Clinical reasoning by pharmacists: fostering clinical decision-making and interprofessional collaboration in pharmacy practice and education

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Chapter 7

Evaluation of an interprofessional education program involving medical and pharmacy students: A mixed-method study

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Abstract

Background

Effective pharmacotherapy requires strong collaboration between physicians and pharmacists, highlighting the need for interprofessional education (IPE) in university curricula. This study evaluated the impact of an IPE program on medical and pharmacy students, focusing on their perceived development of interprofessional collaborative competencies, perceived learning outcomes, and clinical collaboration perceptions.

Methods

A mixed-method approach was employed to evaluate an IPE program that consisted of three mandatory activities with increased complexity and autonomy, that were integrated into the medical and pharmacy students' curricula. From September 2022 to June 2023, using a retrospective pre-post approach, students rated their competence levels after an educational activity using the Interprofessional Collaborative Competency Attainment Scale (ICCAS). The participants also answered open-ended survey questions about their learning outcomes. Medical students participated in both uniprofessional education (UPE) and IPE, while pharmacy students participated exclusively in IPE. Effect sizes for competency development were estimated, and subgroup analyses were performed to examine the impact of multiple IPE activities. Semi-structured interviews provided additional qualitative insights, which were analyzed using thematic analysis.

Results

Of the 309 surveys completed (response rate 64%, with 274 medical and 35 pharmacy students), all 21 ICCAS items showed statistically significant improvement in both UPE (n=127) and IPE (n=182) ($p < 0.05$). While effect sizes for UPE were small across all items, IPE had medium effect sizes for six items and large effect sizes for two items. Overall, students rated themselves as more capable of interprofessional collaboration after IPE, with 55% (n=124) reporting feeling 'somewhat better' and 6% (n=14) feeling 'much better,' compared to 16% (n=12) and 0%, respectively, after UPE. Competency development seems to improve slightly with an increased number of IPE activities. Pharmacy students reported somewhat higher post-activity scores than medical students did. Qualitative data from open-ended survey responses and interviews with six medical students and four pharmacy students highlighted a deeper understanding of professional roles and a greater appreciation for collaborative work through this program.

Conclusions

This IPE program focused on pharmacotherapy improved self-perceived interprofessional collaborative competencies among medical and pharmacy students. Through multiple interprofessional activities, students can develop a deeper understanding of professional roles and improve collaborative skills.

Background

Collaboration between physicians and pharmacists is important for optimizing patient care, ensuring that pharmacotherapy is appropriate, safe, effective, and tailored to each patient's specific health needs. This collaboration extends beyond dispensing medication after prescribing; it encompasses a broader range of responsibilities for both health professionals, directly contributing to improved health outcomes. By working together, physicians and pharmacists can reduce the risk of medication errors, which are a significant cause of adverse health outcomes.[1,2] To ensure that medical and pharmacy graduates are competent to collaborate effectively in practice, many accreditation bodies encourage the integration of interprofessional education (IPE) into university curricula.[3-6] IPE involves two or more health professions learning with, from, and about each other to enhance collaboration and, thereby, quality of care.[7] Growing evidence suggests that IPE enhances learners' opinions, satisfaction, and attitudes toward interprofessional collaboration (IPC).[8-10] A recent scoping review supported the positive relationship between IPE and several key quality health measures, including medical errors and mortality.[11] Specifically for medical and pharmacy students, Reumerman et al. demonstrated improved clinical outcomes through an interprofessional student-run medication review program.[12] Nevertheless, despite the promising outcomes associated with IPE, evidence supporting its superiority over uniprofessional education (UPE) remains limited.[8] This limitation is primarily due to the descriptive and noncomparative nature of related studies.[8]

Despite the reported positive outcomes and the increasing prevalence of IPE activities within healthcare student curricula, there remains room for improvement in the design of these programs to enhance learning outcomes.[8] For instance, aligning students' skills and self-awareness of professional identity can enhance learning in an interprofessional setting.[9] An effective IPE program should also incorporate problem-based learning or other interactive learning modalities, ensure mandatory participation in IPE activities, and strive to improve interaction among students from different health professions.[13] In their most recent report, the Interprofessional Education Collaborative (IPEC) emphasizes that IPE programs should be integrated into curricula and span the entire curriculum length, with activities that increase in depth and complexity, to collectively result in meaningful outcomes.[14] These and other recommendations were considered in the design and implementation of an IPE program focused on pharmacotherapy, and engaging medical and pharmacy students in collaborative learning activities. This study aimed to evaluate the impact of this IPE program on medical and pharmacy students' perceived development of

interprofessional collaborative competencies, perceived learning outcomes, and perceptions of collaboration in clinical practice.

Methods

Study design

To evaluate the impact of the IPE program focused on pharmacotherapy, a mixed-method study was conducted. Initially, data were collected using a survey, which provided a broad overview of the program's effects. To gain deeper insights into students' perceptions of IPC between physicians and pharmacists, semi-structured interviews were then carried out. Our approach was grounded in a constructivist paradigm.[15] The results are reported using the Mixed Methods Appraisal Tool (MMAT) (Appendix 1).[16]

Setting

In the Netherlands, both the medical and pharmacy curricula span six years, and are divided into a three-year bachelor's and a three-year master's curriculum. The bachelor's curricula focus on theoretical knowledge, while the master's curricula for both disciplines include multiple internships in diverse healthcare settings, interspersed with weeks of classroom-based teaching. The IPE program, involving both medical and pharmacy students, was initially designed in 2017 at the Leiden University Medical Center (LUMC) and has been gradually developed and implemented in both master's curricula at this faculty. Integrated throughout their curricula, the program covers a range of clinical areas, increasing in complexity and autonomy. This structured progression is considered relevant for allowing students to develop competencies in various clinical situations over time, providing multiple perspectives on the importance of IPC and its application in real-world settings. Table 1 outlines the three mandatory activities, detailing the estimated time and learning objectives. In the first activity, in the first year of their master's, students are tasked with developing healthcare plans for paper-based patient cases related to myocardial infarction, type 2 diabetes mellitus with hypertension, and kidney failure, using the WHO-6-step method.[17] These three cases, created through discussions with medical and pharmacy experts, are aligned with topics previously covered in their curricula. In small groups, students address one case and present their findings to the others, while actively participating in discussions about the cases presented by the other groups. For the second activity, in their second master's year, students engage in discussions on two paper-based patient cases focusing on pharmacogenetics via digital consultation. For the third activity, students conduct a medication review when

visiting a polypharmacy patient in primary practice. This activity takes place when pharmacy students are in their third master's year, and medical students are at the end of their second master's year, where they conclude their mandatory internships. They collaboratively present their healthcare plan to other students and educators from both professions. Subsequently, the healthcare plan is discussed with the patient, their general practitioner, and their community pharmacist. Due to the greater number of medical students than pharmacy students, medical students participate in the described activities both inter- and uniprofessionally, while pharmacy students participate exclusively in interprofessional activities. Despite some activities being performed uniprofessionally, all learning activities focus on IPC. In each concluding group activity, educators from both professions are present to provide content feedback and facilitate reflection on collaboration. Particularly in instances where no pharmacy student is present, educators elaborate on the pharmacy profession and the role of the pharmacist in these activities in clinical practice.

Table 1. Interprofessional education program focusing on pharmacotherapy, integrated into the medical and pharmacy master curricula

Activity	Description of learning activity	Time	Learning objectives
1	Self-preparation through e-learning with introductory assignments for both professions Informal lunch with assignments Collaborative treatment plan development for paper-based patient cases on campus Joint treatment plan presentation, followed by content discussion and reflecting on collaboration	0,5h 1h 3h 2h	• Get to know each other's curriculum and profession • Get to know each other's sources, way of thinking, and working methods • Experience how to work together on a pharmacotherapeutic treatment plan
2	Self-preparation for paper-based pharmacogenetics cases Digital consultation for discussing testing, results, and treatment plans Content discussion, followed by collaboration reflection	1h 1h 1h	• Get to know each other's sources and working methods around pharmacogenetics • Learn how to work and communicate together • Experience how to work together in an interprofessional consult
3	Preparation visit polypharmacy patient in primary care Conducting medication review Healthcare plan development Healthcare plan presentation, followed by content discussion and collaboration reflection Healthcare plan discussion with patient and healthcare providers	2h 2h 2h 3h 1h	• Get to know each other's working methods of clinical reasoning in practice • Experience how to work together in practice • Experience how to complement each other in practice

Study population

The study population consisted of medical and pharmacy students who held a bachelor's degree in medicine or pharmacy, ensuring (partial) professional identity formation. Both groups of students began the program in their first year of their three-year master's curricula. A group of no more than 25 medical students commenced the program every four weeks. Depending on their schedules and alignment with the pharmacy curriculum, they participated in the learning activity either interprofessionally with pharmacy students or uniprofessionally with only medical students. Given that the LUMC admits only 50 pharmacy students annually, the allocation of pharmacy students to activities was strategically planned to maximize opportunities for interaction with medical students. This approach resulted in eight pharmacy students joining 25 medical students to work on cases in the first IPE activity (IPE1), which occurred six times per year. Similarly, UPE1 also occurred six times per year. For the second activity, 75% of the scheduled activities involved six pharmacy students working with 25 medical students (IPE2). The remaining 25% of activities involved medical students only (UPE2). Four to six medical students from each group of 25 (approximately 20%) conducted a medication review in collaboration with a pharmacy student (IPE3), while the remaining medical students performed a medication review uniprofessionally, with the option of consulting a community pharmacist in clinical practice (UPE3). While it cannot be guaranteed, it is assumed that all medical students participate in at least one interprofessional activity with pharmacy students at some point during their curriculum.

Surveys

Over a ten-month period (September 2022 to June 2023), all participants of the three mandatory activities received the Interprofessional Collaborative Competency Attainment Scale (ICCAS), a validated 21-item self-report tool designed to assess the perceived development of interprofessional core competencies.[18] Based on the competencies reflected in the Canadian Interprofessional Health Collaborative (CIHC) framework,[19] this scale evaluates proficiency in the following competency domains: Communication, Collaboration, Roles and Responsibilities, Collaborative Patient-Centered Approach, Conflict Management, and Team Functioning. The ICCAS employs a retrospective pre-test and post-test self-assessment design, in which participants rate their competence development after the learning activity, reflecting on their levels both before and after the experience. The ICCAS underwent translation from English to Dutch using scale names familiar to the students. Four students tested the comprehensibility of the translated ICCAS, resulting in minor textual adjustments. In addition to the ICCAS, demographic data were

collected including gender, age, study type, and prior involvement in mandatory IPE Pharmacotherapy learning activities to assess the impact of this program throughout the curricula. To further evaluate learning outcomes, three open-ended questions were incorporated into the survey, prompting participants to reflect on their learning experiences, their contributions to the learning experiences of peers, and the application of acquired knowledge and insights in practice. Conducted at the end of each activity (UPE or IPE), the paper-based survey aimed to maximize response rates and facilitate accurate recollection by capturing participants' immediate feedback. The English survey is included in Appendix 2.

Survey data analysis

The demographic data were subjected to descriptive analysis. To compare the development in interprofessional competency (pre-test vs post-test) at the level of each specific item for the entire cohort of students, paired student's t-tests were conducted using SPSS version 27. A predetermined significance level of $p<0.05$ was considered statistically significant. Effect sizes were determined using Cohen's d, with values exceeding 0.8 interpreted as indicating a large effect size, values between 0.5 and 0.79 indicating a moderate effect size, and values below 0.5 indicating a small effect size. These effect size interpretations were comparable with those observed in the validation study of the revised ICCAS tool.[20] For a Cohen's d of 0.5, 33 participants is sufficient to reach a power of 80%. To compare the scores on each item across all IPE activities between medical and pharmacy students, independent samples t-tests were conducted to compare the means of two independent groups (medical and pharmacy students) regarding a continuous variable (ICCAS scores). Linear regression analysis was conducted to explore the relationship between ICCAS scores and the number of IPE activities followed, with the number of activities as the independent variable. This method can establish a linear relationship between continuous dependent variables (ICCAS scores) and a continuous independent variable (number of IPE activities), helping to quantify how the number of activities influences changes in students' perceived competencies. Sensitivity analysis was performed to assess the impact of missing data, which were assumed to be missing completely at random. To assess the internal consistency of the translated ICCAS, Cronbach's Alpha was calculated, with a value above 0.7 considered acceptable.[21] Qualitative data from open-ended questions about students' perceived learning outcomes were analyzed inductively using thematic analysis, informed by the AMEE Guide on thematic analysis of qualitative data.[22] Themes were identified through systematic (re)reading and independent parallel coding by JM and student KK. Discrepancies in code names were resolved through discussion, either between the coders or with a third researcher (MH). Themes

were constructed by JM by analyzing, combining, and comparing codes, and were then discussed with MH and TK. Atlas.ti version 22 was used to support the analysis process. The information power to evaluate perceived learning outcomes was anticipated to be achieved with the planned number of participants for the quantitative analysis.[23] Due to the absence of personally identifiable data, it was not possible to link responses across multiple surveys. As a result, the potential for clustering of responses from students taking the survey multiple times was not accounted for in the data analysis.

Interviews

To gain deeper insights into how this program involving multiple IPE activities influenced students' perceptions of IPC, semi-structured interviews were conducted with medical and pharmacy students who had participated in multiple activities. Invitations were randomly sent to students who participated in IPE activities between October 2023 and April 2024. Participants were invited by a research student after the activity to avoid influencing their participation or experience during the activity. The interviewed students did not participate in the survey study. The face-to-face interviews were conducted as soon as possible after the IPE activity in a private room on campus or via video call using *Microsoft Teams*. The interviews were conducted by research students (RV and LN) with experience in conducting interviews under the guidance of JM and MH. Based on the obtained quantitative and qualitative survey data, a semi-structured interview guide was developed (Appendix 3). This guide included questions about how multiple IPE activities influenced students' perceptions of IPC in clinical practice. After the first two interviews, the interview guide was evaluated and minor adjustments were made. The interviews were audio recorded, transcribed verbatim manually, and anonymized by the research students, with a pseudonym assigned to each participant to ensure confidentiality. Transcripts were randomly checked by JM at intervals, with each transcript reviewed twice.

Interview data analysis

The interview transcripts were analyzed inductively using thematic analysis, guided by the AMEE guide on thematic analysis of qualitative data.[22] Themes were identified through systematical (re)reading and independent parallel coding by JM and either MH or research student RV. Discrepancies in coded text passages and code names were resolved through discussion, either between the coders or with a third researcher. Themes were constructed by JM by analyzing, combining, and comparing codes, and were then discussed with MH and TK, followed by further refinement with CW, AN, and TvK. Atlas.ti version 23 was used to support the

analysis process. After identifying themes from the data, these were then categorized into four competency domains from the most recent IPEC framework: Values and Ethics, Communication, Roles and Responsibility, and Teams and Teamwork.[14] This deductive step allowed us to align the emergent themes with a widely recognized framework, facilitating comparison with the literature and providing clearer insight into how this program influenced students' perceptions in essential collaborative domains. The categorized themes are presented in a table alongside supporting responses. Sampling continued until JM and MH determined that data sufficiency to evaluate students' perceptions of interprofessional collaboration had been reached.[23] This decision ensured representation from at least two pharmacy students and two medical students immediately following IPE2, and two students from each discipline following IPE3.

Reflexivity

The research team for this study comprises two pharmacists (JM, TK), two medical doctors (CW, TvG), one biomedical scientist (MH), one biomedical data scientist (SB), and one educational specialist (AN). Working within a constructivist epistemology,[24] the team was carefully assembled to ensure a diverse range of perspectives. Each member has prior research experience and is actively engaged in health professions education. To mitigate the potential for socially desirable answers, the data was collected by research students. Specifically, survey data collection was conducted by a pharmacy research student, while interviews were conducted by a research student specializing in pharmaceutical business administration at the Utrecht University of Applied Sciences and a medical student from the LUMC, both of whom are in the Netherlands. None of the research students had direct educational relationships with the participants, encouraging them to openly share their experiences and perceptions.

Results

Survey group characteristics

During the study period, 18 educational activities were organized within the program: five for activity 1, six for activity 2, and seven for activity 3. In total, 485 students (432 medical students and 53 pharmacy students) attended these educational activities. Of these attendees, 309 students (274 medical students and 35 pharmacy students) completed the survey, resulting in a response rate of 64%. Of these surveys, 5% of the data was missing, for example, because only post-activity scores were filled in. The results of the sensitivity analysis using mean

imputation – replacing missing values with the mean value of the non-missing values of the variable – indicated that the impact of the missing data did not change conclusions in terms of statistically significant study outcomes (Appendix 4). Table 2 presents the characteristics of the surveyed students. Gender and year of birth did not differ statistically significant between medical and pharmacy students (p=0.793 and p=0.49, respectively). The majority of students were female, which is consistent with the gender distribution in both medical (≈60%) and pharmacy (≈80%) curricula in the Netherlands.[25,26] Among the 274 medical students who completed the survey, 127 completed it following a UPE activity, while 147 did so after an IPE activity. All 35 pharmacy students completed the survey following an IPE activity. In terms of participation in IPE activities within the program, 146 students experienced IPE once, 56 experienced two IPE activities, and 29 participated in three.

Table 2. Survey group characteristics

Characteristic	Medical students n=274 (%)	Pharmacy students n=35 (%)
Female	198 (72%)	27 (77%)
Year of birth		
1998 – 2001	180 (66%)	21 (60%)
Before 1998	85 (31%)	13 (37%)
No. IPE Pharmacotherapy program participated activities		
None	78 (28%)	0 (0%)
Once	134 (49%)	12 (34%)
Twice	50 (18%)	6 (17%)
Three times	12 (44%)	17 (49%)

Survey results

All 20 ICCAS items across the competency domains demonstrated statistically significant improvements with both UPE and IPE (Table 3). For the UPE ICCAS item scores, the effect sizes were small (Cohen's d values 0.06-0.39; ≤0.5: small). In contrast, the IPE ICCAS item scores showed greater variability in effect sizes (Cohen's d range 0.12-1.05; ≤0.5: small, >0.5- <0.8: medium, ≥0.8: large), with several items exhibiting medium to large effects. Specifically, medium effect sizes were noted for items 6 and 7 (Collaboration), 11 (Roles and Responsibilities), 13 and 14 (Collaborative Patient-Centered Approach), and 19 (Team Functioning). Items 8 (Collaboration) and 12 (Roles and Responsibilities) showed large effect sizes. The competency domains with solely small effect sizes were Communication and Conflict Management. Overall (21st ICCAS item), students rated themselves as more capable of interprofessional collaboration after IPE. Specifically, 55% (n=124) reported feeling 'somewhat better', and 6% (n=14) felt 'much better,' compared to 16% (n=12) and 0%, respectively, after UPE. Self-assessed competence level

differences pre- and post-activities seemed to increase with the number of IPE activities students had participated in within this program, although the difference was not statistically significant (Figure 1). While pre-activity self-ratings were generally comparable, the competence level differences between pre- and post-activities tended to be slightly smaller for medical students than for pharmacy students (Figure 2). Statistically significant differences between the two groups were observed in the following items: items 3 (0.13 vs. 0.34; $p = 0.01$) and 5 (0.21 vs. 0.44; $p = 0.02$) (Communication), items 7 (0.33 vs. 0.65; $p = 0.01$) and 8 (0.48 vs. 0.77; $p = 0.01$) (Collaboration), items 9 (0.23 vs. 0.50; $p = 0.05$), 10 (0.10 vs. 0.43; $p = 0.01$), 11 (0.49 vs. 1.00; $p < 0.01$) and 12 (0.49 vs. 0.97; $p < 0.01$) (Roles and Responsibilities), and item 20 (0.27 vs. 0.60; $p = 0.01$) (Team Functioning). Furthermore, four medical students reported lower post-activity scores on multiple ICCAS items. The translated ICCAS demonstrated high internal consistency, with Cronbach's Alpha values of 0.934 for all items following IPE activities and 0.944 for all items following UPE activities.

The open-ended survey questions resulted in eight themes on perceived learning outcomes. Table 4 presents these themes alongside supporting student responses. The learning outcome themes varied across educational activities and aligned with the learning objectives. Following all UPE activities and IPE1, students primarily reported content and skill-focused learning outcomes, whereas IPE2 learning outcomes shifted toward learning from each other's perspectives. After IPE3, students indicated an understanding of their own role, the other's role, and how to complement each other in practice. Overall, similar themes emerged in the responses of both medical and pharmacy students. Medical students frequently emphasized the patient perspective, which was complemented by pharmacy students' responses, which provided more subject-specific content that aligned with the learning outcomes reported by the medical students.

Table 3. Survey item scores pre- and post-activities conducted uniprofessionally or interprofessionally

Competency domains	Item	UPE (n=127)		Cohen's d	Effect interpretation**	IPE (n=182)		Cohen's d	Effect interpretation**
		Pre-activity mean (SD)*	Post-activity mean (SD)*			Pre-activity mean (SD)*	Post-activity mean (SD)*		
Communication	1	3.52 (0.71)	3.68 (0.80)	0.21	Small	3.62 (0.84)	3.94 (0.74)	0.41	Small
	2	3.88 (0.65)	3.98 (0.75)	0.14	Small	4.03 (0.68)	4.24 (0.62)	0.32	Small
	3	3.76 (0.71)	3.87 (0.76)	0.15	Small	3.97 (0.67)	4.10 (0.05)	0.28	Small
	4	3.57 (0.66)	3.70 (0.71)	0.19	Small	3.62 (0.77)	3.85 (0.74)	0.31	Small
	5	3.52 (0.68)	3.72 (0.71)	0.29	Small	3.69 (0.71)	3.94 (0.70)	0.36	Small
Collaboration	6	3.39 (0.79)	3.66 (0.79)	0.34	Small	3.40 (0.90)	3.87 (0.83)	0.54	Medium
	7	3.61 (0.74)	3.8 (0.70)	0.26	Small	3.62 (0.81)	4.11 (0.75)	0.63	Medium
	8	3.56 (0.80)	3.88 (0.85)	0.39	Small	3.58 (0.77)	4.24 (0.73)	0.88	Large
Roles and Responsibilities	9	3.63 (0.68)	3.8 (0.69)	0.25	Small	3.75 (0.78)	4.08 (0.68)	0.45	Small
	10	3.98 (0.69)	4.06 (0.67)	0.12	Small	4.05 (0.74)	4.23 (0.64)	0.26	Small
	11	3.72 (0.68)	3.98 (0.70)	0.38	Small	3.73 (0.75)	4.28 (0.65)	0.78	Medium
	12	3.66 (0.63)	3.94 (0.72)	0.41	Small	3.57 (0.73)	4.30 (0.66)	1.05	Large
Collaborative Patient-Centered Approach	13	3.25 (0.86)	3.59 (0.92)	0.38	Small	3.39 (0.89)	3.93 (0.83)	0.63	Medium
	14	3.28 (0.82)	3.57 (0.85)	0.35	Small	3.40 (0.84)	3.88 (0.83)	0.57	Medium
	15	3.41 (1.02)	3.57 (1.06)	0.15	Small	3.69 (1.03)	3.86 (1.03)	0.17	Small
Conflict Management	16	3.86 (0.83)	3.99 (0.83)	0.16	Small	4.09 (0.68)	4.34 (0.64)	0.39	Small
	17	3.83 (0.74)	3.99 (0.75)	0.21	Small	4.10 (0.66)	4.31 (0.67)	0.32	Small
	18	3.79 (0.786)	3.84 (0.784)	0.06	Small	4.11 (0.78)	4.20 (0.78)	0.12	Small
Team Functioning	19	3.35 (0.74)	3.59 (0.81)	0.31	Small	3.54 (0.75)	4.01 (0.76)	0.62	Medium
	20	3.30 (0.88)	3.47 (0.97)	0.18	Small	3.40 (0.83)	3.80 (0.88)	0.47	Small

UPE: Uniprofessional Education. IPE: Interprofessional Education. SD: Standard Deviation.
The thick border lines indicate the items for which the effect size interpretation differs between UPE and IPE.
* p-value for paired t-test of pre-activity vs post-activity scores <0.05 for all comparisons
** Effect interpretation: Cohen's d ≤0.5: small, >0.5-<0.8 medium, ≥0.8: large

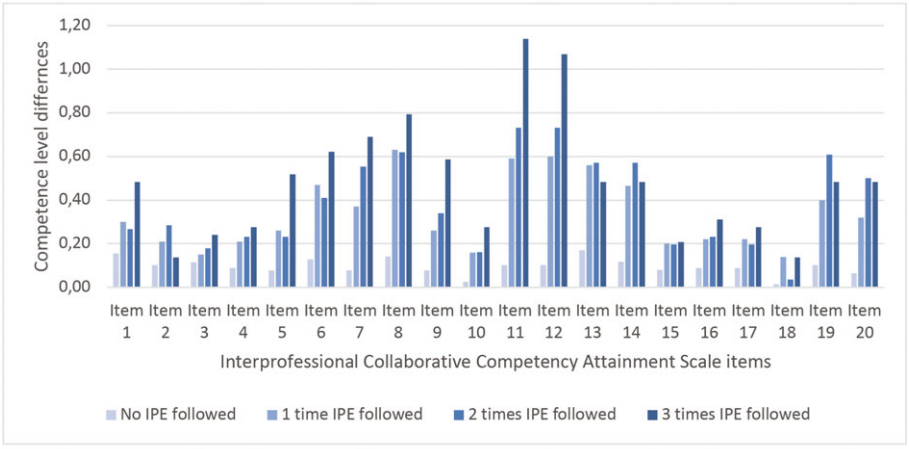

Figure 1. Differences in competence levels pre- and post-activities per number of interprofessional education activities participated

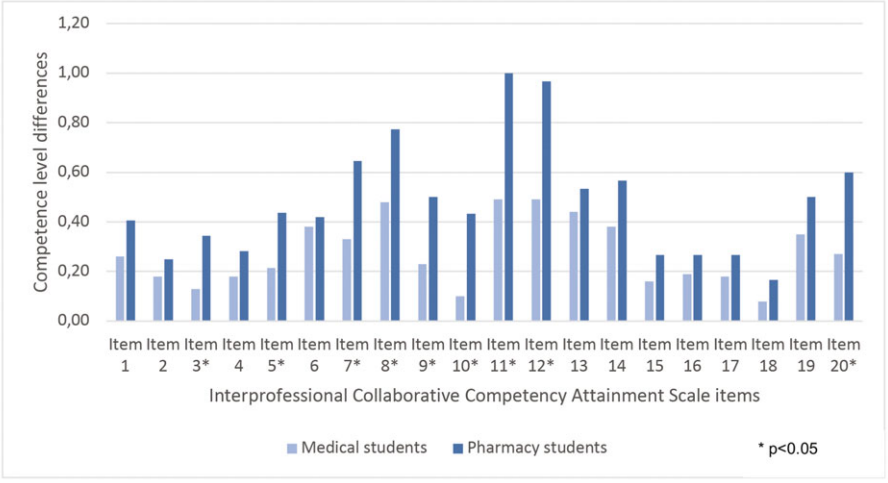

Figure 2. Survey items competence level differences pre- and post- interprofessional education activities per study type

Table 4. Themes on perceived learning outcomes with supporting survey responses

Themes	Supporting survey responses
Content	"[I learned] how certain diuretics work, that lots of drugs influence diabetes and vice versa." – medical student
Skills in approaching patient cases	"Where to find information about drugs." – medical student
Collaboration	"Interprofessional consultation is important in reaching an efficient care plan that is also better for the patient." – pharmacy student
Each other's knowledge and way of thinking	"What pharmacists/pharmacy students know/don't know and where their focus lies. How they view patients and problems." – medical student
Multiple perspectives	"I got to know the different perspective of medical students and learned to use it." – pharmacy student
Considering patient perspectives	"It's not always black and white, and patient perspectives matter"- pharmacy student
How to complement each other	"Consultation with other professionals provides new insights. By working well together, you can quickly fill gaps in knowledge." – medical student
Roles and responsibilities	"I learned about their roles and tasks, where physicians and pharmacists have shared responsibility." – medical student

Interview student characteristics

To gain deeper insights into how this program influenced students' perceptions of IPC between physicians and pharmacists, six medical students (4 female, 2 male) and four pharmacy students (3 female, 1 male) participated in interviews, each lasting approximately 30 minutes. Data sufficiency was determined after interviewing two pharmacy students and three medical students immediately following IPE2, and two pharmacy students and three medical students following IPE3.

Interview results

Thirteen themes emerged from the interview data, and were subsequently categorized into the four competency domains (Table 5).

Within the Values and Ethics domain, the interview responses revealed a growing recognition and appreciation of each profession's contribution to patient care. Although initial perceptions of hierarchy were present, students from both professions described a process of building mutual respect and trust. According to the students, the program facilitated this shift, allowing them to recognize the significance of each other's expertise and perspectives, and the value they both bring to patient care.

Considering Roles and Responsibilities, students frequently reported a growing understanding of the distinct roles and expertise that physicians and pharmacists have in patient care. Medical students valued the pharmacists' deep knowledge of medication, while pharmacy students appreciated physicians' diagnostic skills. The program's IPE activities facilitated in helping students become familiar and comfortable with collaborative work, learning when and how to effectively seek each other's expertise. This mutual recognition of specialized knowledge led to a more complementary approach, in which students reported learning to use each other's strengths to enhance patient outcomes.

Within the Communication domain, both medical and pharmacy students emphasized the importance of aligning goals and communicating effectively to integrate their different perspectives in patient care. Pharmacy students tended to focus more on medication management, while medical students adopted a broader, more holistic view of patient care. One medical student highlighted the value of listening to each other and making space for each other's expertise. Moreover, students recognized that using a common professional language is important for effective interprofessional collaboration, as it facilitates clearer communication and reduces the potential for misunderstandings.

Considering Teams and Teamwork, the responses indicated that the program encouraged reflection on both individual and team dynamics, preparing students for their future professional roles. Students gained a deeper understanding of each other's work methods and identified potential challenges in their collaboration, such as differing access to information. For instance, one student noted that physicians often lack detailed information on medication availability, making collaboration with pharmacists essential during drug shortages. Both groups recognized the importance of mutual support and shared leadership, emphasizing that increased awareness and confidence in their own roles, as well as in each other's roles, can significantly enhance teamwork and, ultimately, patient care.

Table 5. Interview responses on how this program influenced medical and pharmacy students' perceptions of interprofessional collaboration

Competency domains	Themes	Supporting interview responses
Values and Ethics	Navigating perceived hierarchy	"Maybe it sounds a bit derogatory, but it's like they have a sort of assistant role, while they have their own piece. They also just do their work in the pharmacy. They are not just there for us to call, they are not just sitting around waiting for that." – Dennis, medical student
		"I find it unpleasant to say, but I will say it anyway: the arrogance, especially the arrogance in thinking that they can solve everything on their own and that they see us as pharmacists, as being a step below them or something." – Judith, pharmacy student
	Building mutual respect and trust	"[I took away from this program] trust in the pharmacist's skills and professionalism." – Dennis, medical student
		"We were surprised on both sides about each other's knowledge and also the extent to which we could rely on each other." – Simon, pharmacy student
	Valuing each other's expertise	"[I would describe the pharmacist] as a very important player in the entire medical process of the patient. Really like a colleague we couldn't do without." – Rosalie, medical student
		"For the understanding between pharmacy students and medical students, it is a nice addition. You should continue doing it annually so that you really come to see each other's added value." – Emily, pharmacy student
	Valuing multiple perspectives	"Normally you are alone with medical students, so you are quite in a bubble. So I think it is good that you are now also learning to work more with people from other fields. It broadens your view of things." – Olivia, medical student
		"I think it is very nice, especially when you visit a patient as physician and pharmacist, so as medical student and pharmacy student, that you see that we look quite specifically at medication and the physician looks more at the patient in whole."- Simon, pharmacy student

Table 5. continued

Competency domains	Themes	Supporting interview responses
Roles and Responsibilities	Understanding each other's knowledge areas	"Whereas we only learn 'You give this medication for this disease', they know a bit deeper about the mechanism of action, the interaction with other medications, how it is metabolized, and how certain side effects occur. And, at least for me, knowledge kind of stops at some point, where they could still help us more whether to advise something or not based on those underlying processes." – Olivia, medical student
		"They are really competent and knowledgeable in terms of making a diagnosis, but not always in terms of medications." – Emily, pharmacy student
	Understanding each other's roles and responsibilities	"In terms of the stereotypical image in my head, the pharmacist focused, more in black and white, on which medications could not be taken together or on determining the dosages for each medication. And it is true to a large extent that they are very medication-oriented, but in the end they do much, much more than what I thought." – Sander, medical student
		"You can learn from each other about what you can approach each other for. [..] That you understand better how everyone plays their own role." – Emily, pharmacy student
	Utilizing each other to improve health outcomes	"What I liked was that we, as medical students, needed information that could only be obtained from a database available to pharmacy students. So, we really needed them to answer our questions, and they use entirely different sources and resources than we have access to, which means that collaboration is extremely important, also in the future." – Rosalie, medical student
		"I felt that we complemented each other, like 'but have you looked at those medicines? Maybe you have a relationship with the condition and the patient's symptoms are caused by this'. But they also told things about conditions that I knew nothing about. So it really complemented each other, which was very nice to work together." – Judith, pharmacy student

Table 5. continued

Competency domains	Themes	Supporting interview responses
Communication	Aligning goals	"What is feasible then? Say if they, for example, found better alternative medication that you also look a bit more at what is feasible if you have the whole picture of the patient. [..] So maybe look a bit broader, zoom out a bit more." – Olivia, medical student
		"The physician looks more at the patient as a whole. [..] And looks a bit more at what a patient wants. I think that is something nice for pharmacists to learn. It is not always a solution to remove or add medication if it is not necessary for that patient." – Simon, pharmacy student
	Listening to each other	"I think the most important thing is that you know where to let them have their expertise. So that you also give the other person a bit of space to give their advice, that you know that you don't always have the best, that we also have our part, but that you also give room to their expertise to make their plan and then see how you can come together with those two plans to the best plan for the patient." – Olivia, medical student
	Communicating effectively in a common language	"What I mainly learned from it is that we already speak the same language as physicians and pharmacists and that we can build on that." – Simon, pharmacy student
		"It has taught me that good collaboration and teamwork is really crucial. Because at the end you are going to decide what is best for the patient and if we do not communicate well together, nothing will come of it." – Judith, pharmacy student

Table 5. continued

Competency domains	Themes	Supporting interview responses
Teams and Teamwork	Reflecting on work methods and challenges	"What I took from it, it's good to be aware that they don't have an episode list—I think that's something I just hadn't realized. And how their approach is affected by this, so they really look closely to see if they can come up with a logical indication for everything." – Sandra, medical student
		"Physicians do not have much time for consultation. [..] So having good contact with physicians is sometimes quite a challenge." – Emily, pharmacy student
	Self-reflection	"I think, when I become a basic physician soon, that I will be aware that I can call the pharmacist and that I don't always have to ask my supervisor for everything. But I'm not sure if I can do that for every medication question... it's always about asking for help, you know... But I think it could give me a lot of peace if I did it more, and I'm gradually realizing that more and more." – Sander, medical student
		"I am worth the same. I have the knowledge about medication, so I can share it and ensure that patients receive the best care." – Judith, pharmacy student
	Sharing leadership	"You have to continue to work together and that we are also partly dependent on pharmacists in certain steps, that we cannot take at all, that we do not know enough about as a physician." – Rosalie, medical student
		"I think I always found it difficult to express my opinion at the beginning, but this time it was much better. So as the IPE moments progressed, I really started giving my advice more quickly and sometimes even took the lead. So, I think I have improved that leadership competency." – Emma, pharmacy student

IPE: Interprofessional Education

Discussion

This study evaluated the impact of an IPE program on the perceived development of interprofessional collaborative competencies among medical and pharmacy students in the Netherlands. The findings demonstrate that participation in this IPE program significantly enhanced students' self-assessed competencies across various domains, i.e., in Collaboration, Roles and Responsibilities, a Collaborative Patient-Centered Approach, and Team Functioning. These findings align with the program's learning objectives and the broader goals of IPE, which aim to break down professional silos and promote a more integrated approach to patient care.[27]

UPE activities, such as e-learning modules focused on the other profession and instruction from educators from both professions, were found to be valuable. Although the effect sizes were small, the improvements across all the ICCAS items following UPE highlights the effectiveness of this program in enhancing interprofessional collaborative competencies among medical students. However, the larger effect sizes observed with IPE activities indicate that direct collaboration with peers from different professions adds substantial value in preparing students for collaborative clinical practice. This finding is consistent with previous studies that emphasize the superiority of IPE over UPE in fostering interprofessional collaboration skills.[28-30]

Despite significant improvement, the effect sizes for the competency domains of Communication and Conflict Management were smaller than those for the other domains. This could be because none of the activities were explicitly designed to practise communication techniques or address conflict resolution within interprofessional teams. Future iterations of the program will benefit from incorporating targeted interventions, such as simulation-based learning or role-playing exercises, to specifically develop these skills.[31,32]

Although self-assessed competence levels improved slightly with increased participation in IPE activities, the observed differences were minor and not statistically significant. The interview responses supported the cumulative benefits of multiple interprofessional learning activities, aligning with recommendations for integrating a variety of IPE activities throughout healthcare curricula to enhance learning outcomes.[33,34] To gain a more comprehensive understanding of how multiple IPE activities impact competence development, alternative study designs, such as multi-center, cluster-randomized longitudinal studies, would be beneficial.

Notably, pharmacy students scored themselves higher on multiple ICCAS items post-activity compared to medical students. This difference might suggest a systematic bias, as the groups had different mean scores. One possible explanation could be the disproportionate ratio of students involved in the activities; with one pharmacy student often collaborating with five or six medical students in IPE1 and IPE2, pharmacy students may gain more from these interactions, potentially leading to inflated self-assessments. It is also possible that pharmacy students have more exposure to or emphasis on the importance of IPC during their education, especially during internships, compared to medical students, as suggested by the interview findings. Therefore, pharmacy students may inherently value IPC more highly than medical students, which could influence their participation in activities and their

self-assessed competence development scores. Studies have shown that differences in attitudes toward physician-pharmacist collaboration exist, with pharmacists often demonstrating a stronger commitment to collaborative practice.[35-37] Moreover, four medical students reported lower post-activity scores on multiple ICCAS items, possibly indicating increased awareness leading to more critical self-assessment as a result of IPE activities. This phenomenon has been observed in other studies, including that of Teuwen et al.,[38] who used the ICCAS to measure self-perceived competence development among undergraduate medical and nursing students following IPE activities.

The interviews provided deeper insights into students' perceptions of IPC between pharmacists and physicians, complementing the learning outcomes identified from the surveys. While the surveys highlighted the concrete skills and knowledge gained, the interviews revealed the complexities of navigating perceived hierarchies, building mutual respect, and recognizing each profession's unique contributions. As intended, the program fostered greater self-awareness of professional identity by encouraging students to reflect on and understand both their own roles and those of their peers. This awareness was coupled with increased confidence in their respective roles, which is important for contributing effectively to IPC. Pharmacy students, in particular, described how they gained confidence in their knowledge and roles through the program, learned to express their ideas and concerns more and took greater responsibility. These insights could also help clarify, among other factors, why certain ICCAS item scores differed between pharmacy and medical students. The interview data enriched our understanding of interprofessional dynamics and highlighted areas for further development in interprofessional education, such as enhancing mutual respect and refining collaborative practices in clinical settings, as well as with other professions.

Limitations

Although this mixed-methods study provides valuable insights and addresses the shortcomings of previous research in this field, it has several limitations. The use of self-reported measures, such as the ICCAS tool, may be subject to response biases, including social desirability and recall bias. Meaningful comparisons between UPE and IPE among students from two professions are limited, as the validation of ICCAS included a diverse sample of students and practitioners from more than 19 professions.[18] Additionally, using a non-validated translation of the ICCAS and adjusting scale names to those familiar to Dutch students, may introduce measurement and cultural biases. These factors could affect the accuracy and reliability of self-assessments and the comparability of results, although competence

development was still measured on a 5-point scale. Using the ICCAS tool in this setting presented challenges in determining the extent to which multiple IPE activities contributed to competence development. Despite the relatively high response rate, non-response bias cannot be entirely ruled out. Statistically, the analysis did not account for multiple testing or potential clustering (multiple surveys per student), which might lead to an increased number of false positives. However, the high correlation among many outcomes suggested that a Bonferroni correction might be overly conservative. The effect of clustering is estimated to be limited, although its influence on the results cannot be entirely ruled out. In addition to the quantitative limitations, the qualitative component of the study also has limitations. While JM and MH determined that the information power was sufficient and the focused research question reduced the need for many interviews, the small sample may still limit the generalizability of the findings. The interview data are subject to interpretation, which could introduce researcher bias. Although randomly invited, participants who agreed to the interview may represent those with particularly strong opinions or experiences, potentially skewing the results. Overall, the generalizability of the findings may be constrained by the specific context of the program and the healthcare education system in the Netherlands.

Conclusion

This IPE program focusing on pharmacotherapy significantly improved self-perceived interprofessional collaborative competencies among medical and pharmacy students, particularly in the competency domains of Collaboration, Roles and Responsibilities, a Collaborative Patient-Centered Approach, and Team Functioning. The results suggest that repeated exposure to interprofessional learning activities, which increase in complexity and autonomy, fosters competence development. The interviews provided additional insights into students' perceptions of IPC, emphasizing the need to address hierarchical perceptions and promote mutual respect. Future iterations of this and other programs should incorporate targeted interventions to address these aspects and improve competency domains with smaller effect sizes. Future research is needed to determine whether these competencies are sustained and effectively applied in professional practice post-graduation, thereby contributing to the development of collaboratively competent physicians and pharmacists and enhancing patient care.

Abbreviations

IPE	Interprofessional Education
UPE	Uniprofessional Education
IPC	Interprofessional Collaboration
LUMC	Leiden University Medical Center
IPEC	Interprofessional Education Collaborative
ICCAS	Interprofessional Collaborative Competency Attainment Scale
CIHC	Canadian Interprofessional Health Collaborative

Declarations

Ethical approval and consent to participate

Approval for this survey study, with an amendment to conduct interviews, was granted by the Ethics Review Board of the Netherlands Association for Medical Education (case numbers 2022.4.3 resp. 2023.7.4). Prior to the survey, students were informed about the research and invited to participate by a research student at the onset of each learning activity. Interview participants received written information with the invitational e-mail from a research student prior to the interview. All participating students consented to take part in the study by signing a consent form. Survey and interview data were handled anonymously and had no impact on competency assessment or any other aspect of their education.

Consent for publication

Not applicable.

Availability of data and material

Available upon request from the corresponding author.

Competing interests

The authors declare no competing interests.

Funding

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Authors' contributions

JM: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing- Original Draft, Writing- Review & Editing, Visualization. MH: Conceptualization, Methodology, Investigation. TK: Investigation, Writing- Review & Editing, Visualization. SB: Formal analysis, Writing- Review & Editing. AN: Conceptualization, Methodology, Writing- Review & Editing. CW: Conceptualization, Methodology, Investigation, Writing- Review & Editing. TvG: Conceptualization, Writing- Review & Editing, Supervision, Project administration.

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Clinical Trial Number

Not applicable.

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Appendix 1. Mixed Methods Appraisal Tool (MMAT)

Category of study designs	Methodological quality criteria	Responses			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?	x			
	S2. Do the collected data allow to address the research questions?	x			
1. Qualitative	1.2. Are the qualitative data collection methods adequate to address the research question?	x			
	1.3. Are the findings adequately derived from the data?	x			
	1.4. Is the interpretation of results sufficiently substantiated by data?	x			
	1.5. Is there coherence between qualitative data sources. collection. analysis and interpretation?	x			
2. Quantitative randomized controlled trials	2.1. Is randomization appropriately performed?				*n.a.*
	2.2. Are the groups comparable at baseline?				
	2.3. Are there complete outcome data?				
	2.4. Are outcome assessors blinded to the intervention provided?				
	2.5 Did the participants adhere to the assigned intervention?				
3. Quantitative non-randomized	3.1. Are the participants representative of the target population?	x			
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	x			
	3.3. Are there complete outcome data?	x			
	3.4. Are the confounders accounted for in the design and analysis?	x			
	3.5. During the study period. is the intervention administered (or exposure occurred) as intended?	x			

Category of study designs	Methodological quality criteria	Responses			
		Yes	No	Can't tell	Comments
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?	x			
	4.2. Is the sample representative of the target population?	x			
	4.3. Are the measurements appropriate?	x			
	4.4. Is the risk of nonresponse bias low?	x			
	4.5. Is the statistical analysis appropriate to answer the research question?	x			
5. Mixed methods	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?	x			
	5.2. Are the different components of the study effectively integrated to answer the research question?	x			
	5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	x			
	5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	x			
	5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	x			

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Appendix 2. Survey

Translated to English

Thank you for participating in our study on the impact of interprofessional and uniprofessional pharmacotherapy education. We are interested in the development of competencies when pharmacy and medical students engage in this education together (interprofessional education - IPE) compared to education with only medical students (uniprofessional education - UPE). We are also interested in the effect of participating in multiple joint educational sessions throughout the master's programs (longitudinal program). The completed questionnaires will be fully anonymized and take approximately 10 minutes to fill out.

I identify as … (circle one)	Male/Female/Non-binary/Prefer not to say
My birth year is … (fill in)	
I am studying … (circle one)	Medicine/Pharmacy

Which UPE or IPE session have you attended. **including the current session**?

Year 1– Lunch together and discuss cases of atrial fibrillation, Type 2 diabetes mellitus with hypertension, and kidney failure. (circle one)	IPE/ UPE/ not attended
Year 2– Pharmacogenetic patient cases with online interprofessional consultation (circle one)	IPE/ UPE/ not attended
Year 3– Medication review (circle one)	IPE/ UPE/ not attended
Did you visit the patient during IPE3 (circle one)	Yes/ No/ Not applicable

There are 20 statements across 6 competency domains. Please use the scale below to rate your skills before and after attending the IPE or UPE educational session. Your responses to these questions will not affect your final grade or the completion of this course. There are no right or wrong answers. So please be as honest as possible. The statements address general competencies. so even if you completed all the educational sessions alone. You can still evaluate yourself on the statements asked.

1 = Poor	2 = Fair	3 = Sufficient	4 = More than sufficient	5 = Good

Statements	Before participating in the IPE/UPE activity					After participating in the IPE/UPE activity				
Communication	**Before**					**After**				
	P	**F**	**S**	**M**	**G**	**P**	**F**	**S**	**M**	**G**
I promote effective communication among the different students in a team.	1	2	3	4	5	1	2	3	4	5
I actively listen to the problems and concerns of other students.	1	2	3	4	5	1	2	3	4	5
I express my ideas and concerns without being judgmental towards others.	1	2	3	4	5	1	2	3	4	5
I provide constructive feedback to other students.	1	2	3	4	5	1	2	3	4	5
I express my ideas and concerns clearly and concisely.	1	2	3	4	5	1	2	3	4	5
Collaboration	**Before**					**After**				
	P	**F**	**S**	**M**	**G**	**P**	**F**	**S**	**M**	**G**
I seek out other students to address problems.	1	2	3	4	5	1	2	3	4	5
I work effectively with other students to improve care.	1	2	3	4	5	1	2	3	4	5
I learn with, from, and about other students to improve care.	1	2	3	4	5	1	2	3	4	5
Roles and Responsibilities	**Before**					**After**				
	P	**F**	**S**	**M**	**G**	**P**	**F**	**S**	**M**	**G**
I can identify and describe my capabilities that contribute to a team.	1	2	3	4	5	1	2	3	4	5
I take responsibility for my contribution to a team.	1	2	3	4	5	1	2	3	4	5
I understand the capabilities and contributions of other students in a team.	1	2	3	4	5	1	2	3	4	5
I recognize how the skills and knowledge of others complement or overlap with my own skills and knowledge.	1	2	3	4	5	1	2	3	4	5
Collaborative Patient-Centered Approach	**Before**					**After**				
	P	**F**	**S**	**M**	**G**	**P**	**F**	**S**	**M**	**G**
I use a team approach to get a comprehensive picture of the patient's health situation.	1	2	3	4	5	1	2	3	4	5

1 = Poor	2 = Fair	3 = Sufficient	4 = More than sufficient	5 = Good

Statements	Before participating in the IPE/UPE activity					After participating in the IPE/UPE activity				
I use a team approach to meet the care needs of the patient.	1	2	3	4	5	1	2	3	4	5
I involve the patient/family in decision-making.	1	2	3	4	5	1	2	3	4	5
Conflict Management	**Before**					**After**				
	P	**F**	**S**	**M**	**G**	**P**	**F**	**S**	**M**	**G**
I actively listen to the perspectives of other students.	1	2	3	4	5	1	2	3	4	5
I consider the ideas of other students.	1	2	3	4	5	1	2	3	4	5
I address team conflicts in a respectful manner.	1	2	3	4	5	1	2	3	4	5
Team Functioning	**Before**					**After**				
	P	**F**	**S**	**M**	**G**	**P**	**F**	**S**	**M**	**G**
I develop an effective care plan in a team.	1	2	3	4	5	1	2	3	4	5
I negotiate responsibilities within overlapping work areas in a team.	1	2	3	4	5	1	2	3	4	5
Overall										
Compared to the time before the current learning activity, how do you rate your ability to collaborate interprofessionally?	Much worse now ❑									
	Somewhat worse now ❑									
	About the same ❑									
	Somewhat better now ❑									
	Much better now ❑									

Below are 3 open-ended questions (fill in):

What have you learned from the other students?

What do you think you have taught the other students?

What is the most memorable thing from the educational session that you will take with you into your future as a healthcare professional?

Thank you for completing this survey!

Appendix 3. Interview guide

Translated to English

Thank you for the opportunity to interview you about the interprofessional pharmacotherapy education with medical students together with pharmacy students. The questions I would like to ask are about your experiences with this education. both the session you just had and previous interprofessional education in your master's program. As a pharmacy student. I am conducting my research project on this topic to learn more about the impact of interprofessional education on your perspective on the collaboration between doctors and pharmacists. There are no right or wrong answers. The interview will take approximately 30 minutes.

Your participation in this study is voluntary. has no impact on your academic performance. and your responses will be treated confidentially. You can stop the interview at any time or withdraw afterward. Interviews are recorded to ensure accurate transcription. The recording will be deleted after the study is completed. Do you have any questions beforehand?

Shall we begin?

1. Study and IPE activity

    a. Review consent form with participant's characteristics

2. Multiple IPE activities

    a. What do you think about having activities together with medical/pharmacy students?
    b. What did you think of these IPE activities?
        i. What did you learn? Example?
        ii. What stuck with you the most? Example?
    c. What do you think about having multiple activities together with medical/pharmacy students?
        i. Why? In what way better/worse?
        ii. How has attending multiple IPE activities influenced how you will collaborate interprofessionally?
        iii. In what area have you developed the most regarding what is needed to collaborate?
    d. Suppose there had been only one IPE activity. What difference would that have made? Follow-up: Explore both positive and negative consequences.

3. Collaboration

    a. How was the collaboration with students from the other profession during these IPE activities?
        i. Can you give an example?
        ii. How did this collaboration help you?
        iii. What was a barrier for you in this collaboration? (Apart from practical information)
        iv. Did that change with attending multiple IPE activities?
        v. What did you learn from the other student?
    b. How do you now view the collaboration between doctors and pharmacists in practice?
    c. How would you describe the other healthcare professional?
    d. What do you gain from the other healthcare professional in practice?
    e. What do you think hinders collaboration in practice?
        i. What would help the collaboration?
        ii. How has the education influenced this? And specifically. multiple IPE activities?

4. Conclusion

    Your experiences help to further improve the education. for which we are grateful. Is there anything I forgot to ask for your opinion. or would you like to add something?

Thank you very much for your time and answers to our questions. If you have any questions or comments following our conversation. please feel free to contact us. If we have any further questions. may we contact you about them?

Appendix 4 Sensitivity analysis

Post-interprofessional education (IPE)-activity self-assessed survey item score means were calculated using pairwise deletion for missing data and imputed means. The data showed minimal differences between the two methods, indicating that missing data did not significantly affect the IPE assessment results. Additional sensitivity analyses are available upon request from the author.

Competency domains	Item	IPE (pairwise deletion)			IPE (imputed means)		
		n	Pre-activity mean (SD)*	Post-activity mean (SD)*	n	Pre-activity mean (SD)*	Post-activity mean (SD)*
Communication	1	171	3.62 (0.84)	3.94 (0.74)	182	3.62 (0.82)	3.93 (0.71)
	2	172	4.03 (0.68)	4.24 (0.62)	182	4.03 (0.66)	4.23 (0.60)
	3	172	3.97 (0.67)	4.10 (0.05)	182	3.96 (0.65)	4.10 (0.64)
	4	172	3.62 (0.77)	3.85 (0.74)	182	3.62 (0.74)	3.85 (0.72)
	5	172	3.69 (0.71)	3.94 (0.70)	182	3.68 (0.69)	3.94 (0.68)
Collaboration	6	171	3.40 (0.90)	3.87 (0.83)	182	3.40 (0.87)	3.87 (0.80)
	7	171	3.62 (0.81)	4.11 (0.75)	182	3.62 (0.78)	4.10 (0.73)
	8	171	3.58 (0.77)	4.24 (0.73)	182	3.58 (0.75)	4.23 (0.71)
Roles and Responsibilities	9	169	3.75 (0.78)	4.08 (0.68)	182	3.75 (0.75)	4.07 (0.65)
	10	169	4.05 (0.74)	4.23 (0.64)	182	4.05 (0.72)	4.22 (0.61)
	11	169	3.73 (0.75)	4.28 (0.65)	182	3.72 (0.73)	4.27 (0.62)
	12	169	3.57 (0.73)	4.30 (0.66)	182	3.57 (0.70)	4.29 (0.64)
Collaborative Patient-Centered Approach	13	167	3.39 (0.89)	3.93 (0.83)	182	3.38 (0.85)	3.92 (0.79)
	14	167	3.40 (0.84)	3.88 (0.83)	182	3.40 (0.81)	3.87 (0.79)
	15	167	3.69 (1.03)	3.86 (1.03)	182	3.68 (0.99)	3.85 (0.99)
Conflict Management	16	169	4.09 (0.68)	4.34 (0.64)	182	4.09 (0.65)	4.33 (0.62)
	17	169	4.10 (0.66)	4.31 (0.67)	182	4.09 (0.64)	4.30 (0.65)
	18	169	4.11 (0.78)	4.20 (0.78)	182	4.10 (0.75)	3.54 (0.72)
Team Functioning	19	169	3.54 (0.75)	4.01 (0.76)	182	3.54 (0.72)	3.99 (0.80)
	20	169	3.40 (0.83)	3.80 (0.88)	182	3.40 (0.80)	3.80 (0.84)

* p-value for paired t-test of pre-activity vs post-activity scores <0.05 for all comparisons