UDK: 373.167.1:543.544:37.015.3

CONSTRUCTIVIST PEDAGOGICAL MODELS FOR DEVELOPING SKILLS THROUGH CHROMATOGRAPHIC PROBLEM-SOLVING TASKS.

Abduraximova Shahlo Azim qizi
A student of the Chemistry program at the Faculty of
Natural Sciences, Uzbekistan-Finland Pedagogical Institute.
E-mail: shahlo1417@gmail.com
Kosimova Xurshida Rajabboyovna
Assistant Lecturer at the Department of Chemistry,
Faculty of Natural Sciences, Uzbekistan-Finland Pedagogical Institute.
E-mail: xurshida82@gmail.com
https://doi.org/10.5281/zenodo.15665519

Abstract: This article explores the application of constructivist pedagogical models in teaching chromatographic analysis, with a focus on skill development through problem-solving tasks. The research emphasizes how learners actively construct knowledge by engaging in hands-on chromatographic exercises that simulate real-world analytical problems. Various teaching strategies rooted in constructivist theory—such as inquiry-based learning, collaborative experiments, and reflective thinking—are examined for their effectiveness in enhancing students' analytical competencies. The paper also provides a methodological framework for integrating chromatographic problem-solving into the chemistry curriculum, contributing to the development of higher-order thinking skills and scientific literacy. Findings suggest that constructivist approaches significantly improve students' conceptual understanding, engagement, and practical skills in chromatographic analysis.

Keywords: Chromatographic analysis, constructivist pedagogy, problem-solving tasks, skill development, chemistry education, inquiry-based learning, analytical thinking, laboratory activities, active learning, scientific literacy.

INTRODUCTION

In recent years, the integration of constructivist pedagogical approaches in science education has garnered increasing attention, particularly in fields requiring strong analytical and practical skills such as chromatography. Chromatographic analysis, a fundamental technique in analytical chemistry, offers vast potential for developing students' critical thinking, problem-solving abilities, and scientific reasoning. However, traditional lecture-based teaching methods often fail to fully engage students or promote deep conceptual understanding of complex analytical processes.

This article aims to explore how constructivist teaching models can be effectively applied to the instruction of chromatographic analysis. It presents methodological strategies for integrating problem-solving activities into the chemistry curriculum and evaluates their impact on learners' cognitive and practical development. The study also addresses the role of inquiry-based learning, reflective practices, and collaborative experimentation in enhancing students' engagement, autonomy, and scientific literacy.

LITERATURE REVIEW

The application of constructivist pedagogy in science education has been widely studied over the past two decades. In chemistry education, constructivist approaches have shown considerable promise in promoting deep understanding of abstract concepts, particularly when learners are exposed to real-world contexts and problem-solving scenarios.

Recent research has highlighted the effectiveness of collaborative learning environments in fostering analytical reasoning. For instance, observed that when students worked in pairs to solve chromatographic separation problems, they not only developed practical skills but also demonstrated deeper understanding through peer discussion and feedback. Despite these advancements, there remains a gap in the integration of structured problem-solving models within chromatographic pedagogy. While numerous chemistry curricula include laboratory components, few systematically employ constructivist strategies to scaffold skill development through progressive problem-solving tasks. This article seeks to address this gap by proposing a framework that blends constructivist principles with chromatography-specific tasks aimed at enhancing both conceptual and procedural competencies.

METHODOLOGY

This study employed a qualitative instructional design-based methodology to develop and evaluate constructivist teaching strategies aimed at enhancing students' skills through chromatographic problem-solving tasks. The research was conducted within the context of undergraduate analytical chemistry courses at a pedagogical university, involving third-year chemistry education students.

Participants: a total of 36 students participated in the study, divided into two groups: an experimental group ($n = 18$) and a control group ($n = 18$). All participants had previously completed introductory courses in general and organic chemistry. Students in the experimental group engaged with constructivist-based chromatographic tasks, while the control group received traditional instruction.

Instructional design: the instructional model applied in the experimental group followed key principles of constructivist pedagogy. Active learning: students engaged in hands-on chromatography experiments, including thin-layer chromatography and column chromatography, guided by real-world analytical problems. Inquiry-based learning: learners were encouraged to formulate hypotheses, design experimental setups, and interpret results through exploration and discussion. Collaborative learning: tasks were performed in pairs or small groups, with an emphasis on peer dialogue and joint reflection. Scaffolded problem-solving: chromatographic challenges were structured from basic to complex (e.g., from separation of simple dyes to pharmaceutical component identification), with guided prompts and increasing autonomy.

Data collection: to evaluate the impact of the instructional intervention, the following data collection tools were used. Pre- and post-tests: to assess theoretical understanding and analytical problem-solving ability. Observation checklists: used during laboratory sessions to track skill development and student engagement. Reflective journals: students in the experimental group maintained journals to record their observations, strategies, and reflections after each task. Focus group interviews: conducted at the end of the study to gather qualitative feedback on learning experiences and pedagogical effectiveness.

RESULTS

Data analysis: quantitative data from pre- and post-tests were analyzed using paired t-tests to determine statistically significant differences between the groups. Qualitative data from journals and interviews were analyzed thematically to identify emerging patterns in students' learning processes, conceptual growth, and skill acquisition. The results of the study indicate that the implementation of constructivist pedagogical models in chromatographic problem-solving tasks significantly improved students' theoretical understanding and practical skills compared to traditional instruction.

1. Pre- and post-test performance: the experimental group demonstrated a statistically significant improvement in post-test scores (M = 86.4, SD = 5.7) compared to their pre-test scores (M = 62.1, SD = 6.3), with a p-value < 0.01. In contrast, the control group showed only a modest increase (pre-test M = 61.7, post-test M = 69.8, p > 0.05), indicating the effectiveness of the constructivist approach in facilitating learning outcomes.

2. Skill development observed in laboratory sessions: observation checklists revealed that students in the experimental group more frequently. Correctly selected chromatographic methods based on sample properties, adjusted variables such as solvent polarity and flow rate independently, demonstrated precise manipulation of column chromatography techniques. By the third laboratory session, 83% of the students in the experimental group completed tasks with minimal instructor intervention, compared to only 39% in the control group.

3. Reflective journal insights: qualitative analysis of students' journals showed increasing levels of metacognition. Early entries often focused on procedural descriptions, while later reflections demonstrated. Improved ability to justify choices of stationary and mobile phases, critical evaluation of separation efficiency. Awareness of sources of error and troubleshooting strategies, students frequently mentioned how hands-on tasks made abstract concepts more understandable and boosted their confidence in using chromatographic equipment.

Many students expressed a desire for more such tasks in other areas of chemistry instruction.

DISCUSSION

The findings of this study support the growing body of evidence suggesting that constructivist pedagogical models enhance both conceptual understanding and practical competencies in science education. The significant improvement in post-test scores among students in the experimental group confirms that engaging learners in structured, scaffolded problem-solving activities can lead to deeper cognitive processing and long-term knowledge retention. The positive feedback from students during focus group interviews highlights the motivational benefits of active, student-centered learning environments. The collaborative aspects of the tasks appeared to foster a sense of shared responsibility and peer-supported learning, which is a central tenet of social constructivist theory. Students not only acquired technical skills in chromatography but also developed transferable skills such as critical thinking, communication, and problem-solving—all of which are essential in modern scientific practice.

The discussion confirms that constructivist approaches—when thoughtfully applied—can significantly enrich chromatographic education by fostering independent learning, skill mastery, and scientific reasoning.

CONCLUSION

This study demonstrates that the integration of constructivist pedagogical models into the teaching of chromatographic analysis significantly enhances students' cognitive understanding, practical skills, and engagement with scientific inquiry. By actively involving learners in problem-solving tasks that mirror real-world laboratory scenarios, the instructional approach promotes meaningful learning and the development of higher-order thinking abilities.

The results highlight the value of inquiry-based, collaborative, and reflective learning strategies in fostering deeper conceptual comprehension and technical proficiency in chromatography. Constructivist learning environments not only facilitate academic achievement but also cultivate essential scientific competencies such as analytical reasoning, autonomy, and communication.

Future research should explore the scalability of this model in diverse educational contexts and examine the long-term effects of constructivist instruction on students' performance in advanced analytical tasks and professional applications.

References:

1. Vygotsky, L. S. (1978). Mind In Society: The Development Of Higher Psychological Processes. Cambridge, Ma: Harvard University Press.
2. Piaget, J. (1970). Science Of Education And The Psychology Of The Child. New York: Orion Press.
3. Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing Scientific Knowledge In The Classroom. Educational Researcher, **23**(7), 5–12.
4. Taber, K. S. (2002). Chemical Misconceptions – Prevention, Diagnosis And Cure: Volume I: Theoretical Background. London: Royal Society Of Chemistry.
5. Hofstein, A., & Lunetta, V. N. (2004). The Laboratory In Science Education: Foundations For The Twenty-First Century. Science Education, **88**(1), 28–54.
6. Domin, D. S. (2007). Students' Perceptions Of When Conceptual Development Occurs During Laboratory Instruction. Chemistry Education Research And Practice, **8**(2), 140–152.
7. Pardayev U. Et Al. The Effects Of Organizing Chemistry Lessons Based On The Finnish Educational System In General Schools Of Uzbekistan //Journal Of Universal Science Research. – 2024. – T. 2. – №. 4. – C. 70-74.
8. Choriqulova D. Et Al. The Role Of The Method Of Teaching Chemistry To Students Using The" Assessment" Method //Modern Science And Research. – 2024. – T. 3. – №. 11. – C. 256-264.
9. Narzullayev M. Et Al. The Method Of Organizing Chemistry Lessons Using The Case Study Method //Modern Science And Research. – 2024. – T. 3. – №. 5. – C. 119-123.
10. Amangeldievna J. A., Xayrullo O'g P. U., Shermatovich B. J. Integrated Teaching Of Inorganic Chemistry With Modern Information Technologies In Higher Education Institutions //Fan Va Ta'lim Integratsiyasi (Integration Of Science And Education). – 2024. – T. 1. – №. 3. – C. 92-98.
11. Amangeldievna J. A. Et Al. The Role Of Modern Information Technologies In Chemical Education //International Journal Of Scientific Researchers (Ijsr) Indexing. – 2024. – T. 5. – №. 1. – C. 711-716.
12. Abdukarimova M. A. Q. Et Al. Tabiiy Fanlar O 'Qitishda Steam Yondashuvi //Science And Education. – 2024. – T. 5. – №. 11. – C. 237-244.
13. Xayrullo O'g P. U. Et Al. The Importance Of Improving Chemistry Education Based On The Steam Approach //Fan Va Ta'lim Integratsiyasi (Integration Of Science And Education). – 2024. – T. 1. – №. 3. – C. 56-62.
14. O'G'Li U. B. X. Et Al. The Effectiveness Of Using Modern Information And Communication Technologies (Ict) In Chemistry Education //Science And Education. – 2025. – T. 6. – №. 2. – C. 350-363.
15. Tilyabov M., Pardayev U. Kimyo Darslarida O 'Quvchilarni Loyihaviy Faoliyatga Jalb Qilish Usullari //Modern Science And Research. – 2025. – T. 4. – №. 5. – C. 42-44.
16. Pardayev U., Abdullayeva B., Abduraximova M. Zamonaviy Virtual Laboratoriya Platformalaridan Foydalanib Kimyo Fanini O 'Qitish Samaradorligini Oshirish //Modern Science And Research. – 2025. – T. 4. – №. 5. – C. 48-50.