https://doi.org/10.53656/math2025-3-2-saa

Educational technologies
Образователни технологии

STATISTICAL ANALYSIS OF ACADEMIC ACHIEVEMENT AND INTRINSIC MOTIVATION IN STEM STUDENTS EDUCATED THROUGH A COMPETENCY-BASED APPROACH

Muharem Mollov[1)], Dimitar Stoitsov[1)], Gencho Stoitsov[1)]
[1)] Paisii Hilendarski University – Plovdiv (Bulgaria)

Abstract. This study explores the impact of Competency-Based Education (CBE) on students' academic performance in selected STEM disciplines and on their intrinsic motivation. In the context of growing interest in STEM (Science, Technology, Engineering, and Mathematics), the research examines whether the implementation of CBE can enhance student achievement and foster deeper motivation. The study was conducted with two groups of students from "Hristo Botev" High School in the village of Chepintsi. To assess intrinsic motivation, questionnaires were administered before and after the CBE intervention. Academic achievement was evaluated through tests and grades. The working hypothesis suggested that CBE would positively affect both academic outcomes and intrinsic motivation. The results support this hypothesis, highlighting the potential of CBE as an effective educational approach for developing young STEM learners. The findings indicate that CBE contributes not only to improved academic performance but also to greater interest and engagement in scientific and technological fields.

Keywords: competency-based education; motivation; STEM; CBE; PISA 2025

1. Introduction

Competency-based education (CBE) is an innovative constructivist approach that aims to enhance motivation and academic achievement through the development of practical skills aligned with the needs of the community and labour market (Biggs, 1996). According to White (1959), actions such as studying, learning, and problem-solving are driven by intrinsic motivation, which does not depend on rewards or punishments. CBE encourages both intrinsic and extrinsic motivation in students, which are key factors for its successful implementation. Intrinsic motivation is

associated with personal satisfaction and deep acquisition of knowledge (Deci & Ryan, 2000), knowledge retention, and greater engagement in the learning process (Zimmerman, 2000; Ryan & Deci, 2000; Pintrich & De Groot, 1990). In contrast, extrinsic motivation is based on receiving rewards or social approval and generally has a weaker effect (Leary & Baumeister, 2000).

According to Self-Determination Theory (Deci & Ryan, 1985), three fundamental psychological needs – autonomy, competence, and relatedness – are essential for fostering intrinsic motivation. Previous experience shows that when students feel competent and effective in performing tasks, their intrinsic motivation increases. In CBE these needs can be fulfilled through solving practical tasks and developing authentic assessment methods, which provide real-world context and encourage confidence (Ryan & Deci, 2000). Students see a direct connection between their efforts and results (Guskey, 2007).

In this study, a partial modification of the classical ADDIE model (Analyze, Design, Develop, Implement, Evaluate) is presented (Widyastuti 2019), as its use is recommended in an iterative and flexible format called the Successive Approximation Model (SAM)[3]. Each iteration includes feedback on the results achieved by the student, as well as on the difficulties encountered. This feedback is intended for both the teacher and the student and is based on quantitative and qualitative assessments of the outcomes. With each iteration, the student moves closer to the educational goal. According to Hattie (2007), timely and effective feedback is a key factor in CBE, enhancing both competence and motivation.

Students are at the center of the model, as they actively participate in the educational process and develop key competencies described in the European Qualifications Framework (EQF)[2], DigComp 2.2 (Vuorikari et al., 2022), the European[5] and American[6] STEM frameworks, and the PISA frameworks for mathematics (OECD 2017) and natural sciences[4], including competencies for both individual and team work.

Designing the study content simultaneously includes the acquisition of theoretical knowledge and the solving of practical tasks, aiming to develop skills and competencies in the natural sciences. The study materials, tasks, and resources are adapted to the students' needs. Individual competency

levels and interests are considered. The main goal of the educational process is to support students' motivation and engagement, as well as to facilitate the experience of "flow" during learning (Csikszentmihalyi, 1990).

In designing the environment and tools for STEM education, geographic information systems (GIS) may also be used[1]. Kerski (2015) identifies 12 natural connections between STEM and ArcGIS, including the logical integration of the four STEM disciplines, career orientation, alignment with national science education content standards, mathematics, climate studies, investigating STEM topics with GIS, the development of critical thinking skills, and the belief that learning is often most effective when it occurs outdoors, among others.

The assessment of the educational outcomes is a process based on continuous feedback from the students. It includes formative assessment (FA), which provides regular feedback on students' difficulties, as well as summative assessment, which is used for the certification of competencies. Formative assessment includes self-assessment (Garov, 2013; Staribratov 2021) and feedback, while summative assessment includes peer review—also called "peer assessment" (Shotlekov, 2012) – partnership checks, or expert evaluation by a commission consisting of teachers and active professionals. To ensure a realistic assessment, the product developed during the project should be tested in a real-world environment.

2. The study

2.1. The aim of the study

To check the effect of the application of CBE on the students' study results in the studied STEM disciplines and on their intrinsic motivation.

2.2. Hypothesis

Hypothesis: CBE has a positive influence on students' academic achievement in the studied STEM disciplines and enhances their intrinsic motivation.

2.3. Study methodology

In the frames of the internally institutional qualification, the pedagogical personnel passed through an education on topic CBE. For the experimental integration of CBE, a holistic approach was used for the study programs.

According to it, the study content must include real-life topics that form and expand all key competencies of the students[2]. After coordinating the team work, a team of pedagogical specialists created a summarized study program whose education units were projected to be taught in a team, according to the context of the topics. Main cores of the study program are in accordance with the PISA 2025 frames in natural sciences4 and DigComp 2.2 (Vuorikari et al., 2022). The main aim is the formation and development of competencies in the field of natural sciences and environment in personal, national and global context.

Study participants:

– Nine teachers, teaching: information technologies (IT), biology and health education (BHE), chemistry and environment protection (CEP), physics and astronomy (PA), mathematics (M), physical education and sport (PES), technologies and entrepreneurship (TE), geography and economics (GE) and English (E);

– 36 students (two samples of 18 students each), studying with the chosen methodology. After the preliminary test and practical task to determine the starting level before the experiment, one of the samples was categorized as the strong group and the other as the weak group. The results are presented below.

The study includes: 1) an analysis of the study results after the conducted CBE using the chosen methodology; 2) an analysis of the levels of the students' intrinsic motivation before and after the education. The latter is included in this work.

Tools used to obtain the data:

1. A preliminary test to determine the initial level of both groups and a final test to assess the results achieved through the experimental education.
2. Results from solving practical tasks.
3. A questionnaire measuring the level of intrinsic motivation before and after the experimental education.

2.4. Conducting CBE education with the chosen methodology

The joint education included the topics presented in Table 1.

Table 1. Topics for joint education

N	Topic	Teachers in
1.	Protection of Nature and the Environment: An Important Condition for a Healthy Life	BHE, CEP, PES
2.	Smartphone Anatomy: Valuable Materials in Devices	CEP, GE
3.	Green Energy	CEP, PA, GE
4.	Earth in Solar System	PA, GE
5.	Building Effective Ecological Energy-Yielding Systems	IT, M, PA, BHE, CEP
6.	Building an IoT-Based Forest Fire Detection System	IT, M, PA, BHE, CEP
7.	Technologies for Effective Crop Production	IT, PA, BHE, CEP
8.	ArcGIS for Supporting People and the Effective Management of Ecology and Health	IT, GE, PA, BHE, CEP, M, E
9.	Technologies for Supporting People in Danger	IT, GE, PA, BHE, CEP, E
10.	Preparation of Technical Documentation Using MS Office and TinkerCad	IT, E
11.	Financial Analysis of Project Effectiveness	TE, M, IT
12.	Skills for Successful Product Presentation to an Audience Using a Foreign Language	IT, E

Table 2. Realized projects

N	Project	Teachers in
1.	Air Quality Monitoring using Arduino IOT Cloud	IT, CEP, GE, TE, M
2.	IoT Based Forest Fire Detection System with SMS Alert	IT, PA, GE, TE, M
3.	Arduino Fire Fighting Robot with SMS and Call Alert	IT, PA, GE, TE, M
4.	Solar Tracking System	IT, PA, GE, TE, M
5.	Automatic Plant Irrigation System	IT, BHE, CEP, TE, M
6.	Portable GPS Tracker with Arduino	IT, GE, PES, M

Students worked in teams to develop the systems and robots shown in Table 2 and presented their projects to an audience in English.

The total duration was 32 hours (Joint education in theory and laboratory investigation work – 24 hours; Building integrated system or robot – 6 hours; Project presentation in front of the audience– 2 hours).

After the education was completed, the following were conducted: 1) a second questionnaire assessing motivation; 2) verification of academic results through a test.

3. Data analysis of the students' achievements

3.1. Background

The selected sample consisted of 36 students from two samples (8a and 8b) of 18 students each. Sample 8a specializes in ICT and entrepreneurship, while Sample 8b focuses on natural sciences, specifically Biology and Chemistry. Both samples were tested on their preliminary and final levels of ICT knowledge and practical skills using a theoretical test and practical tasks, respectively.

3.2. Test results

The first task was to compare the results achieved at the starting and final level for each sample. Therefore, tests for normality were applied to check if the data for each level of the two samples follows normal distribution or not.

3.3. Preliminary and final test results of Sample 8a

The Kolmogorov-Smirnov test (Table 3) returned a Sig. value below 0.05, which shows that the distribution of the test scores of Sample 8a on the preliminary test is not normal.

Consequently, the non-parametric Wilcoxon Signed Ranks test was used to verify whether there would be a statistically significant difference between the final and starting level of Sample 8a.

In Table 4 there are 10 students ("Positive Ranks") whose test scores have improved after the CBE education compared to the starting level. Additionally, the Asymp. Sig. value of 0.046 from the Wilcoxon Signed Ranks test is below 0.05, indicating a statistically significant difference

between the starting and final test results of the students in Sample 8a (Table 5).

Table 3. Normality testing of the distribution of the scores of Sample 8a from the preliminary and final tests

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	Df	Sig.	Statistic	df	Sig.
Distribution of the scores of Sample 8a on the preliminary test	.205	18	.045	.903	18	.066
Distribution of the scores of Sample 8a on the final test	.150	18	.200*	.947	18	.383

a. Lilliefors Significance Correction

Table 4. Ranking of Sample 8a students based on their final test scores compared to their preliminary test scores

		N	**Mean Rank**	**Sum of Ranks**
Ranking of students	Negative Ranks	6[a]	4.92	29.50
	Positive Ranks	10[b]	10.65	106.50
	Ties	2[c]		
	Total	18		

a. number of students with lower scores on the final test
b. number of students with higher scores on the final test
c. number of students with equal scores on the final and preliminary tests

Table 5. Significance testing of the difference between the scores of Sample 8a on the final and preliminary tests

	Significance
Z	-1.996[b]
Asymp. Sig. (2-tailed)	.046

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.
c. Based on positive ranks.

3.4. Preliminary and final test results for Sample 8b

The Kolmogorov-Smirnov test returned a Sig. value below 0.05, which indicates a distribution that is not normal. As a result, the non-parametric Wilcoxon Signed Ranks test was applied to verify if there would be a statistically significant difference between the results from the starting and final test of Sample 8b.

Table 6. Normality testing of the distribution of the scores of Sample 8b on the preliminary and final tests

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Distribution of the scores of Sample 8b on the preliminary test	.168	18	.195	.933	18	.221
Distribution of the scores of Sample 8b on the final test	.224	18	.017	.901	18	.060

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

From the ranking Table 7, it can be seen that there are 15 students given as positive ranks that improved their test scores from the start. Wilcoxon t-test, presented in Table 8, confirmed that there is a statistically significant difference between the starting and final levels of Sample 8b as it returned a Sig. value below 0.05.

Table 7. Ranking of the students from 8b group by their scores on the final test compared to their scores on the preliminary test

		N	**Mean Rank**	**Sum of Ranks**
Ranking of students	**Negative Ranks**	2[a]	4.50	9.00
	Positive Ranks	15[b]	9.60	144.00
	Ties	1[c]		
	Total	18		

a. number of students with lower scores on the final test

b. number of students with higher scores on the final test

c. number of students with equal scores on the final and preliminary tests

Table 8. Wilcoxon Signed Ranks testing of the difference in the scores of Sample 8b between preliminary and final tests

	Significance
Z	-3.201[b]
Asymp. Sig. (2-tailed)	.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

3.5. Comparison of test results between 8a and 8b groups

The distribution of the students' test scores in both samples was tested for normality. As can be seen from Table 9, Kolmogorov-Smirnov test returned Sig. value below 0.05 for the Sample 8a, which means that the distribution of the results from the theoretical test for this group deviates from normal distribution.

Although Kolmogorov-Smirnov and Shapiro-Wilk tests returned Sig. value above 0.05 for Sample 8b, a non-parametric Mann-Whitney test was used to determine if there is a statistically significant difference between the results of Samples 8a and 8b.

Table 9. Normality testing of the distribution of the scores of Samples 8a and 8b on the preliminary test

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**Df**	**Sig.**	**Statistic**	**df**	**Sig.**
Distribution of the scores of Sample 8a on the preliminary test	.205	18	.045	.903	18	.066
Distribution of the scores of Sample 8b on the preliminary test	.168	18	.195	.933	18	.221

a. Lilliefors Significance Correction

A higher mean rank equal to 23.31 can be found for Sample 8a in Table 10 compared to Sample 8b whose mean rank is 13.69. The obtained ranks confirm the results from the normality tests where the Mean value of the theoretical test scores for Sample 8a was 19.28 while that for Sample 8b

was 14.11. Consequently, Sample 8a is stronger than Sample 8b. For this reason, Sample 8a will be categorized as the strong group and Sample 8b as the weak group.

Table 10. Ranking data for groups 8a and 8b based on their scores on the preliminary test

	Group	**N**	**Mean Rank**	**Sum of Ranks**
Ranking of both groups	**strong**	18	23.31	419.50
	weak	18	13.69	246.50
	Total	36		

As can be seen from Table 11, the achieved Asymp. Sig. (2-tailed) is below 0.05, which means that the difference of 5.17 between the Mean values of the weak (8b) and the strong (8a) group is statistically significant. In other words, the students from both groups did not start from the same starting level.

The next step was to check the results of the weak (8b) group and the strong (8a) group from the test after the finish of the CBE. Firstly, normality tests were performed for both groups.

Table 11. Significance testing of the difference between the students' preliminary test scores of the strong (8a) and weak (8b) group

	Significance
Mann-Whitney U	75.500
Wilcoxon W	246.500
Z	-2.749
Asymp. Sig. (2-tailed)	.006
Exact Sig. [2*(1-tailed Sig.)]	.005[b]

a. Grouping Variable: group

b. Not corrected for ties.

As can be seen from Table 12, Kolmogorov-Smirnov returned a Sig. value below 0.05 for the weak (8b) group, which means that the data does not follow normal distribution. Consequently, the nonparametric Mann-Whitney test for two independent samples (Table 14) can be applied to verify whether there is a statistically significant difference between the results of both groups.

Table 12. Normality testing of the students' scores of the strong (8a) and weak (8b) group from the final test

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Distribution of the scores of Sample 8a on the final test	.150	18	.200*	.947	18	.383
Distribution of the scores of Sample 8b on the final test	.224	18	.017	.901	18	.060

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 13. Ranking data for the strong (8a) and weak (8b) group based on the students' final test scores

	group	N	Mean Rank	Sum of Ranks
Ranking of both groups	strong	18	20.89	376.00
	weak	18	16.11	290.00
	Total	36		

Table 14. Significance testing of the difference between the students' final test scores of the strong (8a) and weak (8b) group

	Significance
Mann-Whitney U	119.000
Wilcoxon W	290.000
Z	-1.379
Asymp. Sig. (2-tailed)	.168
Exact Sig. [2*(1-tailed Sig.)]	.181[b]

a. Grouping Variable: group

b. Not corrected for ties.

Mann-Whitney test showed a Sig. value of 0.168, which is above 0.05 indicating that there is no statistically significant difference between the mean values of the results obtained for both groups. The weak (8b) group and the strong (8a) group finish at the same level after the CBE.

3.6. Preliminary and final task scores for the strong (8a) group

Both Kolmogorov-Smirnov and Shapiro-Wilk tests returned a Sig. value below 0.05, thus, the distributions of the task scores obtained for both samples are not normal (Table 15). Consequently, the nonparametric Wilcoxon Signed Ranks test was used to verify whether there is a statistically significant difference between the scores obtained from the preliminary and final task. Table 16 shows 17 positive ranks, i.e. 17 students from the strong (8a) group have obtained higher scores on the final task compared to the preliminary task. In addition, Wilcoxon Signed Ranks Test (Table 17) returned a Sig. value below 0.05 indicating a statistically significant difference between the scores obtained on the final and preliminary tasks.

Table 15. Normality testing of the distribution of the scores of the strong (8a) group on the preliminary and final tasks

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Distribution of the scores of 8a group on the preliminary task	.374	18	.000	.610	18	.000
Distribution of the scores of 8a group on the final task	.251	18	.004	.775	18	.001

a. Lilliefors Significance Correction

Table 16. Ranking of the students from the strong (8a) group by their scores on the final task compared to their scores on the preliminary task

		N	**Mean Rank**	**Sum of Ranks**
Ranking of students	**Negative Ranks**	1[a]	1.50	1.50
	Positive Ranks	17[b]	9.97	169.50
	Ties	0[c]		
	Total	18		

a. number of students with lower scores on the final task

b. number of students with higher scores on the final task

c. number of students with equal scores on the final and preliminary tasks

Table 17. Wilcoxon Signed Ranks Significance Test of the difference between the students' scores of the strong (8a) group from the preliminary and final tasks

	Significance
Z	-3.676[b]
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

3.7. Preliminary and final task scores for the weak (8b) group

Shapiro-Wilk test returned a Sig. value below 0.05 for both samples, which means that the distribution of the scores on the preliminary and final tasks is not normal.

Table 18. Normality testing of the distribution of the scores of the weak (8b) group on the preliminary and final tasks

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Distribution of the scores of 8b group on the preliminary task	.311	18	.000	.682	18	.000
Distribution of the scores of 8b group on the final task	.189	18	.090	.880	18	.026

a. Lilliefors Significance Correction

For this reason, the nonparametric Wilcoxon Signed Ranks test was used to verify whether there is a statistical difference between the scores of the weak group (8b) on the preliminary and final tasks.

As can be seen from Table 19, there are 18 positive ranks, i.e. all students achieved higher scores on the final task in comparison with the preliminary task. Wilcoxon test (Table 20) returned a Sig. value below 0.05, which also confirmed that the difference between the scores on the final and preliminary tasks is statistically significant.

Table 19. Ranking of the students from the weak (8b) group by their scores on the final task compared to their scores on the preliminary task

		N	Mean Rank	Sum of Ranks
Ranking of students	**Negative Ranks**	0[a]	.00	.00
	Positive Ranks	18[b]	9.50	171.00
	Ties	0[c]		
	Total	18		

a. number of students with lower scores on the final task
b. number of students with higher scores on the final task
c. number of students with equal scores on the final and preliminary tasks

Table 20. Wilcoxon significance test of the difference between the students' scores of the weak (8b) group on the preliminary and final tasks

	Significance
Z	-3.734[b]
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

3.8. Comparison of task scores between the strong (8a) and weak (8b) group

Preliminary level

Kolmogorov-Smirnov and Shapiro-Wilk tests (Table 21) returned Sig. values below 0.05 indicating that the distribution of the results from the practical task for both groups is not normal.

The non-parametric Mann-Whitney test was applied to verify if there is a statistically significant difference between the results from the practical task obtained for the weak (8b) group and the strong (8a) group.

As can be seen from the test statistics, the Mann-Whitney test (Table 23) returned a Sig. value of 0.407, which is above 0.05, leading to the conclusion that there is not statistically significant difference in the starting practice levels of the students from both groups.

Table 21. Normality testing of the distribution of the preliminary task scores of the strong (8a) and weak (8b) group

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Distribution of the scores of 8a group on the preliminary task	.374	18	.000	.610	18	.000
Distribution of the scores of 8b group on the preliminary task	.311	18	.000	.682	18	.000

a. Lilliefors Significance Correction

Table 22. Ranking of the strong (8a) and weak (8b) group based on the scores on the preliminary task

	Group	N	Mean Rank	Sum of Ranks
Ranking of both groups	**strong**	18	19.78	356.00
	weak	18	17.22	310.00
	Total	36		

Table 23. Significance testing of the difference between the students' preliminary task scores of the strong (8a) and weak (8b) group

	Significance
Mann-Whitney U	139.000
Wilcoxon W	310.000
Z	−.830
Asymp. Sig. (2-tailed)	.407
Exact Sig. [2*(1-tailed Sig.)]	.481[b]

a. Grouping Variable: group

b. Not corrected for ties.

Final level

The results for both groups from the practice were tested for normality.

As can be seen from Table 24, Shapiro-Wilk test returns a Sig. value below 0.05 for the weak (8b) group and the strong (8a) group, which is sufficient to conclude that the distributions of the results from the practice

are not normal. For this reason, the non-parametric Mann-Whitney test was selected to find if there is significant difference between the results from both groups.

Table 24. Normality testing of the distribution of the scores of the strong (8a) and weak (8b) group on the final task

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Distribution of the scores of 8a group on the final task	.251	18	.004	.775	18	.001
Distribution of the scores of 8b group on the final task	.189	18	.090	.880	18	.026

a. Lilliefors Significance Correction

Table 25. Ranking of the strong (8a) and weak (8b) group by the students' final task scores

	group	**N**	**Mean Rank**	**Sum of Ranks**
Ranking of both groups	**strong**	18	21.42	385.50
	weak	18	15.58	280.50
	Total	36		

Table 26. Significance testing of the difference between the students' final task scores of the strong (8a) and weak (8b) group

	Significance
Mann-Whitney U	109.500
Wilcoxon W	280.500
Z	-1.675
Asymp. Sig. (2-tailed)	.094
Exact Sig. [2*(1-tailed Sig.)]	.097[b]

a. Grouping Variable: group

b. Not corrected for ties.

Based on the Asymp. Sig. (2-tailed) value, which is above 0.05 (Table 26), it can be concluded that there is not a statistically significant difference between the results of the weak 8b group and the strong (8a)

group. Consequently, both groups finished the CBE education at the same levels of practice.

4. Data analysis of the students' intrinsic motivation

4.1. In the strong (8a) group

Table 27. Normality testing of the distribution of the students' scores in the strong (8a) group collected by answering to questionnaire about their intrinsic motivation before and after CBE

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Distribution of students' starting intrinsic motivation points of 8a group	.130	18	.200*	.964	18	.673
Distribution of students' final intrinsic motivation points of 8a group	.153	18	.200*	.952	18	.454

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The results for the levels of the intrinsic students' motivation in the strong 8a group before and after the application of CBE were tested for normality. According to the Kolmogorov-Smirnov and Shapiro-Wilk tests, the data for the levels of the intrinsic students' motivation before CBE is normally distributed. Correspondingly, both Kolmogorov-Smirnov and Shapiro-Wilk tests returned Sig. value > 0.05 (Table 27).

The Kolmogorov-Smirnov and Shapiro-Wilk tests (Table 27) showed similar results for the distribution of the data on the level of intrinsic students' motivation in the strong (8a) group after CBE.

Therefore, the parametric paired samples t-test was used to check if there is a statistically significant difference between the mean values of the two samples.

The paired samples t-test returned Sig. value of 0.244, which is above the critical significance level of 0.05. Consequently, there is no statistically

significant difference between the starting and final level of the students' intrinsic motivation in the strong (8a) group.

Table 28. Significance testing of the difference between the starting and final levels of students' intrinsic motivation in the strong (8a) group

		Mean	Std. Deviation	Std. Error Mean
Pair 1	**starting intrinsic motivation – final intrinsic motivation**	-2.38889	8.39565	1.97887

95% Confidence Interval of the Difference		t	Df	Sig. (2-tailed)
Lower	**Upper**			
-6.56395	1.78617	-1.207	17	.244

4.2.in the weak (8b) group

The results for the levels of the intrinsic students' motivation in the weak 8b group before and after the application of CBE were tested for normality. According to the Kolmogorov-Smirnov and Shapiro-Wilk tests, the data for the levels of the intrinsic students' motivation before CBE is not normally distributed. Correspondingly, both Kolmogorov-Smirnov and Shapiro-Wilk tests returned Sig. value < 0.05 (Table 29).

Therefore, the non-parametric Wilcoxon Signed Ranks Test was used to check if there is a statistically significant difference between the mean values of both samples.

Table 30 shows that there are 18 positive ranks that correspond to the total number of the students in the weak (8b) group whose motivation was enhanced after the conducted CBE education. Consequently, the Wilcoxon Signed Ranks Test returned a Sig. value below 0.05 indicating that there is a statistically significant difference between the starting and final level of students' intrinsic motivation in the weak (8b) group. The results are shown on Table 31. The Kolmogorov-Smirnov and Shapiro-Wilk tests showed opposite results for the distribution of the data for the level of the intrinsic students' motivation in the weak (8b) group after CBE.

Table 29. Normality testing of the distribution of students' scores of the weak (8b) group collected by answering to questionnaire about their intrinsic motivation before and after CBE

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Distribution of students' starting intrinsic motivation points of 8b group	.270	18	.001	.886	18	.033
Distribution of students' final intrinsic motivation points of 8b group	.164	18	.200*	.906	18	.072

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 30. Ranking of students in the weak (8b) group by their intrinsic motivation after CBE compared to their intrinsic motivation before CBE

		N	**Mean Rank**	**Sum of Ranks**
Ranking of students	**Negative Ranks**	0[a]	.00	.00
	Positive Ranks	18[b]	9.50	171.00
	Ties	0[c]		
	Total	18		

a. number of students with lower intrinsic motivation after CBE

b. number of students with higher intrinsic motivation after CBE

c. number of students with unchanged intrinsic motivation after CBE

Table 31. Wilcoxon Significance test of the difference between the starting and final levels of students' intrinsic motivation in the weak (8b) group

	Significance
Z	-3.728[b]
Asymp. Sig. (2-tailed)	<.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

4.3. Comparative analysis of the starting and final levels of students' intrinsic motivation in both groups

Firstly, it was interesting to verify if the difference between the starting levels of students' intrinsic motivation in both groups is statistically significant. Based on the fact that the data for the starting level of students' intrinsic motivation in the weak (8b) group is not normally distributed compared to that in the strong (8a) group, the non-parametric Mann Whitney significance test was applied (Table 33).

As can be seen from Table 32, the mean rank for the strong (8a) group is higher than that for the weak (8b) group, which means that the starting level of intrinsic motivation is higher for the students from the strong (8a) group. The Mann-Whitney test (Table 33) returned a Sig. value of 0.024, which is below 0.05 proving that the higher starting level of students' intrinsic motivation in the strong 8a group is statistically different than that in the weak (8b) group.

Table 32. Ranking of students' starting intrinsic motivation in the weak (8b) and strong 8a group

	group	**N**	**Mean Rank**	**Sum of Ranks**
Ranking of both groups	**strong**	18	22.44	404.00
	weak	18	14.56	262.00
	Total	36		

Table 33. Mann-Whitney significance test of the difference between the students' starting intrinsic motivation in the strong (8a) and weak (8b) group

	Significance
Mann-Whitney U	91.000
Wilcoxon W	262.000
Z	-2.261
Asymp. Sig. (2-tailed)	.024
Exact Sig. [2*(1-tailed Sig.)]	.024[b]

a. Grouping Variable: group

b. Not corrected for ties.

The next step was to verify if there is a statistical difference between the final levels of students' intrinsic motivation in both groups. Because the data

in both cases is normally distributed then the parametric independent samples t-test was applied to assess the difference between the final level of students' intrinsic motivation in both groups.

Table 34. Independent Samples T-test for testing of the significance of the difference in the final levels of students' intrinsic motivation in the strong (8a) and weak (8b) group

		Levene's Test for Equality of Variances	
		F	**Sig.**
Students' final intrinsic motivation in 8a and 8b group	**Equal variances assumed**	1.856	.182
	Equal variances not assumed		

t-test for Equality of Means						
					95% Confidence Interval of the Difference	
T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
-1.430	34	.162	-2.00000	1.39898	-4.84308	.84308
-1.430	32.286	.162	-2.00000	1.39898	-4.84865	.84865

Levene's test returned a Sig. value > 0.05, thus, equal variances can be assumed for both groups. For this reason, an attention should be paid on the first row of the t-test where the returned Sig. value is also > 0.05. Consequently, there is no statistically significant difference between the final levels of students' intrinsic motivation in both groups. In other words, the students from both groups started with different levels of intrinsic motivation but after the CBE education the students from the weak (8b) group managed to reach the level of intrinsic motivation of the students from the strong 8a group.

5. Interpretation of the results

1. A pedagogical study was conducted with a representative sample of 36 students from "Hristo Botev" High School in the village of

Chepintsi. The aim was to examine changes in both the students' academic performance and their intrinsic motivation following the implementation of CBE in selected STEM disciplines from the curriculum.

2. The obtained results were assessed with the SPSS software of IBM for analysis of study results by using parametric and nonparametric tests in dependence of the type of distribution for rejecting the random character of the results.
3. On the base of the abovementioned actions and obtained results, the following conclusions for the starting level can be made:

3.1. The analysis of the results from the preliminary test on academic achievement, conducted before the implementation of the specialized education, revealed a statistically significant difference between the initial performance levels of the two samples, with 8a outperforming 8b. Consequently, sample 8a was categorized as the strong group and 8b as the weak group.

3.2. The results from the performance of the preliminary practical task showed statistically insignificant difference between the strong group and the weak group.

3.3. The initial intrinsic motivation of the strong group was higher than that of the weak group.

4. The processing of the final results showed:

4.1. Statistically significant difference between preliminary and final test level for each group individually, which confirms the positive influence of the applied methodology on the study results of the students. Same result was observed for the practical tasks in both groups. The intergroup comparison showed statistically insignificant difference between the preliminary results and after that also between the final results from their solving.

4.2. The intergroup comparison showed that the weak group has a lower result at the preliminary test in comparison with the strong group, however, at the final the results from the test were statistically indistinguishable, which means that the methodology has a higher positive effect on the study results of the weak group.

4.3. Statistically insignificant difference between preliminary and final level of intrinsic motivation in the strong group. In contrast, the weak group enhanced their intrinsic motivation. The intergroup comparison showed that the initial intrinsic motivation of the strong group is higher compared to that of the weak group.

The main hypothesis of the pedagogical study stating that CBE influences positively the obtained study results from the education in the studied STEM disciplines and enhances the students' intrinsic motivation was confirmed by the results from the conducted pedagogical experiment.

6. Conclusion

The proposed variant for the practical implementation of the joint CBE concept involves a specific group of study subjects, though it is not the only possible configuration. When considering a design-thinking approach in education, projects can be selected that aim to improve the lives and social environments of citizens. For example, technological solutions for people with disabilities and innovations to enhance community services can be developed. Additionally, projects focused on sustainable energy, smart health-protection devices, ecological innovations, and platforms for social engagement align with various disciplines, including psychology, civic education, natural sciences, and information technologies. By using such an approach, students not only acquire interdisciplinary knowledge, but also develop social responsibility and awareness of the real needs of their communities. This approach adds variety and emphasizes the integration of multiple disciplines.

Acknowledgements

The work on the article is supported by the MUPD-FMI-010 project of the National Program "Young Scientists and Postdoctoral Researchers" – 2.

NOTES

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✉ **Dr. Muharem Mollov**
ORCID iD: 0000-0003-0171-4462
Faculty of Mathematics and Informatics
University of Plovdiv Paisii Hilendarski
236, Bulgaria Blvd., 4003 Plovdiv, Bulgaria
E-mail: muharem.mollov@uni-plovdiv.bg

✉ **Dimitar Stoitsov, Assist. Prof.**
ORCID iD: 0000-0002-7616-1973
Faculty of Chemistry
University of Plovdiv Paisii Hilendarski
24, Tzar Asen St. 4000 Plovdiv, Bulgaria
E-mail: stoitsov@uni-plovdiv.bg

✉ **Dr. Gencho Stoitsov, Assoc. Prof.**
ORCID iD: 0000-0002-9962-941X
WoS Researcher ID: Q-8809-2019
Faculty of Mathematics and Informatics
University of Plovdiv Paisii Hilendarski
236, Bulgaria Blvd., 4003 Plovdiv, Bulgaria
E-mail: stoitzov@uni-plovdiv.bg