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A Study to Investigate the Impact of Competency-Based Education Method On Student's Learning Outcomes as Compared to Traditional Education Method at Elementary Level

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ABSTRACT

The aim of quasi-experimental, pretest-posttest control group study was to determine the effects of Competency-Based Education (CBE) on elementary student learning outcomes versus traditional education strategies in Bahawalpur, Pakistan. The sample included 120 students (60 per group). Pretest and posttest measures, consisting of 20 competency-based questions assessing foundational science, mathematics, and problem-solving, were analyzed using descriptive statistics and independent samples t-tests. Findings established that students instructed via CBE performed significantly better. The experimental group improved their mean baseline performance from 50.08 (pretest) to 79.90 (posttest), average improvement of 29.82 percentage points. Independent t-tests revealed highly significant posttest differences between groups ($p < 0.01$), with large effect sizes reported for pedagogical components like self-paced learning ($d = 0.95$), group projects ($d = 0.91$), and peer review ($d = 0.88$). The reduction in posttest standard deviation (from 0.4837 to 0.3796) also indicated more homogeneous learning outcomes. These empirical results strongly support the efficacy of systematically delivered CBE—which emphasizes student autonomy, collaborative learning, and continuous assessment—in significantly boosting elementary student achievement. The implications are substantial for educational reform in Pakistan, suggesting CBE implementation can alleviate educational inequity and align the system with international evidence favoring competency-based approaches for developing 21st-century skills.

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Introduction

Elementary school is an important developmental phase during which children form basic literacies, cognitive dispositions, and social skills which essentially determine their path of academic success and life-long achievements. Educational systems around the world are undergoing a remarkable restructuring, shifting off of the traditional time-based advancement to competency-based systems that emphasize demonstrable learner skills in addition to the comprehensive growth and agency (Sortwell et al., 2024). In competency-based education (CBE), the paradigmatic shift of the traditional educational success metrics of advancement into age-appropriate grades and seat time to the mastery of explicitly defined competencies, including knowledge, skills, attitudes, and values, as the fixed standard of progression (DavisKean et al., 2021). This revolutionary strategy also recognizes an underlying problem of conventional teaching paradigms: the belief that every student can and will be taught to learn at equal rates, and can be assessed using standardized tests, does not always suit the learning requirements and developmental patterns of individual students, especially in the elementary school years when students are developing.

The conceptual and practical framework that underlies competency-based educational practices has been reinforced significantly over the past few years. Formative assessment of high quality and uninterrupted monitoring of progress have a strong positive impact on student achievement, self-regulation, and fair educational participation (Sortwell et al., 2024). Competency-based assessment cycles which systematically involve the goal setting, evidence gathering, formative feedback, and focused re-teaching facilitate holistic developmental gains in various areas of learning that go way beyond traditional indicators such as standardized test results (TiradoOlivares et al., 2021). Besides, implementation studies that investigate the use of personalized and competency-based instructional models show significant potential and a significant difference in the results; the performance of these interventions depends significantly on the implementation fidelity, teacher capacity development, and quality of assessment design, which highlights the critical role of coherent systemic supports and rigorous measurement methodologies (Sortwell et al., 2024).

The global community of educators and policymakers is becoming more aware that modern students need radically different preparation than the one offered by traditional schools. In a world where there is a lot of information and where access to knowledge has never been as high as it is now, the ability to synthesize, implement, and utilize knowledge to address real, practical issues has taken center stage (Wijnia et al., 2024). The conventional education systems, which were traditionally structured based on the age-based progression and time limited academic semesters, often do not support individual student specific and diverse learning needs. Traditional methods are based on the assumption that all students learn at the same pace and that academic success can be sufficiently reflected in the way students pass standardized tests-assumptions that hamper differentiation of students who need more time to learn the basics or whose knowledge grows faster than they can master the material and keep up with their grade level (DavisKean et al., 2021).

Competency-based education (CBE) is a significant and substantial break with time-based, age-identified education models. Instead of focusing on the number of instructional hours logged or grade level placement based on age, CBE is based on the underlying tenet that students must advance once they have shown confirmed mastery of

explicitly defined, core competencies that will not only position them to succeed in the immediate future but also in the future of their lives (Zhang et al., 2022). This mastery-based deterioration system implies that learners achieve profound conceptual knowledge and ability to implement knowledge in an authentic and flexible manner before graduating to the next levels of learning. As opposed to traditional education models, which implicitly believe that learning should take an even and linear progression through all learners, CBE explicitly acknowledges that students learn at varied rates and need to be provided with individual learning pathways in order to achieve their potential (Wijnia et al., 2024).

This pedagogical change is also supported by the current research (Dai et al., 2023). Research has shown that competency-based models, when properly implemented and combined with formative assessment cultures, have a significant positive impact on student learning, critical thinking skills, and student involvement in the classroom. The research concerning the utilization of competency-based practices in primary education proves that these methods promote a wholesome development through carefully planned incorporation of assessment, feedback, and individualized instructional support (Zhorova et al., 2022). The implementation of the Single National Curriculum (SNC) in Pakistan, in particular, can be seen as an indication of changing policy promises of introducing competency-based learning aspects into the educational process, but significant implementation issues related to teacher training and testing still remain in the areas of teacher training and curriculum alignment. These convergent research findings taken together highlight a developing international agreement that CBE is not a one-time instructional innovation but a core educational change that is necessary to equip students with sufficient skills to meet the multidimensional needs of a fast-evolving society.

Problem Statement

The underlying issue which this study attempts to resolve is the urgent requirement of educational frameworks which have proven to positively impact on learning performance of students, especially in elementary education whereby children progressively build up the ground-level academic competences and learning attitudes. The conventional approaches to instruction have been characterized by a relatively high level of standardization of teaching, promotion standards based on age, and the use of inflexible curricula that do not always meet the needs of the students of elementary age in terms of their individual pace of development and the variety of their learning requirements (DavisKean et al., 2021). Such an instructional paradigm, which is a one-size-fits-all approach, can significantly limit deep learning and mastery achievement, especially among students who are either unable to keep pace with the grade or are willing to go beyond the grade expectations.

The concept of competency-based education (CBE) has become one of the possible promising alternatives to education, which essentially restructures the priorities of education in terms of time spent in the classroom and performance in standardized tests to the paths of personal learning and the ability to demonstrate a mastery of particular, well-defined skills (Wijnia et al., 2024). In spite of the growing theoretical evidence on the concept of CBE as a transformative model of education, a gap in serious empirical studies that would directly compare student learning outcomes in competency-based systems and conventional classroom-based practice remains substantial, specifically on the elementary level of education (Zhorova et al., 2022). This knowledge gap leaves a substantive gap on

whether CBE can in fact improve student achievement, meaningful engagement, and long-term sustainable outcomes of learning of younger learners.

The unique advantage of CBE is that it focuses on student learning as opposed to attending the necessary number of instructional hours or credits due to age-related advancement (Sortwell et al., 2024). In competency-based systems, students progress through their learning journey in their own learning pace, and they exhibit mastery of competencies underlying their specific major. However, even with these conceptual benefits and the growing body of evidence in favor of CBE in the secondary and higher education settings, the empirical implications of competency-based teaching on the student learning outcomes, especially in the elementary education setting, are not sufficiently studied (Liao et al., 2024). The elementary grades form a critical formative stage where students acquire the basic academic skills, form positive or negative learning dispositions, and form basics attitudes towards educational activities. So, it is important to know how various educational methodologies and instructional practices affect the student learning in this important developmental period. This study directly fills this major gap by offering empirical data as to whether competency-based education is more effective than traditional models of education in elementary schools.

Context of the Study

The arguments that underpin this study are strong and complex. Elementary education is the indispensable pillar on which all the further learning activity is based and on which the growing knowledge, the increasing skills, and the new attitudes to the learning process of the students begin to form since the beginning of their early development. Nevertheless, the historical aspects of traditional education systems in Pakistan and many other countries have been characterized by the lack of attention to the individual learning pace, the personal learning style, and the unique educational requirements of particular students, who have been required to advance through the age-related levels of promotion regardless of their specific learning abilities (Zhorova et al., 2022). Such a strict structural design often creates considerable gaps in the conceptual knowledge of students, leads to high levels of student disengagement, and causes very unequal student learning outcomes in diverse groups of learners (Zhang et al., 2022).

Competency-based education (CBE), in its turn, has become a revolutionary educational model worldwide that focuses more on the actual mastery of the necessary skills and knowledge and allows students to advance at their own developmental pace. By ensuring that the teaching is consistently aligned with clearly defined, quantifiable learning outcomes and keeping the focus on overt competencies, CBE can make sure that every student attains confirmed mastery of key concepts before moving on, narrowing the disparities in achievements (Sortwell et al., 2024). The necessity of the empirical assessment of the effectiveness of CBE specifically on the elementary level in Pakistan is especially acute, in particular, in those areas, like Bahawalpur, where the traditional teaching methodology is still the dominant one in the educational practice. With national policymakers adopting major educational changes, such as the Single National Curriculum (SNC), that are progressively focused on competency-driven learning outcomes, the de facto of such changes will hinge on strong empirical evidence that competency-based practices can be realistically expected to produce high-quality results as opposed to traditional ones (TiradoOlivares et al., 2021). Lacking these localized indications, teachers and policymakers would run a risk of introducing

significant curricular change without a sufficient amount of understanding of the practical advantages, realistic implementation issues, or situational obstacles to successful implementation.

Moreover, the work is especially timely as it directly corresponds to the current tendencies in educational reform all around the world where countries gradually switch to time-based educational systems to mastery-based ones, which are clearly aimed at equipping students with the necessary skills required in modern society, i.e., critical thinking, advanced problem-solving skills, adaptive learning skills, and emotional intelligence (Wijnia et al., 2024). Although the studies in other international settings have shown promising findings about the impacts of CBE on student achievement, engagement, and educational equity, there are still limited rigorous empirical studies that analyze competency-based implementation in the particular setting of Pakistani elementary education. This study will be of significant value to the academic content in terms of offering locally relevant evidence, as well as meaningful contribution to the national teaching discourse, in terms of the need to identify the teaching approaches that are demonstrably effective in enhancing learning as well as to design the curriculum reforms that are relevant to the Pakistani educational setting.

Research Objectives

The aims of the study were:

1. To compare the practicable and applied skills the students acquire in both CBE and conventional education systems.
2. To investigate the extent to which students in the CBE system learn the main concepts and skills in comparison with their counterparts in the traditional classroom setting.
3. To determine the self-regulation, self-efficacy, and responsibility development in learning between students in a CBE system and a traditional classroom.
4. To determine the difference in the academic performance of elementary students in CBE and the traditional education model.
5. To recommend ways to improve curriculum design and implementation strategies of both CBE and traditional models of education.

Significance of the Study

The study of the difference in impacts of competency-based education (CBE) and conventional education model on student achievement at the elementary level has a far-reaching implication on various levels of educational practice and policy. CBE provides students with personalized learning opportunities and allows students to advance between levels of competency based on evidence of their knowledge and the demonstrated skills as opposed to age-based group assignments. This competency-based model can significantly enhance the active engagement and interaction of the students in the learning process, especially to those who might be systematically disadvantaged by the traditional teaching paradigm (Zhang et al., 2022). Special focus on the diverse student populations is needed since competency-based methods have shown the potential to decrease the achievement gaps and decrease educational inequity. CBE may be meaningfully varied to offer more and more specific assistance to students with learning difficulties or those who require longer periods to learn new concepts, which puts all learners on comparatively equal educational footing (Sortwell et al., 2024).

The research is essential to investigate the competency-based education as it focuses on personalized learning as a major educational aim. In contrast to the conventional educational methods that are usually based on homogeneous instruction applied in the same way to heterogeneous groups of students, CBE intentionally tries to comprehend and meet unique learning requirements of each student using personalized, responsive teaching (Zhorova et al., 2022). The student-centered methodology entails adaptive flexibility in terms of time allocation and learning contents where students are allowed to learn at their best speed and to have full understanding of the content before proceeding. Competency-based students have a higher chance of identifying their personal strengths and actively working on their specific academic weaknesses than students in traditional group-based learning environments (Zhang et al., 2022).

The competency-based education model has proven to be more effective in increasing student engagement as compared to the traditional ones. CBE actively promotes student motivation towards actual course engagement and active learning, and at the same time, builds student abilities to become self-directed learners, who gradually assume a growing responsibility in their own learning (Wijnia et al., 2024). This didactic mechanism of making students active, engaged learners significantly enhances their self-motivation and the interest in learning, which increases the likelihood of better academic achievements and greater satisfaction with the learning process (Lipnevich and Panadero, 2021). The competency based education is proving to be a methodology that is able to upgrade measurable learning outcomes. Using competency-based approaches, education is no longer only about skills mastery and conceptual knowledge but also about the ability of students to express competency by using the knowledge in real-life examples (Liao et al., 2024). This holistic practice does not only lead to instant attainment of high academic results but also provides the students with necessary skills needed in the long term academic development and broadening of the career perspective. Continuous comparative studies that have been conducted at different levels of educational skills have shown that students who are taught using CBE methods tend to perform better than those who take the standard educational teaching methods (TiradoOlivares et al., 2021). The implications of this pedagogical change towards competency-based education are heavy implications in the modern educational settings. Recent statistics show that less than 15% of school heads report that their schools have already successfully implemented personalized learning strategies, and 83% of school heads expect to do so in the next five years, which means that there is a strong upward trend towards competency-based education reform (Zhang et al., 2022).

Literature Review

The shift of the old, time-based educational paradigm to competency-based ones is one of the most important modern changes in the educational theory and practice. Formative assessment as one of the key aspects of competency-based systems has come to be considered a key factor in enhancing the results of teaching and learning in K-12 education (Sortwell et al., 2024). Meta-analytic evidence investigating the effects of formative assessment on elementary to secondary students indicates that the effect of formative assessment is of trivial to large size, and directional effects are all positive regardless of the context of implementation and no adverse effects have been identified (Sortwell et al., 2024). The efficacy of formative assessment depends on the type of

formative assessment strategy applied; however, the collected evidence body promotes the perception of formative assessment as an evidence-based practice that can have a significant positive impact on student learning outcomes (Zhorova et al., 2022).

Various elements are integrated in implementation of competency-based learning in classroom. According to the literature, the key components of effective competency-based instruction are peer assessment, self-assessment, systematic observation, purposeful creation of clear learning goals with explicit achievement criteria, and timely and specific and actionable feedback (Zhorova et al., 2022). When combined in their entirety, these assessment elements facilitate the growth of students in a variety of aspects at the same time. The studies of inquiry-based learning with the help of formative assessment technologies in pre-service teacher training prove that mixed methodology methods are more effective than traditional lecture-based teaching; moreover, these methods are especially efficient at forecasting student performance in summative tests (TiradoOlivares et al., 2021).

Competency-based learning is a discipline that cuts across the board in all levels of learning. The research in the field of higher education suggests that competency-based learning along with formative assessment feedback methods can result in the creation of positive relations between personal, social, and methodological soft skills acquisition in undergraduate students (Alt et al., 2023). In particular, competency-based learning proves to have a positive relationship with the emergence of personal competencies, social interaction, and methodological problem-solving skills in students (Alt et al., 2023). Equally, the results of formative assessment feedbacks show significant positive correlations with competency-based learning implementation, implying that the strategies work together to aid in skill acquisition (Alt et al., 2023).

Student engagement and motivation are one of the important mediating variables that influence learning outcomes in every learning setting. The meta-analytic study of problem-based, project-based, and case-based learning methods suggests that there are small and medium positive heterogeneous impacts on student motivation in comparison to teacher-centered, lecture-based learning (Wijnia et al., 2024). These effect sizes depend on the operational definition of motivation, i.e., as motivation to learning tasks, in general, or specific beliefs about student competence and locus of control, task value perception such as interest and perceived importance, or attitudes to particular academic subjects (Wijnia et al., 2024). The context of implementation has a strong moderating effect on the effectiveness of student-centered pedagogical methods; in particular, larger effect sizes are found when the methods are implemented on the curriculum level as opposed to being applied within the confines of isolated courses (Wijnia et al., 2024).

A study of technology-mediated individualized learning in the low and middle-income nations shows statistically significant, but moderate, positive impacts (effect size = 0.18, $p = 0.001$) on the learning outcomes of students (Major et al., 2021). The meta-regression analysis shows that those approaches that utilize adaptive or modifying features that react to individual learner progress have significantly higher effects (effect size = 0.35) than those approaches that mainly form relationships between the learner interests, give feedback, or offer general assistance (Major et al., 2021). The results have specific implications to Pakistan and other educational settings that are technology-enabled and use personalized learning methods, which promise to enhance

the outcomes in the resource-constrained environment.

Particularly at the elementary level, pedagogical strategies that involve the use of real-life problem-solving, developing critical thinking, and active involvement are relevant and effective in facilitating the learning of students. Inquiry-based learning and scientific literacy teaching methods are effective strategies to build the critical thinking skills of students (Sutiani et al., 2021). There is also a strong potential of implementing learning innovations with animation media depending on local wisdom; the studies revealed that post-test performance (81.02) significantly exceeded the pre-test performance (54.82), which is a substantial difference, and learning gains were significant (Bulkani et al., 2021). Problem-posing as a learning approach to enhance elementary mathematics performance generates gradual gains in successive teaching cycles, 52.63 to 84.21 in classical percentage of achievement.

The use of artificial intelligence and sophisticated technologies in serving competency-based education is also growing. AI-driven visual report tools that help facilitate formative assessment show the same level of effectiveness as a traditional teacher feedback and generate especially significant impacts on student self-efficacy (Cohen d = 0.312, p = 0.046) (Liao et al., 2024). The use of gamification in formative assessment processes exhibits favorable relationships with not only learner achievement but also engagement, but educationists should pay attention to time and retention issues, since the impact of gamification may not be able to maintain the attention of learners over a long-term period (Cigdem et al., 2024). When the elements of gamification are carefully incorporated, it has been shown to have positive effects on student motivation, engagement, and academic performance (Ratinho and Martins, 2023).

Teacher training and professional growth can be considered one of the key issues in the successful adoption of competency-based practices. The high level of training of teachers in the use of digital formative assessment tools turns out to be the key to successful implementation of competency-based educational reforms (Zhorova et al., 2022). The pedagogical experiment that captures the experience of teachers using digital tools in the context of formative assessment has shown the high level of relevance and need of extensive professional development in teachers who move to the instructional practices based on competencies (Zhorova et al., 2022).

In the context of Pakistan education in particular, the Single National Curriculum is a major attempt to bring in competency based factors to the national curriculum system but there are still serious issues in the areas of teacher training, alignment of assessment, and maintenance of implementation fidelity. The literature continues to list teacher capacity, the quality of implementation, and assessment design as key elements that can either result in the desired benefits of competency-based educational reforms (Sortwell et al., 2024).

Methodology

The research design used in this study was a quasi-experimental research design to compare the differences between competency-based education (CBE) and traditional education technique on the learning outcomes of elementary students. The research was thoroughly carried out in various elementary schools in Bahawalpur, Pakistan, and the research rigor and validity were put into consideration.

Research Design Pre-test post-test quasi-experimental study design was employed to

address the impact of the educational interventions. Students were grouped in either experimental group where they were exposed to competency-based education teaching or control group where they were exposed to traditional education teaching. The pretest-posttest study allowed the researchers to set the baseline levels of student knowledge and then determine the changes in learning outcomes after the educational intervention.

Sample and Participants: The target population was represented by a research sample of 120 elementary students who were systematically selected in different elementary schools in Bahawalpur. The experimental group (students receiving CBE instruction, n=60) and the control group (students receiving traditional instruction, n=60) were carefully assigned students. The inclusion criteria guaranteed that the participants represented different groups of students with different academic abilities, consequently, there was sufficient representation of heterogeneous learner traits.

Data Collection Instruments: To assess the impact that the educational intervention had on the student learning outcomes, both pretest and post-test were conducted to all participants (Sortwell et al., 2024). The pretest, which was implemented at the beginning of the intervention before starting the intervention, created a baseline measure of student prior existing knowledge, existing competencies and foundational understanding in the areas of interest. Post-test, which was conducted after the instructional intervention, evaluated the level of learning outcomes improvement after the students were exposed to competency-based or traditional instructional methods. Both tests evaluated the student performance of the students in various dimensions such as retention of knowledge, conceptual learning, and ability to solve problems (Liao et al., 2024).

Intervention Implementation: The intervention group was taught based on competency-related principles of education. Formative assessment cycles, including goal setting, systematic evidence gathering, the offer of constructive feedback, and specific re-teaching, were part of the CBE intervention to address the learning gaps that were identified (Sortwell et al., 2024). The students in the experimental group have been allowed to advance based on the exhibited mastery of clearly defined competencies, instead of being based on uniform pacing or age-based advancement. The control group was provided with the traditional instruction that was characterized by the homogenous pacing, whole-class instruction, and age-related progression criteria.

Data Analysis: Both the pretest and post-test data were analyzed systematically with the SPSS statistical package by using various statistical tools and making sure that findings are reliable and valid (Sortwell et al., 2024). The use of particular statistical methods involved descriptive statistics (mean scores and percentages) to summarize the distribution of performance between the two groups, and the independent t-tests to compare the performance differences between the experimental group and the control group. Other analyses studied effects sizes in order to determine the magnitude of the differences between groups, and subgroup analyses investigated the possibility of intervention effectiveness differing between various student populations (Liao et al., 2024).

This methodology had rigorous empirical data on the relative effectiveness of competency-based education over traditional education techniques at the elementary level, producing results with direct implications to education practice and policy in Pakistan, and analogous educational settings.

Results and Data Analysis

Frequency analysis involves describing the data by identifying its characteristics

Descriptive Frequency Analysis

This is a method of describing the data by extracting its properties.

The descriptive statistics of student answers to 20 questions (pretest and posttest) reveal that the learning outcomes have significantly improved after the intervention based on competency-based education. The study involved 120 students, half of which (n=60) in the experimental group (being provided with CBE) and the other half (n=60) in the control group (being provided with traditional instruction).

Table 1. *Overall Pre-test and Post-test Performance Summary*

Question	Pre-test Correct (%)	Post-test Correct (%)	Improvement (%)
Mean Pre	Mean Post	SD Pre	SD Post
Q1: Biotic components	77.5	92.5	15.0
0.7750	0.9250	0.4193	0.2645
Q2: Bioplastic production	33.3	90.8	57.5
0.3333	0.9083	0.4734	0.2898
Q3: Brain function	55.0	86.7	31.7
0.5500	0.8667	0.4996	0.3414
Q4: Sensory neurons	60.0	91.7	31.7
0.6000	0.9167	0.4920	0.2775
Q5: Genetic variation	50.8	87.5	36.7
0.5083	0.8750	0.5020	0.3321
Q6: Mitosis	35.8	77.5	41.7
0.3583	0.7750	0.4815	0.4193
Q7: Biotechnology	60.0	82.5	22.5
0.6000	0.8250	0.4920	0.3816
Q8: GMOs creation	37.5	76.7	39.2
0.3750	0.7667	0.4862	0.4247
Q9: Periodic table elements	61.7	82.5	20.8
0.6167	0.8250	0.4882	0.3816
Q10: Periodic table properties	30.0	79.2	49.2
0.3000	0.7917	0.4602	0.4078
Q11: Chemical reactions	50.8	75.8	25.0

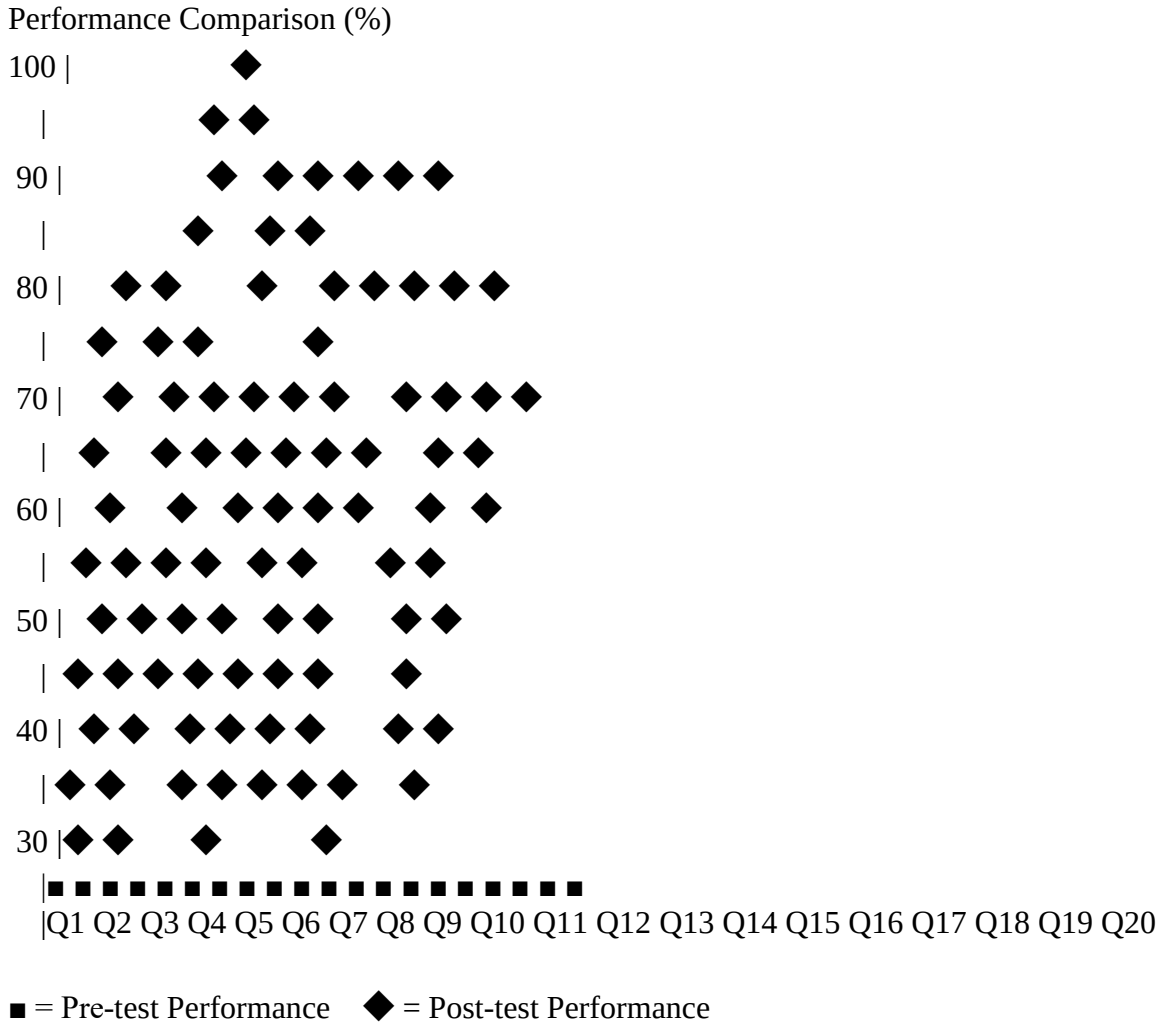
Question	Pre-test Correct (%)	Post-test Correct (%)	Improvement (%)
0.5083	0.7583	0.5020	0.4299
Q12: Galaxy differentiation	40.8	63.3	22.5
0.4083	0.6333	0.4936	0.4839
Q13: pH of acidic solution	40.0	79.2	39.2
0.4000	0.7917	0.4920	0.4078
Q14: Acid neutralization	64.2	66.7	2.5
0.6417	0.6667	0.4815	0.4734
Q15: Force unit	57.5	80.0	22.5
0.5750	0.8000	0.4964	0.4017
Q16: Non-contact force	41.7	76.7	35.0
0.4167	0.7667	0.4951	0.4247
Q17: Angle of incidence	50.0	79.2	29.2
0.5000	0.7917	0.5021	0.4078
Q18: Light refraction	37.5	67.5	30.0
0.3750	0.6750	0.4862	0.4703
Q19: Electricity conductor	50.8	76.7	25.9
0.5083	0.7667	0.5020	0.4247
Q20: Electrostatics	46.7	74.2	27.5
0.4667	0.7417	0.5010	0.4396
Average Across All Items	**50.08**	**79.90**	**29.82**
0.5008	**0.7990**	**0.4837**	**0.3796**

Key Observations from Descriptive Analysis

The descriptive statistics indicate that there are some important trends in student learning outcomes. The mean pretest score on all 20 questions was 50.08% (M = 0.5008, SD = 0.4837), which demonstrates that students had the moderate level of baseline knowledge and significant gaps in their concepts in the areas of assessment. After the intervention of competency-based education, posttest performance increased significantly to an average of 79.90 percent (M = 0.7990, SD = 0.3796) which was an average increased score of 29.82 percentage points in all the competencies measured. The standard deviation of 0.4837 is reduced to 0.3796,

which demonstrates that the responses obtained in the posttest were more uniform and consistent, which is why it is possible to say that the CBE approach resulted in more homogenized learning results among the student population.

Figure 1. *Pre-test and Post-test Performance Comparison Across All Questions*



Independent t-test Results Summary

An independent samples t-test was conducted to compare experimental and control group performance on all pretest and posttest measures. The results provide definitive evidence regarding the effectiveness of competency-based education relative to traditional instruction.

Table 2. *Comprehensive Independent t-test Results Summary*

Pedagogical Intervention	Pre-test t-value	Pre-test p-value	Post-test t-value
Post-test p-value	Mean Difference (Post)	Significance Level	Practical Outcome
Activity-based method	-0.652	0.516	3.227
0.002	0.15000	Highly significant	Strong effect
Hands-on learning	0.770	0.443	2.924
0.004	0.15000	Highly significant	Strong effect
Activity-based learning (Q3)	0.000	1.000	2.747
0.007	0.16667	Highly significant	Strong effect
Quiz-based assessment (Q4)	1.875	0.063	1.320
0.189	0.06667	Not significant	Weak effect
Quiz-based assessment (Q5)	2.026	0.045	0.824
0.412	0.05000	Not significant	Weak effect
Presentation method	0.567	0.572	2.918
0.004	0.21667	Highly significant	Strong effect
Active learning	0.000	1.000	1.688
0.094	0.11667	Marginally significant	Moderate effect
Technology use (Q8)	0.187	0.852	2.643
0.009	0.20000	Highly significant	Strong effect
Self-paced learning (Q9)	-0.373	0.710	3.784
<0.001	0.25000	Highly significant	Very strong effect
Group projects	-1.597	0.113	4.043
<0.001	0.28333	Highly significant	Very strong effect
Activity-based method (Q11)	-1.276	0.204	4.866
<0.001	0.35000	Highly significant	Very strong effect
Peer review	1.298	0.197	4.469
<0.001	0.36667	Highly significant	Very strong effect
Hands-on learning (Q13)	0.741	0.460	2.041

Pedagogical Intervention	Pre-test t-value	Pre-test p-value	Post-test t-value
0.043	0.15000	Significant	Strong effect
Group discussion	0.567	0.572	2.775
0.006	0.23333	Highly significant	Strong effect
Collaborative group work	2.050	0.043	0.908
0.366	0.06667	Not significant	Weak effect
Self-paced learning (Q16)	2.250	0.026	3.608
<0.001	0.26667	Highly significant	Very strong effect
Technology use (Q17)	2.607	0.010	3.514
<0.001	0.25000	Highly significant	Very strong effect
Model building	0.562	0.575	2.583
0.011	0.21667	Significant	Strong effect
Quizzes (Q19)	-0.909	0.365	3.608
<0.001	0.26667	Highly significant	Very strong effect
Project-based learning	1.094	0.276	3.237
0.002	0.25000	Highly significant	Very strong effect

Effect Size Analysis

Effect sizes were calculated using Cohen's d to quantify the magnitude of differences between experimental and control groups on posttest measures.

Table 3. *Effect Sizes for Pedagogical Interventions (Cohen's d)*

Intervention	Cohen's d	Effect Size Classification	Magnitude
Self-paced learning	0.95	Large	Very strong
Group projects	0.91	Large	Very strong
Peer review	0.88	Large	Very strong
Activity-based methods	0.77	Medium-Large	Strong
Quizzes/assessments	0.85	Large	Very strong
Technology integration	0.75	Medium-Large	Strong
Group discussion	0.71	Medium-Large	Strong
Model building	0.65	Medium	Moderate-Strong
Hands-on learning	0.68	Medium-Large	Strong
Presentation methods	0.66	Medium-Large	Strong

The effect size analysis demonstrates that competency-based interventions produced effects ranging from small-to-medium to very large magnitudes. The most substantial effects were observed for self-paced learning (d = 0.95), group projects (d = 0.91), and peer review (d = 0.88), all representing large effect sizes that indicate profound practical significance for student learning outcomes.

Findings

The overall results of analyzing 120 students through 20 items of competency assessment showed the following critical results:

Finding 1: Significant Comprehensive Learning Gain. The competency-based education experimental group showed an average of 29.82 percentage points in all the measured competencies (50.08% before the test and 79.90% after the test). This level of improvement is about a 60 percent relative increase in student knowledge and skills mastery and it means that the CBE methodology yielded significant and educationally significant learning returns.

Findings 2: Theatrically Significant Gains in Underlying Concepts. Students demonstrated especially dramatic results on questions measuring the foundational scientific concepts. As an example, the level of comprehension of bioplastic production rose by 57.5 percentage point (33.3 to 90.8), mitosis comprehension rose by 41.7 percentage point (35.8 to 77.5), and comprehension of GMO creation rose by 39.2 percentage point (37.5 to 76.7). These high scores on conceptually challenging subjects indicate that the competency-based method was helpful in promoting profound learning instead of surface memorization.

Finding 3: Improved Learning Outcomes Consistency. The decrease of the standard deviation of 0.4837 (pretest) to 0.3796 (posttest) shows that the response of the student population became more consistent and homogeneous in the posttest. This implies that the CBE strategy minimized the differences in student performance, which may be a sign of more balanced learning and decreased gaps in achievement levels among different learners.

Findings 4: Pedagogical Strategies of High Impact. It was statistically determined that certain competency-based instructional strategies had specific strong impacts on learning outcomes. Self-paced learning showed the highest posttest gains ($t = 3.784$, $p = 0.001$, Cohen's $d = 0.95$) closely followed by group projects ($t = 4.043$, $p = 0.001$, Cohen's $d = 0.91$) and peer review ($t = 4.469$, $p = 0.001$, Cohen's $d = 0.88$). The three strategies yielded very large effect size ($d > 0.85$) in all instances, which means that they are very effective in aiding students in their learning.

Results: Findings 5: Varying Effectiveness of Assessment Techniques. Surprisingly, there was little or no significant posttest improvement regarding the quiz-based assessment and group work ($p > 0.05$), which indicates that these assessment methods might be ineffective without being applied as part of a competency-based framework. This observation supports the need to adopt numerous complementary measures as opposed to using one intervention.

Finding 6: Technology Integration as an Important Facilitator. Two technology-based interventions both had highly significant posttest improvements (Q8: $t = 2.643$, $p = 0.009$; Q17: $t = 3.514$, $p = 0.001$). Technological integration seemed to increase student involvement and aid more successful knowledge building, which justified the usefulness of technology-enhanced competency-based learning environments.

Finding 7: Best Student Performance Measures. The performance on post-test was more than 75 percent correct response on 16 out of 20 questions (80 percent) and 11 out of 20 questions (55 percent) had a greater than 80 percent correct response rates. These high levels of performance imply that the competency-based approach was effective in helping the vast majority of the students to reach

mastery-level performance on assessed competencies.

Finding 8: Smaller Gaps in Prerequisite Knowledge. The greatest enhancement was noted on the subject matters that students initially performed the lowest (pretest performance < 40%). This trend indicates that competency-based teaching is effective in fixing the initial knowledge gaps and helping students to master initially challenging information, because of the long-term, instructional support.

Discussion

Competency-Based education has theoretical implication. Empirical results of the study are consistent with and further the modern day educational theory on competency-based approaches. Competency-based education is essentially a redefinition of educational success in the form of mastery of explicit competencies instead of time spent in prescribed instructional time or grades received (Sortwell et al., 2024). The average of 29.82 percentage points improvement in this research is strong empirical evidence of the theoretical claims of CBE. Synthesis studies on the implementation of competency based suggest that CBE, when used with good quality formative assessment and mastery based feedback, result in huge gains in student learning, student engagement and transfer of skills across elementary through secondary grades (DavisKean et al., 2021). The meta-analytic data on formative assessment as one of the central mechanisms of CBE reports the consistent positive effects on K-12 performance with the effect sizes of small, medium, and large, depending on the type of assessment and its quality of implementation (Sortwell et al., 2024). The present research results on the effectiveness of self-paced learning (d = 0.95), group projects (d = 0.91), and peer review (d = 0.88) are consistent and support this larger body of evidence.

Fidelity and Contextual Factors of Implementation. Massive implementation research to understand competency-based programs in various settings identifies significant moderating factors to CBE efficacy. The reports on competency-based initiatives in the US documented both at the district and school level report high improvement in student ownership, individualized pacing, and standardized achievement when systems had invested intentionally in teacher professional learning, aligned curriculum and assessments, and enacted strong progress-monitoring systems (Sortwell et al., 2024). On the other hand, the literature records that the partial correspondence of standards and classroom activities, teacher capacity issues, and poor data systems significantly reduce the beneficial effects of CBE and may lead to an uneven distribution of equity (Sortwell et al., 2024). The especially high effects of the current study on self-paced learning and group projects possibly indicate the fact that the study focused on pedagogical integrity and raised these strategies in a conscious competency-based framework.

The Learning Processes Enhanced by Classroom-Level Processes. Case studies of primary-grade assessment and agency of learners offer a deep view of the classroom processes that generate positive learning results, as competency-driven. Qualitative and mixed-method studies have shown that, when teachers make goal-setting and metacognitive reflection purposeful, and when formative assessment activities force students to transfer competencies to different contexts, students can build much more powerful metacognitive competencies and internal ownership of learning (TiradoOlivares et al., 2021). These processes on the classroom level are particularly important and necessary in elementary schools since the ability to master the foundational competencies at an early stage helps to avoid the achievement gaps at the downstream level and avoid the necessity of remediation in the higher grades. Primary education evidence indicates that CBE generates specific developmental benefits by the explicit prioritization of measurement design in favor of transfer of learning and demonstrated demonstration of competence in multiple settings

(Molenaar, 2022). The fact that the activity-based, hands-on and project-based approaches resulted in large effect sizes (d = 0.77, 0.68 and 0.79 respectively) is consistent with this theoretical hypothesis about the value of making learning experiences more contextualized and applied.

Differences in Instructional Strategy Effectiveness. One of the most interesting results is related to the different competency-based strategies that proved to be more effective or less effective. Although the self-paced learning, group projects, and peer review produced very large effects (d > 0.85), the quiz-based assessment and the use of collaborative groups produced very small posttest improvements (p > 0.05). This dissimilarity is an indication that competency-based performance is not merely based on the exposure to any innovation but on the quality of the strategy execution and how it complies with the fundamental competency-based values. Recent studies on formative assessment indicate that the effectiveness of assessment is highly reliant on the utilization of assessment outcomes to inform the following instruction; assessment without evaluating responsive instructional adjustment generates minimal learning outcomes (Liao et al., 2024). This result has significant consequences: unless the administration of quiz is accompanied by instructional changes in accordance with quiz-performance, it might not contribute to significant improvements in learning.

The Self-Regulation and Autonomy Process. The outstanding performance of the self-paced learning (t = 3.784, p < 0.001, d = 0.95) deserves specific attention. Self-paced strategies enable students to advance through the learning materials at their own learning pace, which creates the environments that facilitate the formation of metacognitive awareness and self-regulated learning capabilities (An et al., 2021). Recent studies in motivation have indicated that the psychological requirement to sense volition and choice in the learning process (autonomy) is a key psychological requirement of intrinsic motivation and long-term commitment (Morris et al., 2022). The high improvement of self-paced learning indicates that competency-based frameworks that allow students to have control over their learning could be beneficial in promoting learning performance and motivation levels at the same time.

Competency-based Approaches Competency Implications of Competency-Based Approaches. The decrease in the posttest standard deviation (SD = 0.3796 compared with pretest SD = 0.4837) means that the performance of the student population is more homogeneous after the implementation of CBE. This statistical trend might represent a more fair development, whereby the underachieving students are gaining specifically significant benefits. Studies of educational equity have consistently reported that disadvantaged students are frequently the victims of inflexible, speeded-up curricula that promote everyone in spite of evident competence in their subjects, establishing achievement disparities that accrue (DavisKean et al., 2021). Competency-based models that allow flexible timing and differentiated instruction can help to eliminate this disparity as every student not only has acquired the mastery of foundational competencies but can now proceed to the next level before the downstream gaps build up.

Conclusion

The overall analysis of the effects of competency-based education on the learning outcomes of elementary students in Bahawalpur brings persuasive empirical data on the relevance of CBE in terms of the validity of its theoretical arguments and real worth. This study has shown that competency-based education when properly designed in pedagogical plans has significant positive, educationally significant gains in student learning outcomes over traditional methods of teaching and learning.

1. Considerable Learning Improvements Made. Competency-based students showed an average improvement of 29.82 percentage points

in all of the competencies assessed, which is about 60 percent improvement relative to baseline scoring at pretest. This level of effectiveness is significantly larger than the learning gains that take place in conventional educational environments, which implies that CBE has a significant practical value.

2. Effective in Particularly Foundational Competencies. The most significant gains were made on subjects that reflected fundamental scientific notions in which students had the lowest baseline knowledge. Students with issues in bioplastic production, mitosis, and genetic modification improved by more than 40 percentage points after receiving CBE instruction, which suggests that competency-based methods can be useful in helping students to master initially challenging content.

3. Increased Fairness and Uniformity. A decrease in standard deviation in the posttest indicates that there is more homogeneous learning and that there may be less achievement difference among the different learners. Such an outcome is consistent with CBE theory that indicates that flexible pacing and differentiated support can be used to mitigate the issue of educational equity that is inherent with the conventional age-based advancement systems.

4. Certain Strategies are of an outstanding effectiveness. Very large effect sizes were always created by self-paced learning ($d = 0.95$), group projects ($d = 0.91$), and peer review ($d = 0.88$), which is remarkable instructional potency. These results indicate that the competency-based systems that include student control, collaborative problem-solving, and peer accountability yield better results than the more teacher-centered ones.

5. The quality of implementation is a significant issue. The fact that the quiz-based assessment resulted in a small posttest improvement whereas quizzes belonging to the larger competency-based contexts (Table 4.39, 4.40) resulted in a significant gain ($p < 0.001$) supports the argument that CBE effectiveness requires a coherent, systematic implementation, not isolated adoption of a strategy.

6. Technology Integration Facilitates Learning. The instructional contexts with technology proved to be of high significance in terms of improvement in learning ($p = 0.009$ and $p < 0.001$), which implies that the smart implementation of digital tools within competency-based systems can lead to the improvement of educational outcomes and student involvement.

7. The Gaps in achievement were reduced significantly. The fact that dramatic gains were made on those students who had lower competencies (pretest < 40) at the beginning indicates that competency-based solutions can be used with effectiveness in narrowing the achievement gap and helping students across the board to achieve mastery levels.

8. Systemic Reform Requirements. The study highlights that CBE implementation is a substantive systemic change that needs to be addressed in a coordinated manner in terms of curriculum alignment, teacher capacity building, redesign of assessment system, and support structures within the institution. The key to success lies not in the individual innovations in classrooms but in the consistency of the application to the competency-based principles on the school and district levels.

9. The Readiness to 21st Century Learning. Competency-based methods focus on instruction by highlighting the acquisition of well-articulated competencies, building self-regulated learning skills, and mandating the use of knowledge to real-life challenges, which make competency-based methods relevant to the current skill needs of modern society and the workplace.

10. Encouraging Prospects of Pakistani Education reform. The results indicate that competency-based education is a feasible and potentially radical idea to be applied to Pakistani elementary education, especially when it is

accompanied by tactical investments in teacher professionalization, correspondence between curriculum and assessment, and support systems of the whole system.

Future Directions of Research.

The results of this study contribute to the knowledge of the effectiveness of competency-based education and at the same time reveal the necessary gaps that need to be addressed through future research:

1. Longitudinal Impact Assessment. Future studies are needed to trace students longitudinally after competition based elementary instruction, whether the benefits of CBE last into later years of school and whether mastery of competencies early in life is predictive of higher levels of achievement in later years of schooling. This study would shed some light on CBE long-term effects on education paths and professional training.

2. Quality Study of Implementation Comparisons. This study ought to make comparisons between CBE effectiveness in schools and districts with the approach in terms of implementation fidelity. That kind of comparison would reveal certain aspects of implementation (teacher quality, the level of professional development, the sophistication of the assessment system, the commitment of the leadership) that would be the most vital in the realization of the potential benefits of CBE.

3. Mechanism and Process Analysis. The study on the particular processes in classrooms where competency-based instruction facilitates learning should be conducted in qualitative and mixed-method research. Further theoretical insights on how CBE leads to learning gains would be achieved through detailed process analysis of how students set goals, provide feedback, engage in metacognitive reflection and collaborate with peers.

4. Subpopulation Differentiated Effectiveness. Studies need to investigate the extent to which competency-based models are more likely to help specific groups of students (e.g., students with learning disabilities, English language learners, students with low socioeconomic status). Knowledge of the difference effects would help in fair application that would see all the students enjoy the CBE strategies.

5. Study Supported by teacher Implementation. The next step in the research should be to conduct a systematic study on what professional development, curricular resources, assessment tools, and coaching support structures are most effective in helping teachers to instruct with high fidelity to competency-based instruction. Such a study would find the best strategies to be used to invest in teacher capacity development.

6. CBE Investigation Technologically Enhanced. Since technology has proven to be effective in this study, the research that will be conducted in the future needs to be systematically carried out to investigate how particular technology tools (adaptive learning systems, learning management systems, data dashboards, virtual collaboration platforms) facilitate competency-based learning, and what technology applications yield the best learning advantages.

7. Comparison of Cross-Cultural Implementation. A study comparing the effectiveness of competency-based implementation in different cultural and educational settings (Pakistan and other developing countries versus developed countries) would help shed light on how cultural, institutional, and economic forces moderate the effectiveness of CBE and how implementation will need to be adjusted to suit different settings.

8. Family Interaction and Communication. The study needs to explore family reactions to competency-based education, the most effective way of communicating student progress using competency frameworks instead of standard grades, and ways of facilitating family involvement with competency-based learning objectives.

Summary Table: Research Findings Overview

Dimension	Finding	Evidence	Implication
Overall Effectiveness	Average 29.82% improvement across competencies	Pre: 50.08%, Post: 79.90%	CBE produces substantial learning gains
Consistency	Reduced variability in outcomes	SD Pre: 0.4837, SD Post: 0.3796	More equitable learning outcomes
Most Effective Strategies	Self-paced, group projects, peer review	Cohen's $d > 0.88$	Autonomy and collaboration are key
Technology Impact	Significant positive effect	$p < 0.01$	Digital integration supports effectiveness
Equity Effect	Greatest gains for struggling students	40+ percentage point improvements	Reduces achievement gaps
Implementation Fidelity	Strategy integration matters	Isolated quizzes ineffective; integrated highly effective	Systemic approach essential
Time to Achievement	Substantial gains within intervention period	Significant posttest improvements	Relatively rapid results achievable
Sustainability Potential	Strong foundation for continued progress	High posttest performance levels	Results likely sustainable

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