

Original Article

Development of a Pharmacognosy Laboratory Manual for First-Year Pharmacy Students: A Cross-Sectional Needs Assessment

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Abstract

Pharmacognosy is a core discipline in pharmaceutical education that relies on laboratory-based learning to develop students' skills in identifying medicinal plant materials. However, first-year pharmacy students often face challenges in understanding microscopic structures and laboratory procedures due to limited visual and structured resources. This study aimed to design a pharmacognosy laboratory manual based on the educational needs of first-year students at the University of Tripoli. A descriptive cross-sectional design was adopted, and a structured questionnaire was distributed to students enrolled in or who had completed the course. A pilot study (n=32) was conducted to assess reliability, followed by a final sample of 142 valid responses. The questionnaire covered demographics, laboratory difficulties, learning preferences, and improvement suggestions. Content validity was confirmed by academic staff review, and reliability was established using Cronbach's alpha (0.70–0.766). Data were analysed using SPSS with descriptive statistics. Most students (90.2%) supported the need for an integrated guide linking theory with microscopic visualization and assessment. Challenges included limited access to microscopic images (50.7%) and fragmented digital resources (58.5%). Difficulties were reported in identifying calcium oxalate crystals, fibers, vessels, and trichomes. Students highly valued digital PDF resources with QR codes (97.2%) and experiment checklists (93.0%). High agreement was also observed for peer learning, botanical garden integration, and the use of Libyan medicinal plants. The findings support the development of an interactive pharmacognosy laboratory manual to enhance students' understanding, engagement, and practical skills.

Keywords. Pharmacognosy, Laboratory Manual, Microscopy, QR Codes, Medicinal Plants.

Introduction

Pharmacognosy is a fundamental branch of pharmaceutical sciences that focuses on the study of natural products, particularly medicinal plants, as important sources of therapeutic compounds [1]. It involves the study of the sources of natural materials, their chemical composition, physical properties, biological activity, and therapeutic uses [2]. Medicinal plants have played a significant role in the treatment of diseases since ancient times. They have been widely used in various traditional medical systems such as Traditional Chinese Medicine, Ayurveda, and Unani medicine, as well as Western herbal medicine [3].

Pharmacognosy is characterized by its multidisciplinary nature, integrating several scientific fields such as botany, phytochemistry, pharmacology, toxicology, and pharmaceutical quality control [1]. This integration contributes to a deeper understanding of the structural, chemical, and pharmacological properties of medicinal plants, while also enabling the evaluation of their safety, quality, and therapeutic effectiveness [2].

Practical training represents an essential part of pharmacognosy education and enables students to apply theoretical knowledge in real laboratory environments, thereby enhancing their understanding and developing their analytical and technical skills [4].

One of the most important tools in pharmacognosy laboratories is the microscope, which enables students to examine microscopic characteristics of medicinal plants and natural drugs, such as plant cells, tissues, stomata, trichomes, fibers, vessels, and calcium oxalate crystals. These microscopic features play a critical role in identifying and authenticating plant materials, detecting adulteration, and ensuring the quality control of herbal drugs [5].

With the evolution of higher education practices, integration of modern educational tools has become essential in improving the teaching and learning process, particularly in subjects that rely heavily on practical training [6]. Several studies have shown that visual educational tools such as illustrations, scientific images, diagrams, and instructional videos can significantly enhance students' understanding of complex scientific concepts [7].

Moreover, a recent study reported that the use of Quick Response (QR) codes in educational materials enables students to quickly access additional learning resources such as instructional videos and supplementary explanations, thereby enhancing student engagement and supporting interactive learning [8]. In addition, several researchers have also examined the role of laboratory manuals in improving practical education in pharmaceutical sciences. A study conducted by Sachin Sunil Thakur, Darren Michael Svirskis, and Louise Elizabeth Curley investigated pharmacy students' perceptions of laboratory manuals delivered in two formats: traditional paper-based manuals and electronic laboratory manuals. The results showed that students considered the electronic laboratory manual easier to use and more supportive for independent learning during laboratory sessions [9]. Similarly, another study evaluating the implementation of a laboratory quality system in pharmacy teaching laboratories found that structured laboratory

documentation and standardized experimental procedures help students perform laboratory experiments correctly and improve the organization of practical sessions [10].

While several global studies support the importance of visual and interactive learning tools in pharmaceutical education, no study has yet developed a structured, visual, and interactive pharmacognosy laboratory manual specifically designed for first-year pharmacy students at the University of Tripoli. This gap highlights the need for an organized educational resource that integrates theoretical knowledge, practical laboratory procedures, and digital learning tools to improve students' laboratory understanding and engagement.

Methods

Study design

This study was designed as a cross-sectional descriptive study aimed at developing a practical laboratory guide for first-year pharmacy students in the Pharmacognosy course. The study combined quantitative survey data with educational design principles to ensure the guide meets students' learning needs and enhances laboratory performance.

Study Setting and Participants

The study was conducted at the Faculty of Pharmacy, University of Tripoli, Libya, between February and March 2026. The target population included all pharmacy students who had studied or were currently enrolled in the pharmacognosy course. This wide-ranging approach was adopted to capture views from students at different stages of their academic study, including those currently experiencing the challenges, those who had recently completed the course, and those with retrospective insights from repeating the course. A total of 142 students participated in the study.

Data Collection Tool

Data were collected using a structured questionnaire developed by the researchers based on a review of relevant literature. The questionnaire included sections on demographic characteristics, students' perceptions of laboratory sessions, challenges faced during practical work, preferred learning methods, and opinions on the need for a laboratory guide and its key features (e.g., images, step-by-step instructions, QR codes, and safety guidelines). Responses were measured using a Likert scale, along with multiple-choice and open-ended questions.

Validity and Reliability

Content validity of the questionnaire was ensured through faculty review by five academic staff members from the Department of Pharmacognosy at the Faculty of Pharmacy, University of Tripoli. The academic staff reviewed the instrument for clarity, relevance, and adequacy in relation to the study objectives, and their feedback was used to improve and expand the questionnaire. Following this stage, a pilot study was conducted on 32 pharmacy students to assess the clarity and applicability of the questionnaire items. Based on the pilot results, minor modifications were made before final distribution. The reliability of the instrument was then assessed using Cronbach's alpha coefficient. The final dataset showed acceptable internal consistency, with Cronbach's alpha values meeting the recommended threshold ($\alpha \geq 0.70$), indicating that the questionnaire was reliable for the main study.

Data Collection Procedure

Data were collected over four weeks (February–March 2026). The last version of the questionnaire was distributed electronically using Google Forms to ensure easy access and data handling. Before data collection, participants were informed about the aim of the study, the voluntary nature of participation, and the confidentiality of their responses. The questionnaire link was shared through multiple communication channels, including classroom announcements, student groups, and direct messaging, to maximize response rate. Reminder messages were sent periodically during the data collection period to encourage participation and improve completion rates.

Data Analysis

Data were analysed using SPSS version 26. Descriptive statistics were applied to summarize students' responses, including frequencies and percentages for categorical variables. Then, results were presented in the form of tables and figures to illustrate response patterns across different sections of the questionnaire. In addition, open-ended responses were analyzed using thematic analysis to identify common ideas and suggestions related to the development of the practical laboratory guide.

Developing the Guide

The pharmacognosy guide was developed based on students' learning needs. The collected data were reviewed and used to identify the main difficulties in laboratory work. Based on this, the guide was prepared

in a clear and simple format to help students understand the practical sessions and improve their skills (Figure 1).

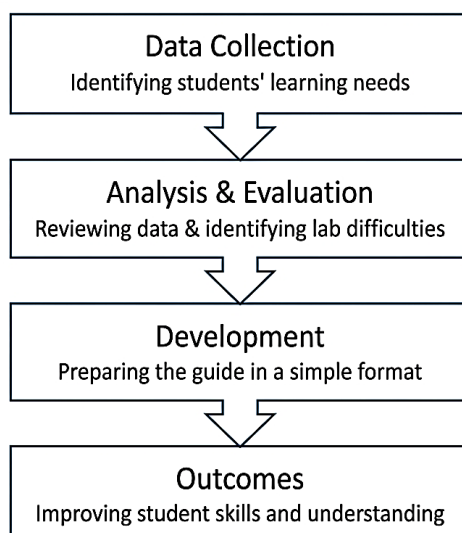


Figure 1. Flowchart of the pharmacognosy guide development process based on student needs.

Results

Demographic Characteristics

A total of 142 responses were analysed. Participants were distributed across different academic levels, with fourth-year students showing the largest group (49.3%). Most respondents had already passed the pharmacognosy course (76.8%). Detailed demographic data are presented in (Table 1).

Table 1. Demographic Characteristics of Study Participants (N=142)

Characteristic	Category	Frequency (n)	Percentage (%)
Academic Year	First Year	24	16.9
	Second Year	20	14.1
	Third Year	19	13.2
	Fourth Year	70	49.3
	Graduate	9	6.3
Academic Status	Passed the course	109	76.8
	Repeating the course	21	14.8
	Currently enrolled	12	8.5

Laboratory Learning Challenges

Students reported several key challenges in pharmacognosy laboratory learning. The main difficulties included limited access to microscopic images during sessions and insufficient dependence on informal learning resources for exam preparation. Primarily, there was a strong agreement on the need for structured learning support, as students expressed a clear demand for an integrated laboratory manual. Additionally, a considerable proportion (n=98) reported increased self-learning burden due to the absence of an official manual (Table 2).

Table 2. Student Agreement on Laboratory-Related Challenges (N=142)

Challenge Statement	Strongly Disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly Agree n (%)	Combined Agree/Strongly Agree n (%)
Difficulty accessing microscopic images quickly during lab work	3 (2.1)	26 (18.3)	41 (28.9)	45 (31.7)	27 (19.0)	72 (50.7)
Telegram channels/scattered images insufficient for practical exam preparation	5 (3.5)	27 (19.0)	27 (19.0)	44 (31.0)	39 (27.5)	83 (58.5)
Need for an integrated guide linking theory, real images, and drawing/assessment	0 (0.0)	3 (2.1)	11 (7.7)	44 (31.0)	84 (59.2)	128 (90.2)
Absence of a departmental manual requires individual effort to compile material	3 (2.1)	13 (9.2)	28 (19.7)	44 (31.0)	54 (38.0)	98 (69.0)

Difficulty in Identifying Microscopic Structures

Students experienced variable levels of difficulty depending on the microscopic structure. Fibers, xylem vessels, calcium oxalate crystals, and trichomes were reported as the most challenging, while starch grains were the easiest to identify, and stomata showed moderate difficulty (Figure 2).

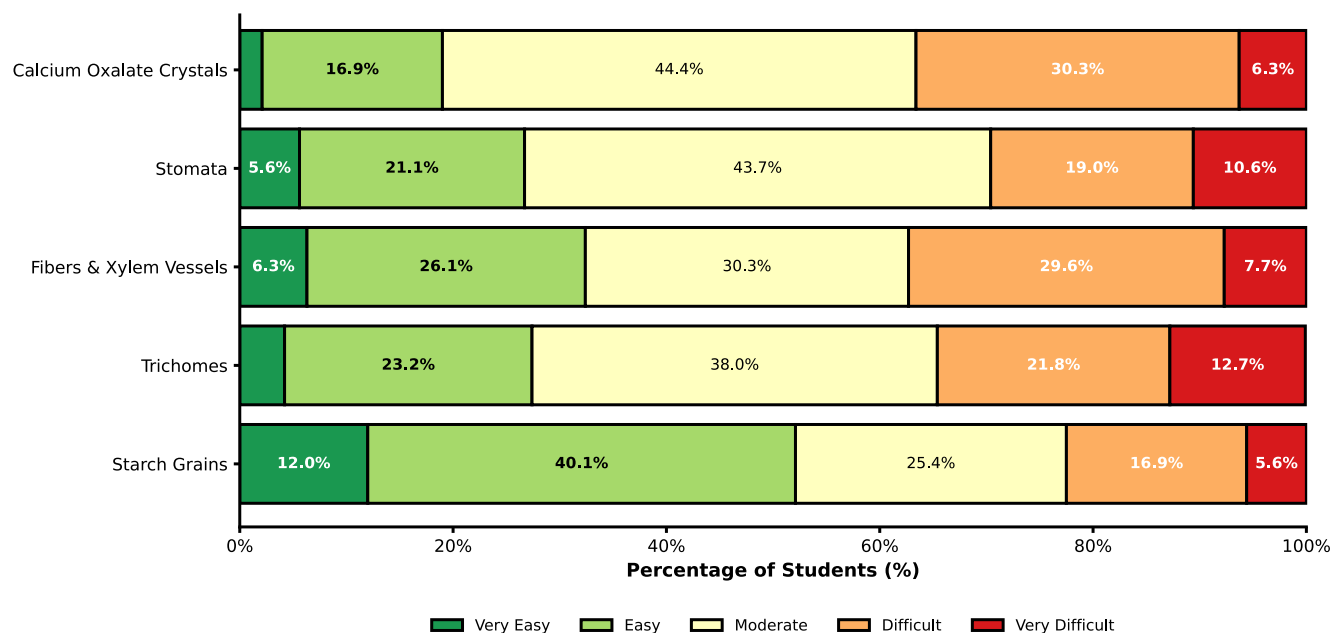


Figure 2. Perceived difficulty levels in identifying key microscopic botanical structures (N=142).

Peer Learning and Organizational Preferences

There was strong support for collaborative and structured learning approaches. Students highly favored the inclusion of both instructor- and student-generated images in an official manual. In addition, most participants supported supervised drawing activities and the use of a single standardized reference for assessment. Peer collaboration was particularly emphasized, with nearly all students expressing interest in a platform for sharing microscopic images. Detailed responses are shown in (Table 3).

Table 3. Student Agreement on Peer Learning and Organizational Aspects (N=142)

Statement	Strongly Disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly Agree n (%)	Combined Agree/Strongly Agree n (%)
Compiling images from instructors and students into the official manual increases reliability	0 (0.0)	5 (3.5)	7 (4.9)	39(27.5)	91 (64.1)	130 (91.6)
Dedicated drawing space in manual under instructor supervision improves microscopy skills	5 (3.5)	14 (9.9)	22(15.5)	41(28.9)	60 (42.3)	101 (71.2)
Prefer manual as the sole reference for laboratory assessment	3 (2.1)	8 (5.6)	27 (19)	41(28.9)	63 (44.4)	104 (73.3)
A welcome platform for students to share microscopic images among themselves	1 (0.7)	1 (0.7)	3 (2.1)	43(30.3)	94 (66.2)	137 (96.5)

Manual Features and Technical Preferences

Students demonstrated a clear preference for a hybrid learning model. While printed manuals were considered important, digital enhancements received even stronger support. Almost all participants favored a digital PDF version with QR-linked content, and most supported structured checklists for laboratory experiments. Furthermore, students expressed strong support for integrating botanical garden resources into the laboratory manual. This included introductory materials and plant identification references as permanent learning tools to support field-based learning. These preferences are shown in (Table 4).

Table 4. Importance of Laboratory Manual Features (N=142)

Feature	Not Important at All n (%)	Not Important n (%)	Neutral n (%)	Important n (%)	Very Important n (%)	Combined Important/Very Important n (%)
Printed (paper) manual for direct drawing and instructor assessment	1 (0.7)	8 (5.6)	22(15.5)	56 (39.4)	55 (38.7)	111 (78.1)
Digital PDF version with interactive files or QR codes for videos	0 (0.0)	0 (0.0)	4 (2.8)	45 (31.7)	93 (65.5)	138 (97.2)
Checklist for each experiment showing the elements students must identify	0 (0.0)	2 (1.4)	8 (5.6)	36 (25.4)	96 (67.6)	132 (93.0)
Including an introduction about the botanical garden's importance helps recognize its scientific value as an independent lab	3 (2.1)	3 (2.1)	15(10.6)	58 (40.8)	63 (44.4)	121 (85.2)

Discussion

The findings suggest a need for a structured laboratory manual for integrated educational resources in pharmacognosy laboratories at the University of Tripoli. Most participants (90.2%) showed a preference for a manual that bridges theoretical knowledge with practical microscopic visualization. This finding may be supported by evidence showing that structured microscopy-based learning tools improve student performance and engagement in laboratory education [11].

The reported difficulty in identifying fibers and xylem vessels (37.3%) reflects the intrinsic complexity of microscopic plant anatomy. This finding is consistent with Bombela et al. (2025), who emphasized the importance of longitudinal training in developing students' pattern recognition skills in plant anatomy [12]. In addition, the reliance on informal social media resources (58.5%) underscores a learning resource gap that may lead to inconsistent learning outcomes. This is because peer-generated content may suffer from variability in quality and limited reliability, requiring instructor oversight to ensure consistency with formal instructional materials [13].

The results show a substantial proportion of student preference for both printed and digital formats of the laboratory manual, with a clear dominance of the digital version. While the printed manual was rated as important or very important by 78.1% of respondents, it remains essential for supporting in-lab activities such as drawing, explanation, and instructor feedback, which are critical for developing practical microscopy skills [14]. However, the digital PDF with interactive features was almost totally preferred (97.2%), reflecting strong acceptance of digital learning tools in laboratory education [15]. Moreover, the inclusion of QR codes and video resources may enhance understanding of complex microscopic structures through visual support, consistent with findings in active learning research that emphasize improved comprehension through multimedia engagement [16]. These results also reflect broader trends in blended learning approaches in health professions education, where combining digital and traditional resources improves student learning outcomes [17]. In addition to digital enhancements, students also highlighted the importance of structured guidance and contextual learning components within the laboratory manual. The checklist for each experiment received high support (93.0%), indicating that students value clear step-by-step instructions that facilitate accurate identification of plant structures and improve laboratory organization [18]. Similarly, the inclusion of an introductory section on the botanical garden was supported by 85.2% of respondents, reflecting its perceived importance in enhancing understanding of plant resources and supporting the scientific value of field-based learning environments [19].

Conclusion

This study reveals the value of an interactive pharmacognosy laboratory manual that combines structured guidance with digital learning tools accessed via QR codes. Students showed high level of agreement for plant identification checklists and video-based instructions, which improved clarity, accuracy, and accessibility of laboratory procedures. The inclusion of botanical garden-based learning was also well received, highlighting the importance of experimental education. Overall, the findings support a blended learning method that enhances practical skills and bridges the gap between theory and practice in pharmacognosy education.

Limitations

This study is limited by its single-institution scope at the Faculty of Pharmacy, University of Tripoli, which may restrict the generalizability of the findings. Future research should assess the long-term impact of the

developed guide on students' academic performance and practical skills within the same curriculum framework.

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Ethical Approval

Ethical considerations were followed. Participation in the online Google Forms survey was voluntary, and informed consent was implied upon completion. Anonymity and confidentiality were maintained, and no personal data was collected.

Conflict of Interest

The authors declare no conflict of interest.

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