# OVERCOMING CHALLENGES IN MODERN CHROMATOGRAPHY LEARNING: ANALYZING STUDENT NEEDS FOR SCAFFOLDING-BASED INTERACTIVE MEDIA

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**Abstract**

Modern chromatography is a crucial analytical technique in chemistry, yet it is often challenging for students to grasp. This difficulty arises from the complexity of the theory and the gap between theoretical concepts and laboratory practice. This study aims to identify the barriers students face in learning modern chromatography and to assess their needs for scaffolding-based interactive learning media as a potential solution. Using a qualitative descriptive approach, the research involved 43 students and alumni from the Chemistry Education Program at the Faculty of Teacher Training and Education, Universitas Terbuka. A questionnaire was employed to explore their understanding of the material, use of learning media, and independence in learning. The results reveal that students encounter significant challenges in comprehending modern chromatography theory, primarily due to limited access to learning resources, a lack of hands-on practice, and insufficient visual explanations. Scaffolding-based interactive learning media is considered capable of addressing these issues by providing clear visualizations, interactive exercises, and step-by-step feedback. The use of interactive media is expected to enhance both material comprehension and learning interest, while the scaffolding approach is deemed effective in helping students overcome difficulties in understanding complex concepts. The findings indicate that although respondents have high confidence in using technology, there are challenges in self-directed learning and the effectiveness of online tutorials. The study recommends the development of more adaptive and interactive learning media, as well as enhanced support in online tutorials to better meet student needs. By leveraging interactive learning media and the scaffolding approach, it is anticipated that students' understanding of modern chromatography will significantly improve, along with their ability to develop stronger independent learning skills.

Keywords: Educational technology, Interactive learning media, Modern chromatography, Scaffolding, Self-directed learning.

## 1 INTRODUCTION

In the instrumental analytical chemistry course, modern chromatography is one of the essential analytical techniques that students need to master, yet it is often challenging to understand. Modern chromatography is applied in various industries such as pharmaceuticals, food, and environmental management (Vargas et al., 2021), where a thorough understanding of this method is crucial. Many students struggle to grasp both the theory and practical application of modern chromatography. These difficulties typically arise from the complexity of the material and the gap between classroom theory and the necessary laboratory practice. Previous research has shown that many students find it difficult to fully master this subject (Jordheim et al., 2021; Woodfield et al., 2004).

With the advancement of digital technology, interactive learning media have emerged as a promising solution to overcome these challenges. Digital media can make learning more engaging and interactive, thereby increasing students' interest and motivation to learn (Maulana et al., 2021). The scaffolding approach, where learning is conducted gradually by providing support according to the students' needs, can help them achieve a deeper understanding. Based on constructivist theory, interactive learning supported by technology can make education more effective and relevant (Jemberie, 2021; Yaşar & Sözbilir, 2019).

This study was conducted due to the need to improve the way modern chromatography is taught among chemistry education students. By utilizing scaffolding-based interactive media, this method is expected to provide an effective solution to the current learning challenges. The goal is to bridge the gap between complex theory and the practical realities often encountered in the field.

The primary issue this research aims to address is the lack of learning media that can help students achieve a comprehensive understanding of modern chromatography. Students frequently express concerns about the insufficient materials or learning aids available to them. Therefore, it is crucial to identify students' needs and find the best ways to implement interactive technology and scaffolding within the chemistry curriculum.

One proposed solution is to develop learning media that not only provides information but is also interactive and engaging. With the help of simulations and adaptive assessments, this media can help students learn in a more personalized way, meeting their individual needs (Rahmawati et al., 2022; Swiecki et al., 2022). This approach ensures that students not only receive the necessary knowledge but also actively engage with the material, making the learning process

more effective. By tailoring the learning experience to each student's unique pace and understanding, it also promotes deeper comprehension and retention of complex concepts.

The purpose of this study is to analyze students' needs for interactive learning media and to assess how effective the scaffolding approach is in improving their understanding of modern chromatography. By offering practical and applicable solutions, this research aims to inspire new teaching methods that can be widely adopted. The findings are expected to bridge the gap between complex theoretical knowledge and practical application, ultimately enhancing students' learning experiences and outcomes in chemistry education.

In practice, interactive learning media has already proven to be effective in various other fields of study (Siemieniecka et al., 2017). Therefore, combining this media with the scaffolding approach in chemistry can lead to significant advancements in technology-based teaching and learning. This study is also supported by extensive literature highlighting the importance of customized and adaptive learning, especially in an ever-changing educational environment (Christodoulou & Angeli, 2022; Contrino et al., 2024).

The benefits of this research extend beyond modern chromatography learning and also contribute to the overall development of the chemistry education curriculum. Specifically, it addresses the needs of the current generation of students who are more familiar with technology and require more engaging and structured learning methods. By placing students at the center of the learning process, it is hoped that they will more quickly grasp the material and hone their analytical skills.

Overall, the findings of this research are expected to provide practical recommendations that can be implemented across various educational institutions to enhance the quality of learning and offer long-term benefits to all stakeholders involved in chemistry education. Consequently, this approach could serve as an innovative learning model for other educational fields as well. By demonstrating the effectiveness of interactive media and scaffolding in improving student comprehension, the study aims to contribute to more engaging and effective teaching practices across diverse subjects.

## 2 METHODOLOGY

This study employs a descriptive qualitative approach to identify and address challenges in learning modern chromatography through the analysis of students' needs for interactive scaffolding-based media (Masbukhin et al., 2024). The research is conducted within the Chemistry Education Program at FKIP Universitas Terbuka from April to June 2024. This timing and location were chosen based on the academic calendar to facilitate the collection of relevant data and support the students' learning process.

The subjects of the study are students who have completed the instrumental analytical chemistry course. Purposive sampling was used to select 43 students and alumni as respondents, ensuring that each participant had direct experience with the material being studied, namely modern chromatography. This approach allows for the collection of specific and in-depth data regarding the challenges and needs faced by students in their learning.

The research procedure involves the distribution of a carefully designed questionnaire to explore the execution of analytical chemistry instruction, specifically in the topic of modern chromatography. The questionnaire contains a series of questions aimed at uncovering students' and alumni's perceptions of the effectiveness of their learning experience and the potential use of interactive media and scaffolding approaches.

The research instruments are divided into three main aspects. The Understanding and Difficulty of Material aspect investigates how well students comprehend chromatography material and the difficulties they encounter. The Interactive Learning Media and Scaffolding aspect explores students' views on how the use of interactive technology and scaffolding approaches can facilitate their learning. Finally, the Independence and Support in Learning aspect assesses the level of students' independence and the learning support they receive in completing related tasks.

The collected data are analyzed descriptively and qualitatively. The analysis process includes data reduction, data presentation, and conclusion drawing to describe patterns and themes emerging from student responses. This analysis aims to identify the main obstacles in learning modern chromatography and evaluate the need for more interactive and adaptive learning media. The research findings are expected to provide practical insights for the development of curricula and more effective teaching approaches in the future.

## 3 FINDINGS AND DISCUSSION

In this study, a needs analysis was conducted with 29 active students and 14 alumni from the Chemistry Education Program at FKIP-UT who have taken the instrumental analytical chemistry course, with respondents distributed across UT Medan, Palangkaraya, Purwokerto, and Makassar. The respondents were from various age groups, the majority being between 26 and 35 years old, with a higher proportion of females (29 females vs. 14 males). Most were in their early to mid-semesters (semesters 1-10) and had relatively limited teaching experience (0-5 years, with 23 individuals). This demographic variation provides a comprehensive view of the different challenges faced by students and alumni in understanding modern chromatography. Preliminary findings indicate that the need for scaffolding-based interactive learning media is highly relevant, especially to support those who are still in the early stages of their studies or new to teaching. Figure 1 below provides a comprehensive overview of the respondents' demographics.

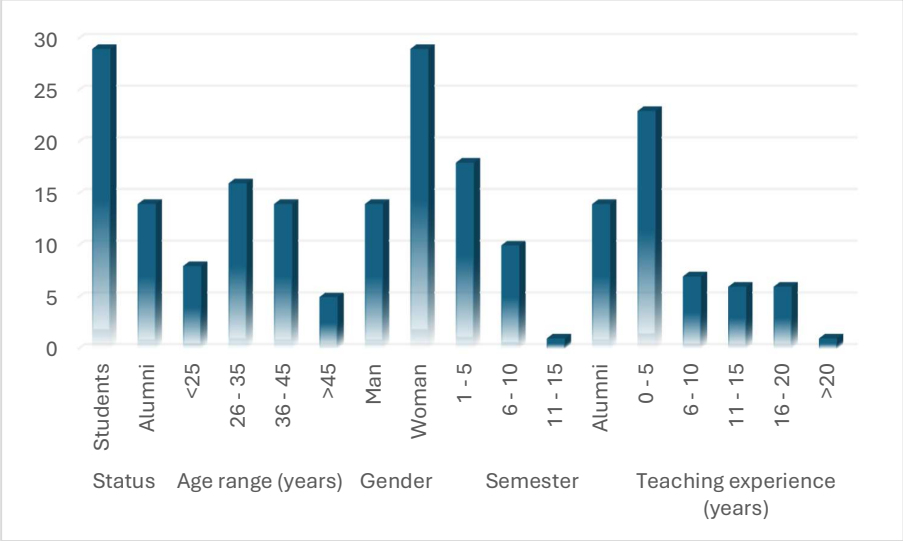


*Figure 1. Respondent Demographics.*

### 3.1 Understanding and Difficulty with the Material

The aspect of understanding and difficulty with modern chromatography is a primary focus of this study. According to the respondents, many reported struggling to grasp the concepts of modern chromatography, particularly when faced with the technical complexity and its application in chemical analysis. Major barriers identified include limited access to in-depth learning resources, insufficient opportunities for hands-on practice, and a lack of visual and interactive explanations in the presented material. Additionally, many respondents found it

challenging to engage in self-directed learning, especially with material perceived as abstract and difficult to understand without direct guidance. These issues are compounded by limited interaction during online tutorials, where students often have difficulty asking questions or receiving adequate feedback from tutors. Overall, these findings highlight an urgent need for interactive learning media that can support students' understanding and engagement with modern chromatography.

Table 1 presents various obstacles faced by respondents in modern chromatography learning. The first indicator shows that the level of difficulty in understanding modern chromatography material is at a neutral value, with an average score of 3.28 on the Likert scale of 1-5. This shows that respondents experienced significant challenges in understanding the material, but not to the extreme. This neutral value indicates that despite the difficulties, the level of difficulty is considered moderate and does not lead to an inability to fully understand the material (Setia et al., 2022).

In the second indicator, the main obstacles in understanding modern chromatography material include limited equipment, difficulty understanding complex theoretical concepts, and problems in data visualization and interpretation. Respondents also noted the lack of hands-on practice as a major factor hindering understanding. Limitations in equipment and technology often prevent students from gaining the practical experience necessary to understand theoretical concepts in depth. This limitation is in line with previous research that shows that complex theories in chromatography require practical experience to be fully mastered (Zhou et al., 2016).

*Table 1. Constraints of Modern Chromatography Learning.*

| No. | Indicator | Respons |
|---|---|---|
| 1 | The level of difficulty in understanding modern chromatography material. | • The mode is at a value of 3 (Neutral).<br>• The mean value is 3.28 on the Likert scale 1-5. |
| 2 | The main obstacles faced in understanding modern chromatography material. | • Limited equipment.<br>• Difficulty understanding complex theoretical concepts.<br>• Problems in data visualization and interpretation. |

| | | |
|---|---|---|
| | | • Lack of hands-on practice. |
| 3 | Difficulties in carrying out independent learning activities. | • Busy work.<br>• Time constraints.<br>• Difficult access to learning resources. |
| 4 | Obstacles experienced while participating in the online tutorial of the instrumental analytical chemistry. | • Lack of real practice.<br>• Difficulty understanding the module material.<br>• Internet signal constraints.<br>• Limited interaction with tutors and access to virtual labs. |

The third indicator reveals that difficulties in carrying out independent learning activities are often caused by busy work, time constraints, and difficulties in accessing learning resources. These issues interfere with respondents' ability to learn independently, which is an important aspect of modern, open, and distance learning (Kocdar et al., 2018). Research shows that poor time management and difficulties in accessing learning resources can hinder the achievement of optimal learning outcomes, especially in terms of learning that requires depth of material and practicality (Rață et al., 2022).

Finally, the obstacles during participating in the online tutorial of the instrumental analytical chemistry include a lack of real practice, difficulty understanding the module material, a weak internet signal, and limited interaction with tutors and access to virtual laboratories. This indicates the need for improvements in the design and delivery of online tutorials, including increased access to technology and interactive support. Limitations in simulation and real practice, as noted in other studies, suggest that hands-on experience and adequate guidance are essential for effective understanding in technical courses such as instrument chemistry (Kusmawan, 2022).

### 3.2 Interactive Learning Media and Scaffolding Aspect

The aspect of interactive learning media and scaffolding is a significant focus of this study, as respondents consistently indicated that the use of interactive learning media is considered to help them understand modern chromatography more effectively. The majority of respondents

believe that interactive media would not only clarify complex concepts but also increase their interest in the subject, making learning more engaging and enjoyable. Additionally, the scaffolding approach is seen as highly beneficial in helping them overcome difficulties in understanding abstract chromatography concepts and in developing better self-directed learning skills. Respondents also provided input on the essential components that should be included in this learning media, such as clear visualizations, interactive exercises, and step-by-step feedback to guide them through the learning process. They hope that the developed media will provide the necessary support to deeply understand the material and help them achieve the expected competencies in the field of modern chromatography.

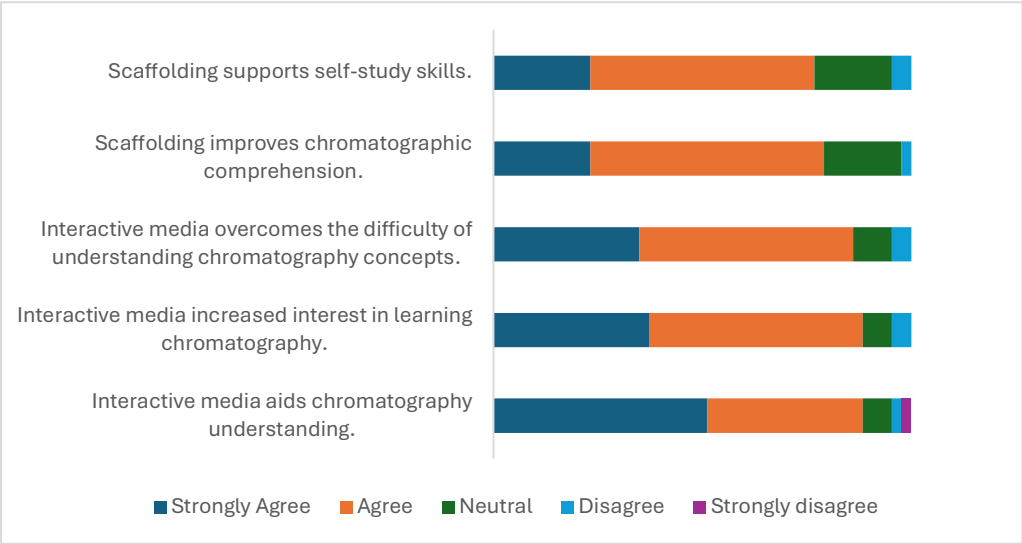


*Figure 2. Percentage of Respondents about Interactive Media and Scaffolding.*

Based on Figure 2, the use of interactive learning media and the scaffolding approach received significantly positive responses from the 43 respondents. A majority of respondents (51.16%) strongly agreed that interactive learning media would help them better understand modern chromatography, while 37.21% agreed with this statement. This suggests that interactive media is perceived as an effective tool for facilitating the understanding of complex material, aligning with research that shows visual and interactive media can enhance comprehension of abstract concepts (Yulina et al., 2021).

Regarding interest in the subject matter, 51.16% of respondents felt that interactive learning media could increase their interest, while 37.21% agreed. These results are consistent with (Marina & Prima, 2020), which indicates that interactive media not only aids in material comprehension but also boosts student motivation and engagement. Additionally, respondents

expressed confidence that such media could help overcome difficulties in understanding chromatography concepts, with 51.16% agreeing and 34.88% strongly agreeing, supporting the view that interactive tools are effective in addressing learning challenges (Ahmad et al., 2021). The scaffolding approach also received positive feedback, with 55.81% feeling that this approach would improve their understanding of the material and 53.49% believing that scaffolding would help develop their independent learning skills. This approach, which provides gradual support, has been proven effective in helping students build knowledge and independent learning skills (Black, 2019; Fleischer et al., 2023). Overall, these findings suggest that interactive learning media and scaffolding can significantly contribute to enhancing students' understanding and learning skills in the modern chromatography course.

*Table 2. Recommendations for the Development of Learning Media.*

| No. | Indicator | Response |
|---|---|---|
| 1 | The important component in interactive learning media with a scaffolding approach to modern chromatography. | • Interactive videos, visual materials, lab supplies, and interactive simulations.<br>• Clear learning objectives, structured content, and step-by-step guides.<br>• Direct and constructive feedback and collaborative. |
| 2 | Suggestions and expectations for the development of interactive learning media with a scaffolding approach on modern chromatography materials. | • Complete and structured material.<br>• It has interactive elements as well as the provision of personalized feedback.<br>• Adaptive and easy-to-use application and platform development. |

Table 2 presents recommendations for the development of interactive learning media using a scaffolding approach for modern chromatography material. For essential components, respondents emphasized the need to integrate interactive videos, comprehensive visual materials, and interactive simulations to enhance understanding. Additionally, learning objectives should be clear, content should be well-structured, and step-by-step guidance should

be provided. Immediate and constructive feedback, along with active collaboration, are also considered crucial to support an effective learning process.

In terms of suggestions and expectations, respondents expressed a desire for media that presents content in a complete and structured manner. They expect in-depth interactive elements with personalized feedback that can help students better understand the material. The development of adaptive and user-friendly applications and platforms is also a primary expectation, ensuring accessibility and effectiveness in using the media for learning.

### 3.3 Independence and Support in Learning

The aspect of independence and support in learning indicates that respondents exhibit a relatively high level of confidence in using interactive technology to support their studies. Many are capable of engaging in self-directed learning activities by utilizing various learning resources they have independently found, and they are accustomed to using laboratory-based websites as tools to aid in understanding the material. Positive experiences with online tutorials for instrumental analytical chemistry courses were also highlighted, with these tutorials being considered highly beneficial for deepening their understanding of the subject matter. Additionally, some respondents are already familiar with using supplementary websites beyond the online tutorials to support their learning process. However, there is still variation in respondents' knowledge of the Chemistry Education program website at FKIP-UT, indicating an opportunity to increase awareness and utilization of the program website as a more integrated learning resource. These findings underscore the importance of accessible technological support and learning resources to enhance students' independence in mastering complex subjects such as instrumental analytical chemistry.

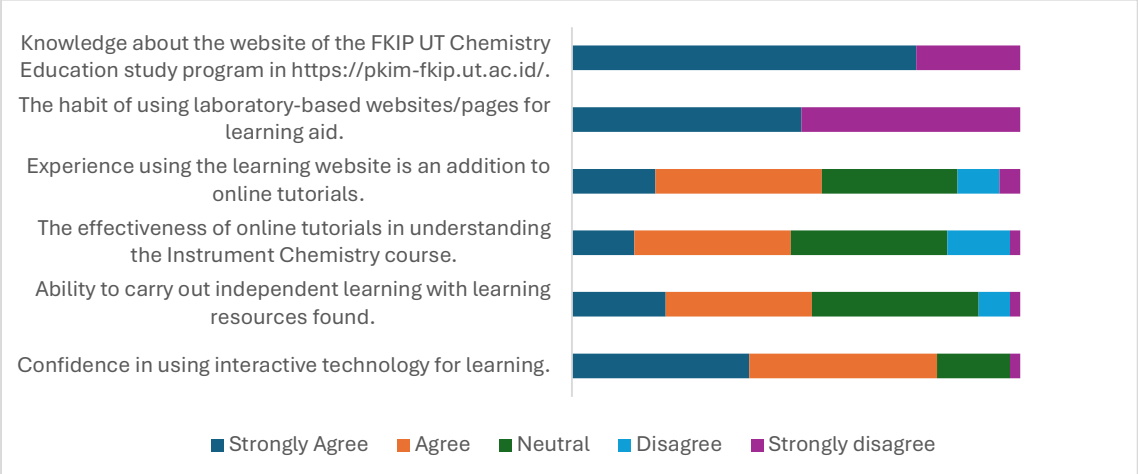

*Figure 3. Percentage of Respondents' Confidence and Experience in the Use of Learning Technology.*

Based on Figure 3, it can be known that various levels of confidence and experience in using technology and learning resources for the instrumental analytical chemistry. Overall, there is a relatively high level of confidence in using interactive technology, with 39.53% of respondents strongly agreeing and 41.86% agreeing. This suggests that the majority of respondents feel confident in utilizing interactive technology for learning, which aligns with previous studies emphasizing the importance of confidence in technology use for effective learning (Carstens et al., 2021).

However, when assessing the ability to engage in self-directed learning, the percentage of respondents who strongly agree drops to 20.93%, while 32.56% agree. This indicates that, despite their confidence in technology, not all respondents feel fully capable of conducting independent learning with the resources they find. This may reflect a need for further support in guiding students to become more independent in their learning, a notion supported by research highlighting the importance of additional support in self-directed learning (Yusuf & Ali, 2022).

The effectiveness of online tutorials in understanding instrumental chemistry courses received varied levels of agreement, with 13.95% of respondents strongly agreeing and 34.88% agreeing. This indicates that while online tutorials are considered beneficial by some respondents, there is still room for improvement in terms of their effectiveness. Research by Sekarwinahyu et al. (2023) shows that the success of online tutorials often depends on their design and implementation, as well as integration with other learning methods.

Regarding the habit of using laboratory-based websites as learning aids, 51.16% of respondents strongly agreed with the use of this tool. However, no respondents indicated agreement or neutrality towards the use of laboratory-based websites as learning aids. This suggests that while the use of such websites is highly appreciated when available, they may not be consistently utilized. Additionally, knowledge of the Chemistry Education program website at FKIP-UT at https://pkim-fkip.ut.ac.id/ is very high, with 76.74% of respondents strongly agreeing that they are aware of its existence, indicating good awareness of the available resources (Camel et al., 2020).

## 4 CONCLUSION

This study indicates that interactive learning media based on scaffolding holds great potential for overcoming various challenges faced by students in understanding modern chromatography. An analysis of the needs of Chemistry Education students and alumni at FKIP-UT revealed that limited access to learning resources, difficulties in grasping complex concepts, and a lack of hands-on practice are the primary issues that need to be addressed. By implementing learning media that provides interactive videos, in-depth visual materials, and practical simulations, it is expected that students will find it easier to understand the material and engage actively in the learning process. The need for immediate and constructive feedback also emerged as a key projection, underscoring the importance of interaction in enhancing understanding and developing independent learning skills.

Furthermore, the study's findings show that while there is a high level of confidence in using interactive technology, significant challenges remain in conducting self-directed learning and in the effectiveness of online tutorials. This points to the necessity of developing more adaptive and user-friendly applications and platforms, as well as enhancing support in online tutorials to ensure that the developed learning media can effectively meet students' expectations and needs. The high awareness of the FKIP-UT Chemistry Education program website also highlights the potential to leverage existing resources to support learning. Thus, the development of more interactive and integrative media, along with improved access and support in learning, is expected to facilitate better understanding and more independent learning skills in studying modern chromatography.

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