiads.

II. MATERIALS AND METHOD

The variables that will be analyzed in this article are: the result of the high school Matura and their first year at the university in the mathematics program. The sample contains a group of 124 high school students who continued in different programs at the university: mechanical engineering at the Tirana Politechnic University, mathematics and informatics at the University of Durres, and finance at the University of Tirana. The group class contains 85 STEM students, and 39 non-STEM students, 34 boys, and 90 girls. The Calculus course (or Analyses 1) is chosen considering the familiarity with mature mathematics; it contains well-known topics such as sets, functions, domains, derivatives, integrals with applications, etc.
M. Office Excel is used to calculate descriptive statistics (tables 1, 2; t-paired test) for the data (STEM (Non-Stem Matura and University), tables 3, 4; and SPSS is used to calculate descriptive statistics, histograms, and Q-Q plots to verify the Normal Distribution of data groups (Figures 1–6).

Table 1. Matura results, STEM and No- STEM groups.

STEM MATURA		**NON-STEM MATURA**	
Mean	87.36470588	Mean	82.1025641
Standard Error	0.463770643	Standard Error	0.680155249
Median	88	Median	81
Mode	85	Mode	81
Standard Deviation	4.275754066	Standard Deviation	4.24756817
Sample Variance	18.28207283	Sample Variance	18.04183536
Kurtosis	-0.051761227	Kurtosis	-0.560587838
Skewness	-0.331789798	Skewness	0.111847648
Range	20	Range	16
Minimum	75	Minimum	73
Maximum	95	Maximum	89
Sum	7426	Sum	3202
Count	85	Count	39

Table 2. Unıversıty results, STEM, No-STEM.

STEM UNIVERSITY		NON-STEM UNIVERSITY	
Mean	66.56470588	Mean	56.41025641
Standard Error	0.984110037	Standard Error	1.288754406
Median	68	Median	55
Mode	72	Mode	64
Standard Deviation	9.07304624	Standard Deviation	8.048268688
Sample Variance	82.32016807	Sample Variance	64.77462888
Kurtosis	0.091110839	Kurtosis	-1.082277957
Skewness	-0.858038353	Skewness	-0.312122615
Range	36	Range	30
Minimum	44	Minimum	38
Maximum	80	Maximum	68
Sum	5658	Sum	2200
Count	85	Count	39

Table 3. t-Test: Paired Two Sample for Means

	STEM MATURA	STEM UNIVERSITY
Mean	87.36470588	66.56470588
Variance	18.28207283	82.32016807
Observations	85	85
Pearson Correlation	0.591183848	
Hypothesized Mean Difference	0	
df	84	
t Stat	25.92070735	
P(T<=t) one-tail	3.86425E-42	
t Critical one-tail	1.663196679	
P(T<=t) two-tail	7.7285E-42	
t Critical two-tail	1.988609667	

Table 4. t-Test: Paired Two Sample for Means

	NON-STEM MATURA	NON-STEM UNIVERSITY
Mean	82.1025641	56.41025641
Variance	18.04183536	64.77462888
Observations	39	39
Pearson Correlation	-0.224503024	
Hypothesized Mean Difference	0	
df	38	
t Stat	16.1940281	
P(T<=t) one-tail	6.0227E-19	
t Critical one-tail	1.68595446	
P(T<=t) two-tail	1.20454E-18	
t Critical two-tail	2.024394164	

Table 5. SPSS- descriptive statistics.

STATISTICS					
		MATSTEM	MATNOSTEM	UNSTEM	UNNOSTEM
N	Valid	85	39	85	39
	Missing	0	46	0	46
Mean		87.3647	82.1026	66.5647	56.4103
Std. Deviation		4.27575	4.24757	9.07305	8.04827
Skewness		-.332	.112	-.858	-.312
Std. Error of Skewness		.261	.378	.261	.378
Kurtosis		-.052	-.561	.091	-1.082
Std. Error of Kurtosis		.517	.741	.517	.741
Minimum		75.00	73.00	44.00	38.00
Maximum		95.00	89.00	80.00	68.00

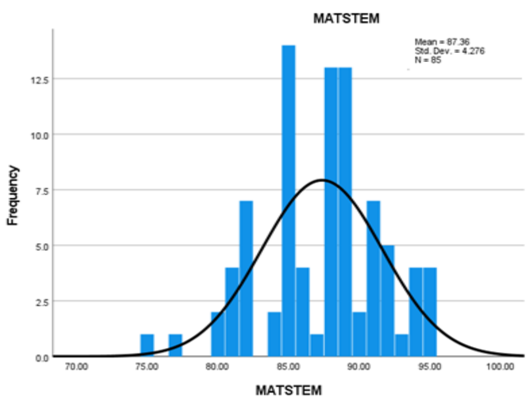

Fig.1 Histogram, Matura STEM

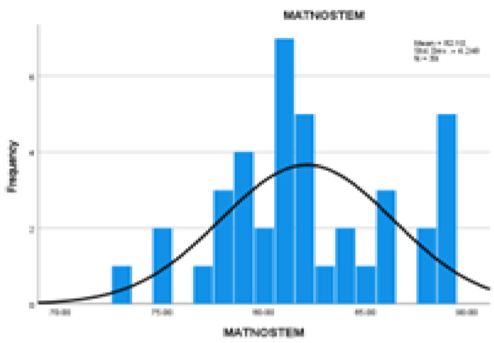

Fig. 2 Histogram, Matura Non-STEM

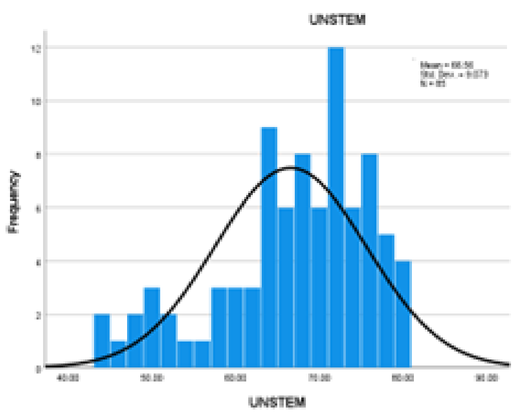

Fig.3 Histogram, University STEM

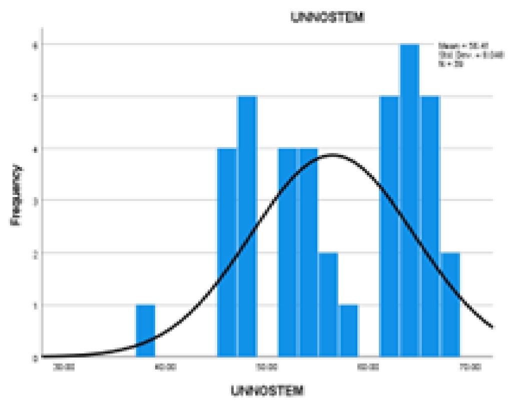

Fig. 4 Histogram, University Non-STEM

Q-Q Plot (Quantile-Quantile Plot)

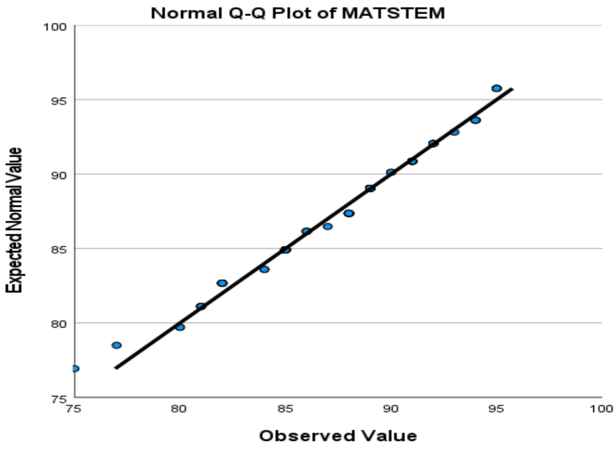

Fig. 5. Matura STEM

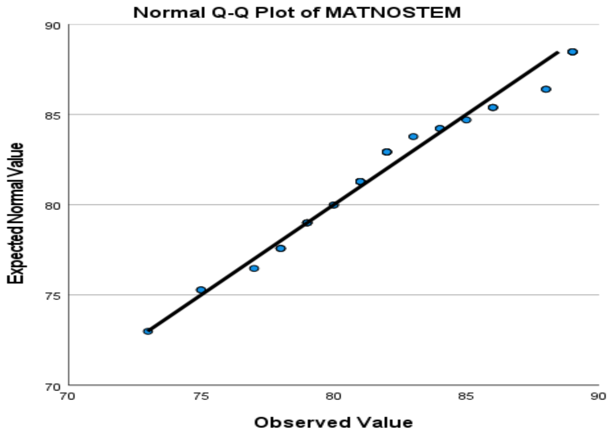

Fig. 6 Matura Non-STEM

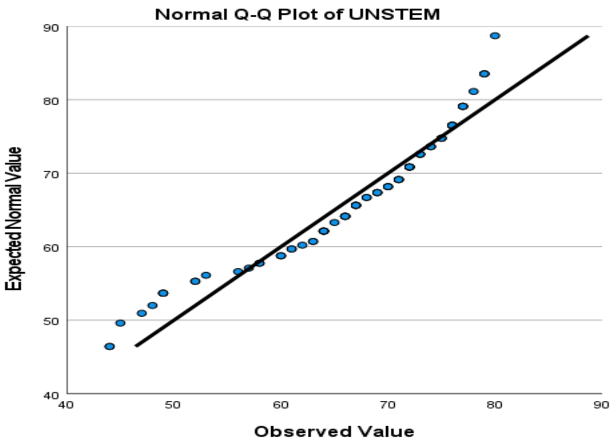

Fig. 7. University STEM

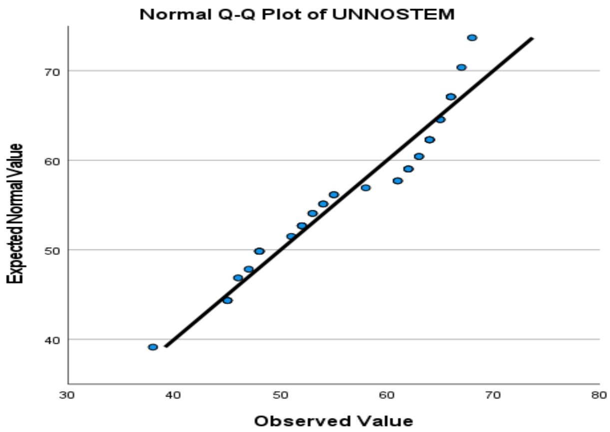

Fig. 8 University Non-STEM

III. RESULTS AND CONCLUSION

Comparative analyses have been performed to verify whether there are any significant differences in students' academic achievement in terms of STEM or non-STEM groups.

Descriptive statistics show that the means of Matura scores for the groups (STEM and non-STEM) are approximately equal, and the same situation exists among the Calculus score means of groups (STEM and non-STEM). The mean of STEM is higher than the non-STEM scores.

The results of the t-paired test also show that there are differences in means among the Matura and Calculus groups (STEM and non-STEM).

Generally, there is a significant difference between the means of Matura and Calculus scores, $p = .000 < .05$ (the Matura average score is significantly lower than the university average score, meaning that students generally perform badly in the first year of university and the high school program doesn't help them effectively, even the STEM program).

There is also a significant difference between the means of Matura and Calculus scores for non-STEM groups, $p = .000 < .05$ (even in university programs with basic mathematics).

There is a significant difference between the means of Matura and Calculus scores for the STEM group, $p = .000 < .05$, meaning that also the STEM program students perform very badly during university years and the STEM high school program is not effective.

IV. CONCLUSIONS

Several conclusions are drawn from the results:

Many considerable factors affect the students' performance in high school and university; some of the main factors are personal skills, commitment, attention, family background, type of school, motivations, purpose, etc.

In general, there is a significant difference between student performance when comparing results in high schools and universities, so the high school programs need to be re-evaluated.

The main reason for the almost drastic decline in student performance at university is the lack of preparation during high school; one of the main factors that have caused this are the frequent changes, which have weakened the system, the curricula, and the textbooks.

Albanian universities should get involved in the process of improving pre-university performance and quality, especially in high school.

As high school STEM education continues to evolve, further research and policy initiatives are needed to ensure access to quality STEM education and to prepare students for success in university and beyond.

Addressing resource limitations, improving teacher quality, and promoting gender inclusivity are vital to overcoming the challenges faced by STEM education in Albania. Despite efforts to improve infrastructure and provide resources, Albania still faces challenges in adequately equipping schools with modern STEM facilities and materials.

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