The effectiveness of modern teaching methods in developing academic achievement and critical thinking among secondary school students in mathematics and chemistry

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Abstract

In this research, the researcher will look into how effective modern strategies are at developing achievement levels and critical thinking in secondary students' mathematics and chemistry classes. The significance of this study stems from the increasing need to move away from traditional teacher-directed instructional strategies, and move toward more learner-centered instructional strategies that will develop high-order thinking skills, creativity, and problem-solving. The researcher will conduct a quasi-experimental research method using two groups of students – one group receiving instruction through modern methods such as problem-based learning and cooperative learning, and a second group receiving traditional instruction. An achievement test and a critical thinking scale were given to both groups before and after the experiment to measure any changes in academic performance or critical thinking due to the use of modern strategies.

The results of the study show there were statistically significant differences between both groups with an advantage toward the experimental group. This indicates that modern teaching techniques greatly improved student performance and promoted the development of

students' critical thinking skills. The effects of modern teaching techniques were found to be somewhat greater in the area of chemistry versus mathematics; this may be attributed to the experimental and inquiry-oriented nature of the chemistry learning process. The overall conclusion of the study is that when modern teaching techniques are used, students will gain deep understanding, become actively engaged in learning, and develop their ability to critically analyze concepts. The research recommends that teachers receive the professional development necessary to properly implement modern teaching methods and integrate them into secondary education curricula.

KeyWords: modern teaching methods, academic achievement, critical thinking, secondary education, mathematics, chemisty

فاعلية طرائق التدريس الحديثة في تنمية التحصيل الدراسي والتفكير الناقد لدى طلبة المرحلة الثانوية في مادتي الرياضيات والكيمياء

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ملخص

يبحث هذا البحث في مدى فعالية الاستراتيجيات الحديثة في تطوير مستويات التحصيل والتفكير النقدي لدى طلاب المرحلة الثانوية في مادتي الرياضيات والكيمياء .تكمن أهمية هذه الدراسة في الحاجة المتزايدة إلى الابتعاد عن استراتيجيات التدريس التقليدية التي يوجهها المعلم، والتوجه نحو استراتيجيات تعليمية أكثر تركيزًا على المتعلم، والتي من شأنها تنمية مهارات التفكير العليا والإبداع وحل المشكلات .سيُجري الباحث دراسة شبه تجريبية باستخدام مجموعتين من الطلاب :مجموعة تتلقى تعليمًا باستخدام أساليب حديثة مثل التعلم القائم على حل المشكلات والتعلم التعاوني، ومجموعة أخرى تتلقى تعليمًا تقليديًا .خضعت المجموعتان لاختبار تحصيلي ومقياس للتفكير النقدي قبل التجربة وبعدها لقياس أي تغييرات في الأداء الأكاديمي أو التفكير النقدي نتيجة استخدام الاستراتيجيات الحديثة.

أظهرت نتائج الدراسة وجود فروق ذات دلالة إحصائية بين المجموعتين، مع تفوق المجموعة التجريبية .يشير هذا إلى أن أساليب التدريس الحديثة حسّنت بشكل كبير أداء الطلاب وعززت تنمية مهارات التفكير النقدي لديهم .وقد وُجد أن تأثير أساليب التدريس الحديثة كان أكبر نوعًا ما في مجال الكيمياء مقارنةً بالرياضيات .قد يُعزى ذلك إلى الطبيعة التجريبية والاستقصائية

لعملية تعلم الكيمياء .ويتمثل الاستنتاج العام للدراسة في أنه عند استخدام أساليب التدريس الحديثة، سيكتسب الطلاب فهمًا عميقًا، وينخرطون بنشاط في التعلم، ويطورون قدرتهم على التحليل النقدي للمفاهيم .وتوصي الدراسة بتلقي المعلمين التدريب المهني اللازم لتطبيق أساليب التدريس الحديثة بشكل صحيح ودمجها في مناهج التعليم الثانوي.

الكلمات المفتاحية :أساليب التدريس الحديثة، التحصيل الدراسي، التفكير النقدي، التعليم الثانوي، الرياضيات، الكيمياء

Introduction:

In today's fast-paced environment, scientific and technological progress is changing the expectations of education. Schools will not only convey information anymore, yet create students who can critically evaluate, analyze, resolve, and develop innovative solutions through science/mathematics/Chemistry rather than just memorising or following instructions. Using memory-based (rote) learning and direct instruction will not prepare students for achieving those objectives; they cannot produce mathematically minded students due to the depth of knowledge required to solve a problem or create something new.

There is an abundance of new research on contemporary teaching methodologies including, but not limited to, cooperative learning, problem-based learning (PBL), project-based learning (PjBL), and flipped classrooms (FC). Studies have shown that these methodologies produce significantly improved levels of academic achievement and develop higher order thinking skills. All of these methodologies have placed the student at the centre of the educational experience and fostered an environment that fosters interaction, collaboration, discovery, and metacognitive thinking in the learning environment.

The importance of this study is to address the need for improved quality of educational programmes in secondary schools in order to comply with contemporary standards for excellence and innovation in teaching and learning. The purpose of this study is to determine the effectiveness of each of these modern methodologies in enhancing academic

achievement and critical thinking skills of secondary school students. The results of this study will also provide empirical evidence for use by teachers and educational policy makers to make informed decisions regarding more effective instructional strategies that are appropriate for meeting the learning needs of students in the 21st century.

Innovative, student-centered methods of teaching are necessary for the development of critical-thinking skills, problem-solving abilities and the use of knowledge in real-world applications in 21st-century education. Teacher-centered, passive and memorization-based approaches to education no longer adequately prepare learners for the demands of modern technological society, particularly with regard to subjects like math and chemistry, both of which require in-depth understanding and analytical reasoning.

Among the most frequently employed contemporary teaching methods are project-based learning, cooperative or group work, and problem-based learning. These active methods help kids to participate actively in their own learning and to participate in creative, cooperative, and critical-inquiring learning processes. Consequently, the teacher's function evolves from one of being a typically accepted knowledge source to that of a helper of the student's own unique experience of knowledge construction by means of discovery and communication with others .

The goal of this research is to evaluate how well current teaching approaches improve academic performance and critical thinking in mathematics and chemistry among secondary school students. It seeks to ascertain the degree to which these creative methods can improve learning results over against conventional approaches. The results of this study are projected to offer insightful information for teachers, curriculum designers, and educational policymakers trying to enhance the quality of secondary education and encourage higher-order thinking

skills among students. Thus, this study seeks to offer data supporting the use of creative teaching techniques in secondary school education by examining the degree to which modern teaching methods improveacademic achievement and critical thinking among secondary school mathematics and chemistry students .

Study questions: Many secondary school pupils still battle poor academic attainment and poor critical thinking abilities, especially in scientific topics such mathematics and chemistry, despite constant educational changes. Traditional educational approaches sometimes stress memorizing over analysis and comprehension. Consequently, this research aims to address the central query: To what degree do modern teaching techniques successfully enhance mathematics and chemistry among secondary school pupils while also developing critical thinking ?

Research Questions: Modern teaching approaches will be examined for their influence on pupils' mathematics and chemistry grades. Explore how these strategies help to sharpen students' ability to reason analytically. contrast the relative success of conventional vs contemporary teaching methods. Give secondary school teaching techniques advice .

Importance of Research: Because it helps to raise the quality of teaching and learning in secondary schools, this research is especially important. Theoretically, it enhances educational material on contemporary teaching techniques and critical thought. Practically, it provides direction for instructors and educational administrators on how to implement effective, learner-centered techniques that stimulate active involvement and thorough grasp.

Research Hypotheses: Students taught using contemporary teaching approaches statistically differ in academic achievement from those taught using traditional methods, therefore favoring the experimental group. Modern teaching approaches may vary in their efficacy

depending on the subject matter—mathematics or chemistry. Spatial Range: This research is carried out in chosen secondary schools .

Definitions: Modern pedagogical approaches stressing active learning, student participation, and knowledge creation include group projects, problem-based learning, and project-based learning .

Academic Success: Measured by achievement tests, the degree of knowledge, comprehension, and skills students have learned .

The cognitive process of examining, assessing, and rationally thinking to make educated decisions or fix issues is known as critical thinking .

In the subjects of arithmetic and chemistry, students in the second cycle of secondary school (usually Grades 10–12 .(

Past Investigations

Modern Pedagogical Approaches: Based on student-centered learning, modern teaching techniques depend on students actively creating information rather than just absorbing it. Interaction, cooperation, investigation, and reflection are the mainstays of these approaches. Some instances include: Students develop critical thinking and application of knowledge by solving actual problems in Problem-Based Learning (PBL .

Cooperative Learning: In little groups, pupils collaborate to reach shared academic objectives, so improving communication and cooperation skills .

Project-Based Learning promotes creativity and self-directed study as students work on long-range projects combining several topics and abilities .

turned over Classroom: Students debate or work on problem-solving projects during class time after studying instructional materials at home .

These techniques help pupils to investigate ideas and use them in significant situations by changing the teacher's role from a lecturer to a facilitator and guide .

Educational performance: Academic success is measured by the degree of pupils' learning results as seen in assignments, tests, and practical performance. It shows how well pupils grasp, remember, and use what is taught in class. By raising engagement and relating education to actual circumstances, contemporary instructional methods seek to improve performance .

Critical Thinking: The process of evaluating, synthesizing, and analyzing information to form justified opinions is known as critical thinking. Facione (2015) says it consists of self-regulation, interpretation, analysis, inference, assessment, explanation, and other skills. By promoting inquiry, exploration, and evidence-based argument, contemporary teaching techniques foster these skills .

Connections among critical thinking, academic success, and modern teaching techniques. Relationship of Modern Teaching Methods, Critical Thinking, and Academic Success. Research show that contemporary approaches to education help both critical thinking and academic performance. Active learning approaches help understanding and retention by engaging pupils cognitively and emotionally. Furthermore, research-based learning environments encourage critical thinking and problem-solving skills .

Earlier Research: Encouragement of more profound conceptual knowledge in problem-based learning helps students in chemistry to do better, according to Al-Khatib (2022). Cooperative learning improved critical thinking abilities among math students in secondary schools, according Al-Anzi (2023). According to Al-Saeed (2021), incorporating active learning techniques in science classrooms resulted in more academic achievement and improved involvement. These studies taken together seem to support the hypothesis that conventional techniques are less successful at fostering important cognitive abilities than modern, student-centered teaching techniques .

Research Methodology

Study Design: Using a quasi-experimental design, this study looks at how well contemporary teaching techniques improve academic performance and critical thinking in secondary school students in arithmetic and chemistry. The design divides two sets :

Experimental Group: Modern teaching techniques including problem-based learning, group work, and project-based learning are used .

The control group learns using conventional teacher-centered techniques .

Before and following the intervention, both groups were examined to assess growth and ascertain the effect of the teaching technique .

Secondary school pupils enrolled in math and chemistry classes during the academic year 2025–2026 comprise the study's population .

To guarantee parity in academic background and performance level, a sample of around 60 pupils—30 in the experimental group and 30 in the control group—was randomly chosen from two similar secondary schools. Two primary tools were used to gather information: Developed by the investigator to assess students' grasp, application, and analysis of essential ideas in chemistry and mathematics. Designed to evaluate students' reasoning, assessment, and decision-making abilities, the Critical Thinking Scale is adapted from the Watson–Glaser Critical Thinking Appraisal.

To guarantee reliability and validity, experts in psychology and education verified both tools. To assess their starting points, both groups took the achievement test and critical thinking scale before the intervention. Over six weeks, the experimental group was taught using contemporary teaching methods whereas the control group received conventional teaching. Following the intervention, the same instruments were given to both groups to measure change. Statistical examination of the data was done to assess variations between the two groups .

Descriptive and inferential statistics, including: were used for data analysis .

Means and Standard Deviations to evaluate group performance .

t-tests to find statistically significant variations in pre- and post-test scores .

The hypotheses of the study were tested at a significance level of ($\alpha = 0.05$).

The methodology, subjects, tools, and procedures employed to investigate how modern teaching strategies affect academic achievement and critical thinking. The experimental and control groups' results and data analysis are given in the following chapter .

Implementation Guidelines:

Step one: Preparation phase Based on contemporary pedagogical techniques, the researcher created thorough lesson plans . Both mathematics and chemistry courses now include learning resources and problem-based projects .Participants teachers received instruction on how to correctly use the novel strategies .

Step 2: Start Before the beginning of the experiment to assess their starting levels, both groups finished an achievement test and a critical thinking test .

Step 3: Instructional Period (six week)

The experimental group was taught utilizing contemporary methods :

Student solved actual problems involving mathematical formulas and chemical reactions via problem-based learning .Cooperative Learning: Assignments were finished by groups of pupils and solutions were discussed .Project-Based Learning: Pupils developed little initiatives like building models or doing mathematics and chemistry related experiments .

Through conventional instruction, the control group kept learning emphasizing lectures, note-taking, and teacher explanations .

Step 4: Post-test: Six weeks apart, both groups were re-tested using the same instruments to assess gains in critical thinking and academic performance .

Observation in the classroom: Classroom observations were carried out during the experiment to note student participation, motivation, and interaction. It was discovered that : Students in the experimental group showed more activity, motivation, and involvement .

They inquired more often, worked well together, and showed more thorough grasp of issues . Conversely, students in the control group were more passive and frequently relied on the instructor for answers.

Evidence that is practical: The gathered data revealed :

A noticeable rise in experimental group accomplishment scores .

A clear development in critical thinking skills, particularly in logical reasoning and problem solving analysis .

Students reported more happiness with the updated teaching techniques as the lessons were more engaging and simpler to grasp .

Working Practical

The practical component of the research thus offers compelling proof that better learning results and more engagement follow from the use of contemporary teaching approaches in secondary education, notably in mathematics and chemistry .

Table 1: Comparing Academic Achievement Scores

Students in the experimental group, instructed with current teaching techniques, had a dramatically higher post-test mean score than those in the control group. This shows that the modern approaches improved the academic performance of the pupils .

Table (2): Comparison between experimental and control groups in chemistry success

group	Test type	Mean	Standard deviation	t-value	Significance
Experimental	Pre-test	61.8	8.01	-	-

Group					
Experimental Group	Post-test	86.3	5.78	5.84	0.001 (Significance)
Control Group	Pre-test	60.9	7.99	–	–
Control Group	Post-test	68.1	6.95	1.32	0.19 (not Significance)

Compared to those in the control group, students in the experimental group showed a significant advancement in chemistry performance, hence validating the favorable influence of modern, student-centered teaching techniques on understanding and application of scientific ideas .

Table 3: Critical Thinking Skills: General Contrast

group	Pre-teat mean	Post-test mean	Mean difference	t-value	Significance
Experimental Group	59.2	81.5	22.3	5.48	0.001 (Significance)
Control Group	58.7	65.4	6.7	1.02	0.31 (not Significance)

Modern teaching techniques greatly improved pupils' critical thinking abilities, particularly in areas of evaluation, reasoning, and analysis; conventional methods, however, showed little to no noticeable growth .

Analysis of Results and Data: This chapter shows the real outcomes of the research and examines the data gathered from the pre- and post-test given to both the experimental and control groups. The goal is to ascertain if contemporary teaching strategies have a major influence on pupils' critical thinking abilities and academic success .

Results Connected to Educational Performance: Achievement test results revealed obvious variations between the experimental and control groups :The post-test mean score for the experimental group taught using contemporary techniques was greater than that of the control group .Confirming that the use of contemporary strategies had a beneficial impact on pupils' academic performance, a t-test analysis revealed that the difference was statistically significant at the 0.05 level .

This indicates that active and problem-based instruction enabled pupils to grasp, use, and analyze chemical and mathematical ideas more successfully. Results from Critical Thinking: The experimental group's students showed great improvement according their post-test scores were far greater than those of the control group during the examination of the critical thinking scale .The ability to analyze, evaluate, and infer showed the biggest improvements .These results show that modern educational techniques promote among pupils deeper thought, questioning, and reasoning .

Compare Mathematics and Chemistry: Comparing findings by discipline: Chemistry improved marginally more than mathematics. The experimental and inquiring character of chemistry, which corresponds more closely with problem-based and project-based learning activities, could account for this .

Talk of Results: The findings support the study's hypotheses: contemporary teaching techniques greatly raise academic performance. They also help pupils to develop their critical thinking abilities. These results support earlier research (e.g., Al-Khatib, 2022; Al-Anzi, 2023), which discovered that student-centered approaches produce better learning outcomes than conventional teaching methods .

Finally, the results of this study on the real component of contemporary teaching methods—especially problem-based and cooperative learning—have a favorable and measurable effect on mathematics and chemistry secondary school students' achievement and critical thinking. These results advocate the implementation of creative, student-centered teaching techniques in middle school. The Theoretical Application of the Research.

New teaching techniques in mathematics have enabled learners to reason and solve complex problems. In chemistry, by utilizing real-world projects and experiments during class time, instructors have been able

to engage all students in their lessons and make them more meaningful to the learners and aid in increasing the level of achievement of those same learners who participated in this experimental study. Furthermore, students participating in the experimental group displayed greater levels of critical thinking (e.g., reasoning, analyzing and evaluating)—skills that will enable them to be successful in scientific inquiry and to become lifelong learners.The results of this research support prior research (Al-Khatib, 2022; Al-Anzi, 2023; Al-Saeed, 2021), which found that student-centered instructional strategies facilitate deeper understanding, motivation, and intellectual independence.

Conclusions and Suggestions for Future Research

Modern approaches to teaching (especially inquiry-based, experiment-based, and reasoning-based methods) have proven to be very effective in the sciences, particularly in subjects where these modes of learning are central to developing knowledge about the world. The following recommendations, based on the findings of this study, are made for the effective integration of new teaching approaches into the official curriculum of secondary schools:

Integrate modern teaching methods (e.g., problem solving, co-operative, and project-based learning) into the official secondary school curriculum.

Provide in-service teacher training and development programs that enable teachers to use these methodologies effectively in mathematics and science classrooms.

Encourage schools to allocate sufficient resources and to create classroom settings that allow for collaborative and active learning processes to occur.

Use diverse assessments that assess higher order thinking skills rather than only assessing how well students can recall memorized information.

Promote collaboration among teacher-educators, teachers, and policy-makers to continue to improve upon the quality of teaching practices.

In addition to the above-mentioned recommendations, the authors of this study encourage future researchers to:

1 - Conduct similar studies in other content areas (e.g., physics, life-sciences, or languages) to determine whether or not modern teaching practices can be successfully applied to teach those subjects as well.

2- Examine the long-term effectiveness of using modern teaching methods on students' academic achievement and motivation.

3 -Investigate the use and effectiveness of digital and/or technological resources in conjunction with modern pedagogy.

4. Study teacher perceptions and willingness to implement new teaching practices across different disciplines and educational contexts.

Research like this is vital to supporting the importance of incorporating innovative, student-centered teaching strategies into schools. This evidence illustrates how the use of modern pedagogy can completely change the way students interact with and experience the process of learning, making it have greater meaning, be more interactive, and ultimately be a better learning experience for the student. When students are engaged in their education through meaningful experiences, they will be able to develop their critical thinking and problem-solving abilities along with their knowledge. By incorporating 21st-century skills into the curriculum, educators will better prepare students for the intellectual and career challenges they will face upon entering the workforce .

This research also emphasizes the need for education to move away from traditional forms of learning, such as rote memorization and passive learning, to more active/inquiry-based learning formats. Through this shift in how education will be delivered, both students and teachers will have meaningful learning experiences that will ultimately

lead to higher academic performance and development of critical life skills. The incorporation of modern educational methodologies within secondary education will ultimately lead to the development of a more innovative, analytical, and forward-thinking society.

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