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The impact of evidence-based medicine curricula on information literacy among clinical medical undergraduates and postgraduates in China

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Abstract

Background Information literacy (IL) is vital in health education, yet studies indicate medical students' IL might be insufficient or deficient. This study aims to evaluate the impact of an integrated Evidence—based Medicine (EBM) course in improving information literacy (IL) skills among Chinese undergraduate and postgraduate medical students.

Methods This study included 5—year and 7—year undergraduate students as well as postgraduate students majoring in clinical medicine from West China School of Clinical Medicine at Sichuan University who took the EBM course for the first time between January 2010 and December 2010 and participated in all sessions of the course. This study would employ a pre-and post-course comparison method to assess the impact of the integrated EBM course on the IL across different academic stages of Chinese medical students, in order to offer new and reliable strategies for the improvement of medical education of IL. The study incorporated an Evidence—Based Medicine (EBM) course intervention, followed by a comprehensive assessment of its impact. The course impact is defined as the alterations in students' self—perceived Information Literacy (IL) competencies, measured by the differences between pre—and post—course self—evaluations, along with the objectively demonstrated evidence application skills as reflected in the teacher—graded reports. Specifically, the evaluation of impact contains two parts: 1) subjective assessment, which was students' self-assessments of IL (information acquiring competency, information processing competency and information utilizing competency), conducted before and after the EBM course; 2) objective assessment, which was a teacher's assessment, conducted by having each student submit an evidence-based medical record report after the EBM course, and then the teacher assigning grades based on the records.

Results A total of 288 medical students participated in the intervention course, including 5-year undergraduates ($n=106$), 7-year undergraduates ($n=57$) and postgraduates ($n=125$). 1) Information acquiring ability: after the course, students demonstrate a more proactive and enthusiastic inclination towards acquiring information. Their capabilities and expertise in information gathering have notably improved. 2) Information processing ability, exhibited by a 9.7% increase in the number of students who can differentiate types of information ($p<0.05$), and a 9.8% decrease in students who are unable to evaluate the accuracy of information ($p<0.05$) after EBM course; 3) Information utilizing ability, with the percentage of medical students who can cite references in a standard format and synthesize information effectively increased by 18% ($p<0.05$) and 10.1% ($p<0.05$) respectively after EBM course. And multiple aspects

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of the three dimensions of IL showed significant improvement in the postgraduate students. 4)Post-course evaluations of the evidence-based medical record indicate that students have demonstrated commendable proficiency in constructing PICO-based questions and applying evidence to formulate clinical decisions rooted in actual clinical scenarios. Notably, over half of the students attained an A grade in this assessment; However, students exhibit relatively weaker skills in acquiring evidence and critical appraisal, particularly among the 5-year undergraduates and postgraduates; In terms of after-effect evaluation, only 10% of the students evaluated both self-evaluation and clinical effect, while most students evaluated the clinical effect alone.

Conclusions The integrated Evidence—based Medicine (EBM) course contributes to the improvement of information literacy (IL) skills among Chinese medical students, as is evidenced by the preliminary pre—and post—course comparative analysis. Further randomized controlled trials (RCTs) are needed for a more comprehensive and in—depth evaluation of the impact of EBM on IL. In the future, there should be a reinforced emphasis on the skills related to acquiring information and critical appraisal specifically tailored to clinical questions. Moreover, it is essential to provide differentiated curricula to meet the specific needs of students in different grade levels.

Keywords Information literacy, Medical education, Evidence-based medicine, China

Introduction

We reside in an era of information overload, and the COVID- 19 pandemic has additionally led to a rapid and extensive adoption of digital resources in higher education. Therefore, Information Literacy (IL) is considered as "the acquisitions of information age skills" [1]. IL, according to the Association of College and Research Libraries (ACRL) (2016), is the integration of a set of skills to discover and use information ethically in the process of creating new knowledge [2]. Moreover, IL could be specifically subdivided into as the abilities to discern vast amounts of information; the abilities to extract and synthesize knowledge accurately; and the abilities to augment the continuum from data, information and knowledge to wisdom in clinical practice by integrating computer, information and cognitive sciences [3]. Furthermore, IL also requires individuals to be capable of utilizing information to create new knowledge in various contexts [4, 5].

The importance of IL in health professional education has long been recognized. The Institute for International Medical Education put forward informatics competency as a minimum essential requirement for undergraduate in 2003 [6]. IL, especially when it comes to the quality of collected information as well as the reliability and validity of their decision-making, is crucial for undergraduate and postgraduate healthcare professionals. Firstly, IL is an indispensable skill for the professional development of medical students. With the widespread application of internet technology, there is an explosive increase in the volume of medical literature. And the rapid evolution of knowledge and technologies requires that medical students commit to lifelong learning to stay updated on new treatments, drugs, and techniques. Efficient and accurate information acquisition enables healthcare professionals to apply their expertise adaptively, ensuring precise, individualized medical decisions amidst complex clinical challenges. Secondly, IL of medical students is directly related to patient safety. Incomplete or inaccurate information, along with misuse or misunderstanding, may result in misdiagnoses and improper treatments, extending patient recovery and potentially threatening their lives. Therefore, enhancing IL is crucial for medical students, due to their unique responsibility in health care. The IL of medical students is vital for safe, effective, and high-quality medical practice, and it holds significant implications for enhancing public health, ensuring patient safety, and advancing medical development.

However, research conducted across different nations suggest that the IL of contemporary medical students might be insufficient or deficient. A study conducted in Australia has revealed the current non-optimistic situation of nursing students'informatics competency, with only 40.84% of students achieved a"competent"level [7]. And students were found unconfident in applying the IL they had learned to their practical work [8, 9]. Furthermore, even for those students who have tried to apply IL to their practices, there remains a significant inconsistency in their understanding of informatics [10]. The deficiency in IL among medical students may stem from factors such as inadequate infrastructure [11], limited information sources [12, 13], insufficient search skills [12, 13], and a lack of knowledge and skills in assessing and utilizing digital technologies [14]. In brief, the medical education of IL is currently facing challenges, and better methods or strategies are needed to enhance students'IL and to facilitate their application of IL in practice.

At present, the field of medical practice is undergoing a transition from the traditional experience-based model of healthcare to the paradigm of Evidence-Based Medicine (EBM). As a widely accepted paradigm for medical practice, EBM has been deeply integrated into

clinical care over the past two decades [15, 16]. The education of medical students'IL is closely related to the education of EBM: In EBM, medical professionals are required to comprehensively search for relevant evidence and to critically appraise the authenticity, reliability, and practicality of the evidence, and then apply the best evidence from such research to clinical practice. Hence, the education of EBM could also be seen as a guide to understand and master IL for medical students. Amidst a concern for medical education, EBM emerged as a core competency to be mastered by healthcare professionals [17]. In 2008, the American Medical Association recommended that all medical schools offer a course series on evidence-based public health [18]. Previous studies have shown that the EBM course, as an educational intervention, demonstrates positive effects on the development of medical students'abilities. These include enhancing their knowledge, changing the attitudes of medical students, improving critical thinking and self-reported critical appraisal skills [19].

Current researches on the impact of EBM course in cultivating IL are rather limited, particularly when considering the context of medical education in China. Thus, the purpose of this study is to evaluate the impact of an integrated EBM course in enhancing IL skills among Chinese undergraduate and postgraduate medical students.

Method

Study design

This study would employ a pre-and post-course comparison method to assess the impact of the integrated EBM course on the IL across different academic stages of Chinese medical students, in order to offer new and reliable strategies for the improvement of medical education of IL. The course impact is defined as the alterations in students'self—perceived IL competencies, measured by the differences between pre—and post—course self—evaluations, along with the objectively demonstrated evidence application skills as reflected in the teacher—graded reports. Specifically, the evaluation of impact contains two parts: 1) subjective assessment, which was students'self-assessments of information acquiring competency, information processing competency and information utilizing competency, conducted before and after the EBM course; 2) objective assessment, which was a teacher's assessment, conducted by having each student submit an evidence-based medical record report, and then the teacher assigning grades based on the records. Subjective assessment covered all the students while the objective assessment only covered the registered students not auditing students.

Study participants

This study adopted the following inclusion criteria. Firstly, participants had to be 5—year and 7—year undergraduate students as well as postgraduate students majoring in clinical medicine from West China School of Clinical Medicine at Sichuan University. Specifically, they needed to have taken the EBM course for the first time during the period from January 2010 to December 2010. Secondly, it was mandatory for all selected participants to participate in all sessions of the course.

This study is an exploratory analysis. According to the existing literature, the Population Variability and Margin of Error required for calculating the corresponding sample size have not been found. However, in this study, all eligible participants were included, and the data obtained is roughly equivalent to the full—scale dataset. A total of 288 medical students participated in the intervention course. Among them, there were 106 five—year undergraduates, 57 seven—year undergraduates, and 125 postgraduates. A 5-year undergraduate refers to a student who enrolls in a five-year program in medicine pursuing a bachelor's degree, while a 7-year undergraduate refers to a student who enrolls in a seven-year program in medicine with combined pursuit of bachelor's and master's degree. Among them, 205 medical students were registered students while 83 students were auditors. Initially, 317 students signed up for the course (123 five—year, 64 seven—year undergraduates, and 130 postgraduates). 29 were excluded due to incomplete participation. Thus, 288 eligible participants (91% of initial sign—ups) were included. For the overall student population (195 five—year undergraduates, 64 seven—year undergraduates, and 252 postgraduates), inclusion proportions were 54% (106/195), 89% (57/64), and 50% (125/252) respectively, with an overall ratio of 56% (288/511).

This study received approval from Sichuan University Medical Education Research and Development Center (00721) and Chinese Society of Medical Education, Chinese Association of Higher Education, Medical Education Committee (2012-KT- 2). Students were free to opt out of the study. The questionnaire is anonymous to protect student privacy. Participation did not impact students' evaluations. The study was approved and waiver of informed consent by the Biomedical Research Ethics Committee of West China Hospital, Sichuan University (No: 2024–1344).

The Integrated EBM course

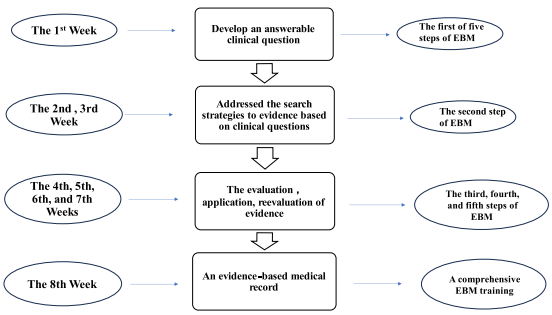
EBM practice lays out a five-step process: 1) converting the need for information (about prevention, diagnosis, prognosis, therapy, causation, etc.) into an answerable question; 2) tracking down the best evidence with which

to answer that question; 3) critically appraising the evidence, one should consider three aspects: the authenticity of the research results; what the research results are (in the case of a therapeutic study, it refers to the magnitude and precision of the treatment effect) [20]; and the applicability of the study (whether it is suitable for my patients). The first two aspects are related to the information—processing ability in IL. That is, while discerning the authenticity of information, one should judge the practical application value of research results from a clinical professional perspective. The third aspect is associated with the information—utilization ability in IL; 4) To formulate clinical decisions, we integrate critical appraisal with our clinical expertise and the unique biology, values, and circumstances of our patients; 5) evaluating our impact and efficiency in executing steps 1 to 4 and seeking ways to improve them both for next time [21]. This process aims to help doctors formulate independent opinions on medical issues [22].

The course (8 weeks, three sessions per week, a total of 24 h of study.) was conducted using the course material developed by The Chinese Cochrane Center. It was taught by 8 EBM professional teachers (one per week) in a classroom at Sichuan University. Additionally, this course provides students with online resources for supplemental learning outside of class [23]. The course mainly involved the five steps of EBM. The design of this course integrates case-based teaching with student practical application. During the first seven weeks, teachers went through the EBM five-step with empirical cases, and students practiced these steps. In the eighth week, students, drawing upon the skills acquired over the preceding seven weeks, formulated resolutions to the clinical problems they had encountered in hospitals, and then they were asked to evaluate the efficacy of these proposed solutions.

Specifically, the course during the first week covered the first of five steps of EBM. Students were asked to develop an answerable clinical question based on etiology, diagnosis, therapy and prognosis according to the PICO format, P (Patient or Population), I (Intervention), C (Comparison or control), and O (Outcome). The course for the second and third weeks focused on the second step of EBM, specifically the search strategies informed by EBM. For numerous databases, we taught students to select databases based on the 6S principles of EBM resource types, which are: Systems, Summaries, Synopses of Syntheses, Syntheses, Synopses of Studies, and Studies (6S). Specifically, this search process is structured in a pyramid shape (see Supplement 2), prioritizing searches from the top of the pyramid, beginning with the highly integrated databases of higher evidence levels—namely, systems. If evidence to resolve the clinical question cannot be found at this level, the search proceeds sequentially downward through the layers. This method enables us to assist medical students in rapidly, accurately, and reliably obtaining the best available evidence, thereby guiding clinical decision-making.

The courses from the fourth to the seventh week covered the third, fourth, and fifth steps of EBM. Students were asked to evaluate, apply and reevaluate evidence systematically according to a specific type of clinical question (etiology, diagnosis, therapy and prognosis). In the eighth week, students were expected to establish a problem-solving model based on clinical issues encountered in their own practice according to the five steps of EBM, and submitted an evidence-based medical record.



Measurements

IL was objectively assessed using a refined and reasonable questionnaire in a paper format before and after the eight-week integrated EBM course. The items were developed from 14 items in a large-scale IL survey questionnaire [24], which comprised three parts, among which 7 items reflected the information acquiring competency, 4 items reflected the information processing competency and 3 items reflected the information utilizing competency. To evaluate the content validity of the questionnaire, we consulted 10 experts who came from various fields including clinical medicine (2 people), informatics (3 people), public health (2 people), and evidence-based medicine (3 people), with 6 of them engaged in teaching. The evaluation of the items is categorized into four levels: 1) Excellent: The content fully meets the requirements of the item. 2) Good: The content largely meets the requirements of the item, with only minor non-essential aspects omitted. 3) Average: The content partially meets the requirements of the item, with significant essential aspects missing. 4) Poor: The content does not align with the requirements of the item at all. For the overall evaluation of the questionnaire, 5 experts rated it as "Excellent" and 5 rated it as "Good" (see Supplement 1). The results indicated that the questionnaire possessed high content validity. To assess the test–retest reliability of the questionnaire in the pilot study, a random sample of

10 students from the same group who had not enrolled in the course was selected. These students completed the same information scale twice, with a 10-day interval between completions. The test–retest reliability coefficient was 0.9.

To address the inherent subjectivity of self-reported data, the study incorporates "Evidence-based medical record" — real clinical issues encountered by students during their clinical practice, which are addressed according to the five steps of evidence-based practice. The cases and processes through which students ultimately resolve clinical problems (i.e., evidence-based medical records) are assessed through a comprehensive third-party evaluation conducted by non-teaching faculty according to standardized criteria blindly. This method transitions from a sole self-assessment by students to a dual evaluation incorporating third-party assessments, thereby providing a more objective and comprehensive analysis of the course's impact on medical students' IL and their problem-solving skills in clinical settings. The registered students were required to submit an evidence-based medical record, including a problem-solving model based on a clinical case of their majors and an assessment of their problem-solving model. The results contained 6 different parts with four grades (A, B, C, D) for each part, determined by the quality of the records.

Data analysis

The database was established by Epidata software. Statistical analysis was conducted with SPSS 27.0 and Excel 2010 software and the results were described with constituent ratio. The ranked variables among the result-options before and after the course were analyzed by the Mann–Whitney U test and the categorical variables of result-options were analyzed using the Chi-square test. The results of multiple-choices were described by using frequency percentage. The data were independently analyzed. All statistical tests were two-tailed, $P < 0.05$ was interpreted as statistically significant. Following consultation with statisticians, Chi-square tests were not performed on the distribution of multiple-choice answers as the differences were deemed insufficient to explain the variance among the options.

Results

In total, 288 medical students, including 5-year undergraduate($n = 106$), 7-year undergraduate($n = 57$) and postgraduate($n = 125$), participated and completed pre- and post-EBM course questionnaire. All students took this course for the first time. They were predominately female ($n = 179$) (see Table 1) and from thirty different majors. Among the group, 205 registered students successfully submitted their EBM medical record reports, in contrast to 83 students who failed to do so. In this study, both students in the five-year and seven-year undergraduate programs are in the preclinical phase, which refers to the foundational learning stage for acquiring medical knowledge and scientific principles prior to engaging in clinical practice, while graduate students are in their first year of the postgraduate program.

Information acquiring ability

Figure 1 and Table 2 show the information acquiring ability before and after the course intervention. The students who have developed the habit of consulting the library catalog before borrowing books experienced a significant increase of 16% (Fig. 1– 1) ($p < 0.05$), with a particularly notable rise of 26% among graduate students ($p < 0.05$). Also, there has been a 10% increase ($p < 0.05$) among graduate students in their ability to develop research strategies. Across items 4–7 in multiple-choice questions, the overall frequency of multiple selections after class was higher than before class, particularly in the use of commonly used databases (an increase from 469 to 703 times, representing a 50% increase). In terms of Access to Information, there was an increase (2–3%) in the method of obtaining information through libraries and bookstores (Fig. 1– 2), while the method of communicating with teachers and classmates correspondingly decreased (3%). In the Methods of Obtaining the Original Text, there was a slight increase (2%) in the use of inter-library loans. Regarding Commonly-used Databases, PubMed and OVID saw increases of 2.6% and 5.4% respectively, with OVID offering the option to utilize integrated data resources based on the 6S principles of EBM."Whether the useful reference database related to the research topic can be expanded"and"Reasons for frequently using the databases"showed no significant changes. Therefore, students have become more proactive and diligent in obtaining information after class, with both their information acquiring ability and professionalism improving.

Information processing ability

Figure 2 and Table 3 show the information processing ability before and after the course intervention. Students who

Table 1 Demographic Information of the participants

	5-years ($N = 106$)	7-years ($N = 57$)	Postgraduate ($N = 125$)	Total($N = 288$)
Male, n (%)	43 (15)	18 (6)	48 (17)	109(38)
Female, n (%)	63 (22)	39 (13)	77 (27)	179(62)
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**/**
Age	22.13 (0.85)	22.64 (0.91)	24.45 (2.38)	/

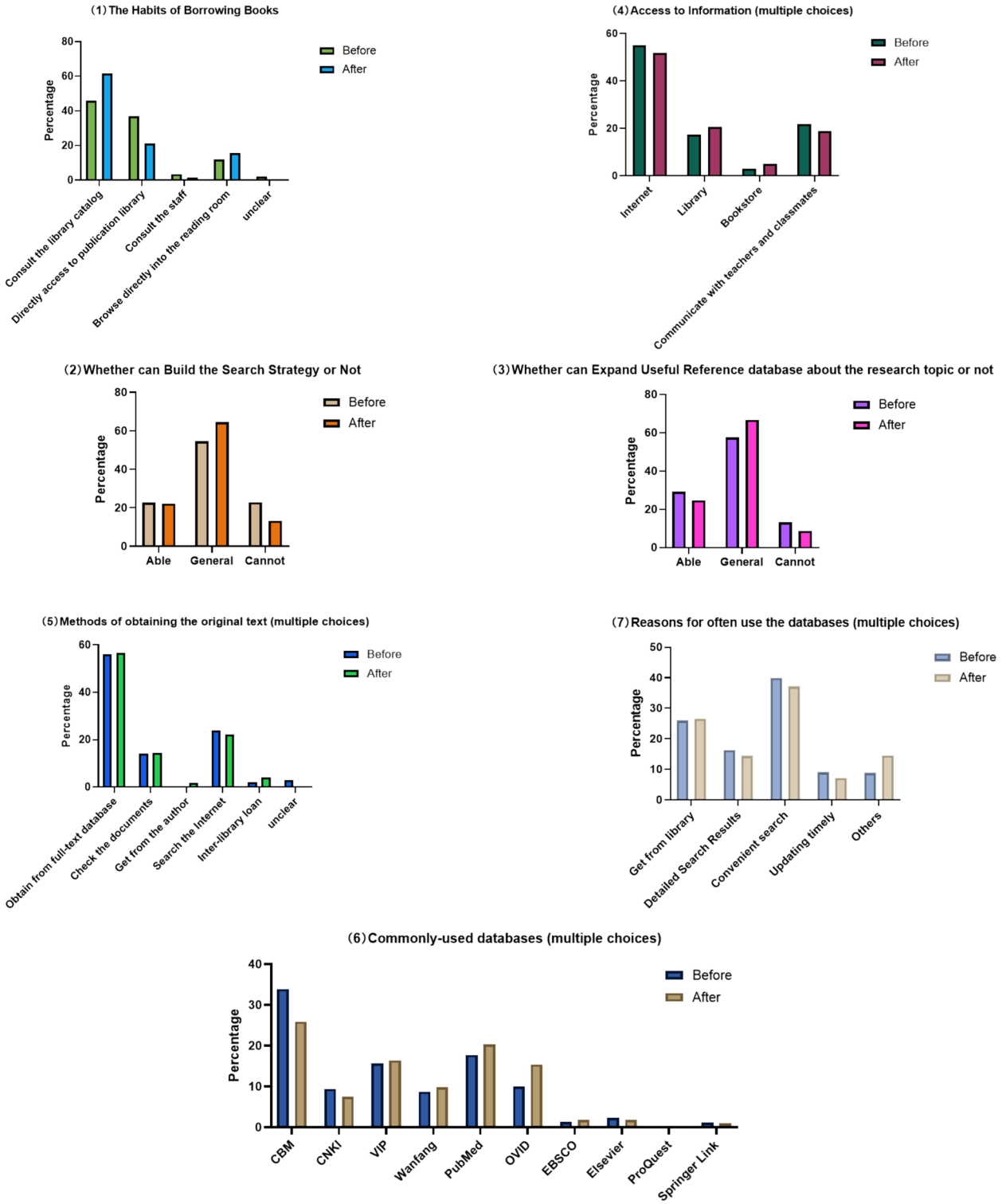


Fig. 1 Information acquiring ability (1–4). Information acquiring ability (5–7)

Table 2 Information acquiring ability

Items	Options	5-years (*N* = 106)		7-years (*N* = 57)		Postgraduate (*N* = 125)		Total (*N* = 288)	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
1.The habits of borrowing books	Consult the library catalog	63(59.4)	67(63.2)	16(28.1)	25(43.9)	53(42.4)	85(68.0)	132(45.8)	177(61.5)
	Directly access to publication library	29(27.4)	22(20.8)	28(49.1)	14(24.5)	49(39.2)	25(20.0)	106(36.8)	61(21.2)
	Consult the staff	5(4.7)	3(2.8)	0	1(1.8)	5(4.0)	0	10(3.5)	4(1.4)
	Browse directly into the reading room	8(7.6)	14(13.2)	12(21.0)	16(28.0)	14(11.2)	15(12.0)	34(11.8)	45(15.6)
	Unclear	1(0.9)	0	1(1.8)	1(1.8)	4(3.2)	0	6(2.1)	1(0.3)
	Total	106(100)	106(100)	57(100)	57(100)	125(100)	125(100)	288(100)	288(100)
	χ^2	4.127		8.352		23.886		26.354	
	P	0.361		0.041		0		0	
2.Whether can build the research strategy or not	Able	33(31.1)	22(20.8)	15(26.3)	12(21.1)	17(13.6)	30(24.0)	65(22.6)	64(22.2)
	General	53(50.0)	74(69.8)	32(56.2)	39(68.4)	72(57.6)	73(58.4)	157(54.5)	186(64.6)
	Cannot	20(18.9)	10(9.4)	10(17.5)	6(10.5)	36(28.8)	22(17.6)	66(22.9)	38(13.2)
	Total	106(100)	106(100)	57(100)	57(100)	125(100)	125(100)	288(100)	288(100)
	Wilcoxon	11,227		3176		12,257		80,077	
	P	0.771		0.915		0.013		0.086	
3.Whether can expand useful reference database about the research topic or not	Able	32(30.2)	22(20.8)	13(22.8)	6(10.5)	39(31.2)	43(34.4)	84(29.2)	71(24.7)
	General	60(56.6)	69(65.0)	37(64.9)	44(77.2)	69(55.2)	79(63.2)	166(57.6)	192(66.7)
	Cannot	14(13.2)	15(14.2)	7(12.3)	7(12.3)	17(13.6)	3(2.4)	38(13.2)	25(8.7)
	Total	106(100)	106(100)	57(100)	57(100)	125(100)	125(100)	288(100)	288(100)
	Wilcoxon	10,836		3077		12,685		82,789	
	P	0.195		0.216		0.113		0.862	
4.Access to information (multiple choices)	Internet	94(59.9)	88(51.2)	45(57.0)	50(56.2)	100(50.3)	115(50.7)	239(54.9)	253(51.8)
	Library	20(12.7)	32(18.6)	16(20.3)	18(20.2)	40(20.1)	50(22.0)	76(17.5)	100(20.5)
	bookstore	5(3.2)	9(5.2)	4(5.1)	3(3.4)	4(2.0)	13(5.7)	13(3.0)	25(5.1)
	Communicate with teachers and classmates	32(20.4)	35(20.3)	14(17.7)	17(19.1)	49(24.6)	40(17.6)	95(21.8)	92(18.9)
	Conferences	3(1.9)	7(4.1)	0	0	6(3.0)	7(3.1)	9(2.1)	14(2.9)
	Others	3(1.9)	1(0.6)	0	1(1.1)	0	2(0.9)	3(0.7)	4(0.8)
	Total	157(100)	172(100)	79(100)	89(100)	199(100)	227(100)	435(100)	488(100)
5.Methods of obtaining the original text (multiple choices)	From full-text database	95(60.9)	100(56.2)	47(58.0)	50(61.0)	101(51.5)	120(55.6)	243(56.1)	270(56.7)
	Check the documents	17(10.9)	26(14.6)	8(9.9)	12(14.6)	36(18.4)	31(14.4)	61(14.1)	69(14.5)
	Get from the author	1(0.6)	2(1.1)	0	0	0	7(3.2)	1(0.2)	9(1.9)
	Search the Internet	36(23.1)	41(23.0)	23(28.4)	17(20.7)	44(22.4)	47(21.8)	103(23.8)	105(22.1)
	Inter-library loan	3(1.9)	9(5.1)	0	1(1.2)	6(3.1)	10(4.6)	9(2.1)	20(4.2)
	Unclear	2(1.3)	0	2(2.5)	2(2.4)	9(4.6)	0	13(3.0)	2(0.4)
	Others	2(1.3)	0	1(1.2)	0	0	1(0.5)	3(0.7)	1(0.2)
	Total	156(100)	178(100)	81(100)	82(100)	196(100)	216(100)	433(100)	476(100)
6.Commonly-used databases (multiple choices)	CBM	66(35.5)	78(31.5)	37(48.1)	37(30.8)	56(27.2)	67(20.0)	159(33.9)	182(25.9)
	CNKI	10(5.4)	20(8.1)	4(5.2)	6(5.0)	30(14.6)	27(8.1)	44(9.4)	53(7.5)
	VIP	29(15.6)	44(17.7)	13(16.9)	16(13.3)	31(15.0)	55(16.4)	73(15.6)	115(16.4)
	Wanfang	13(7.0)	22(8.9)	11(14.3)	18(15.0)	17(8.3)	29(8.7)	41(8.7)	69(9.8)
	Pub Med	39(21.0)	48(19.4)	7(9.1)	24(20.0)	37(18.0)	71(21.2)	83(17.7)	143(20.3)
	OVID	21(11.3)	34(13.7)	5(6.5)	18(15.0)	21(10.2)	56(16.7)	47(10.0)	108(15.4)
	EBSCO	3(1.6)	0	0	0	3(1.5)	13(3.9)	6(1.3)	13(1.8)
	Elsevier	3(1.6)	1(0.4)	0	0	8(3.9)	12(3.6)	11(2.3)	13(1.8)
	ProQuest	0	0	0	0	0	0	0	0
	Springer Link	2(1.1)	1(0.4)	0	1(0.8)	3(1.5)	5(1.5)	5(1.1)	7(1.0)

Table 2 (continued)

Items	Options	5-years (*N* = 106)		7-years (*N* = 57)		Postgraduate (*N* = 125)		Total (*N* = 288)	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
	Total	186(100)	248(100)	77(100)	120(100)	206(100)	335(100)	469(100)	703(100)
7.Reasons for often use the databases (multiple choices)	Get from library	41(30.1)	46(29.5)	12(20.7)	18(27.3)	33(24.1)	47(24.1)	86(26.0)	111(26.6)
	Detailed search results	18(13.2)	21(13.5)	8(13.8)	7(10.6)	28(20.4)	32(16.4)	54(16.3)	60(14.4)
	Convenient search	48(35.3)	66(42.3)	30(51.7)	28(42.4)	54(39.4)	61(31.3)	132(39.9)	155(37.2)
	Updating timely	11(8.1)	10(6.4)	5(8.6)	2(3.0)	14(10.2)	18(9.2)	30(9.1)	30(7.2)
	Others	18(13.2)	13(8.3)	3(5.2)	11(16.7)	8(5.8)	37(19.0)	29(8.8)	61(14.6)
	Total	136(100)	156(100)	58(100)	66(100)	137(100)	195(100)	331(100)	417(100)

The underlined sections in the table are the results that are highlighted in the Results section

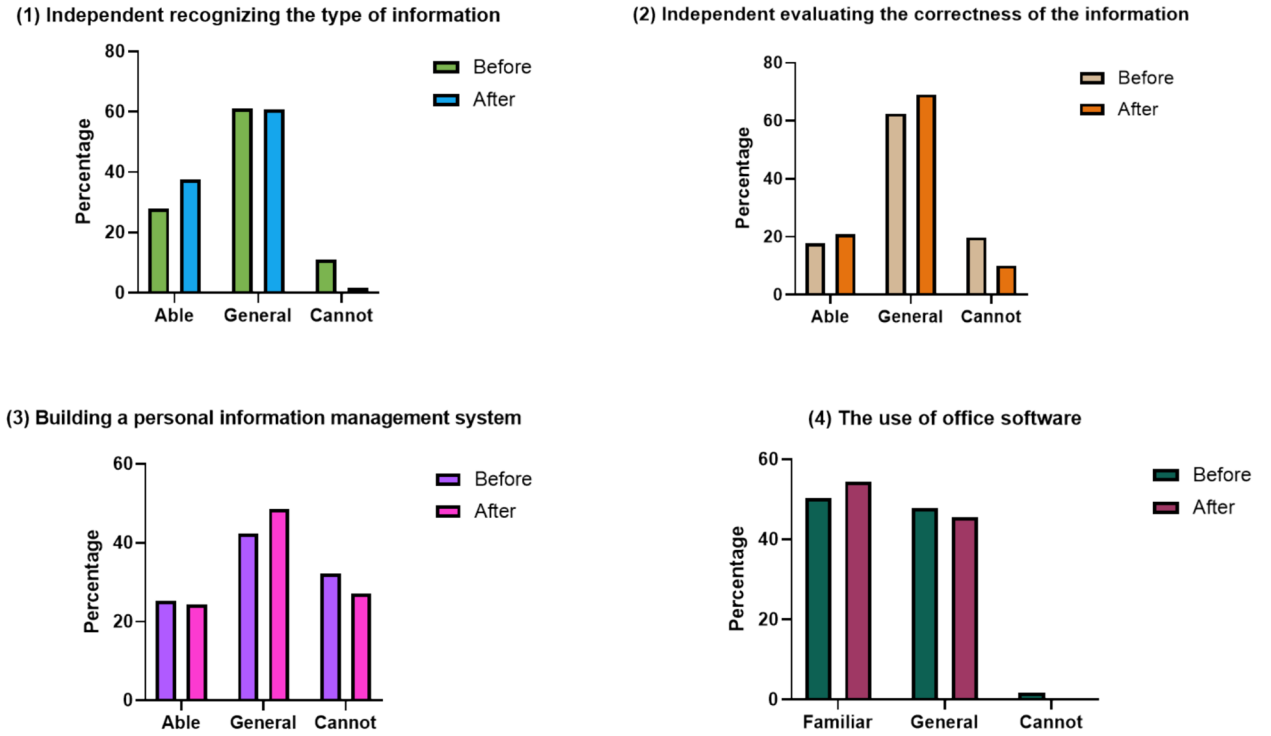


Fig. 2 Information processing ability

are able to distinguish the type of information increased by 9.7% (Fig. 2–1) ($p < 0.05$), particularly graduate students, who saw a 21% increase ($p < 0.05$). While those who cannot evaluate the correctness of the information decreased by 9.8% (Fig. 2– 2) ($p < 0.05$), particularly the 7-year undergraduate, which decreased by 18% ($p < 0.05$)."Building a personal information management system"and"The use of office software"showed no significant changes.

Information utilizing ability

Figure 3 and Table 4 show the information utilizing ability before and after the course intervention. Medical students who could cite references in standard format increased by 18% ($p < 0.05$) (Fig. 3–1), and those who could synthesize and apply the information increased by 10.1% ($p < 0.05$) (Fig. 3–2), respectively. Particularly, graduate students increased by 33% ($p < 0.05$) and 13% ($p < 0.05$), respectively. However, there was no change in discussing the information obtained with others ($p > 0.05$).

Hierarchical analysis of educational level

Three educational levels (5-year undergraduate, 7-year undergraduate and postgraduate) were selected and a

Table 3 Information processing ability

Items	Options	5-years (*N* = 106)		7-years (*N* = 57)		Postgraduate (*N* = 125)		Total (*N* = 288)	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
8.Independent recognizing the type of information	Able	30(28.3)	28(26.4)	15(26.3)	19(33.3)	35(28.0)	61(48.8)	80(27.8)	108(37.5)
	General	62(58.5)	74(69.8)	35(61.4)	38(66.7)	79(63.2)	63(50.4)	176(61.1)	175(60.8)
	Cannot	14(13.2)	4(3.8)	7(12.3)	0	11(8.8)	1(0.8)	32(11.1)	5(1.7)
	Total	106(100)	106(100)	57(100)	57(100)	125(100)	125(100)	288(100)	288(100)
	Wilcoxon	11,169		2941		11,862		76,696	
	P	0.461		0.088		0.001		0	
9.Independent evaluating the correctness of the information	Able	22(20.7)	13(12.3)	11(19.3)	14(24.6)	18(14.4)	33(26.4)	51(17.7)	60(20.8)
	General	55(51.9)	81(76.4)	34(59.6)	41(71.9)	91(72.8)	77(61.6)	180(62.5)	199(69.1)
	Cannot	29(27.4)	12(11.3)	12(21.1)	2(3.5)	16(12.8)	15(12.0)	57(19.8)	29(10.1)
	Total	106(100)	106(100)	57(100)	57(100)	125(100)	125(100)	288(100)	288(100)
	Wilcoxon	11,078		2895		12,798		78,730	
	P	0.332		0.042		0.164		0.009	
10.Building a personal information management system	Able	22(20.8)	21(19.8)	8(14.0)	12(21.1)	43(34.4)	37(29.6)	73(25.3)	70(24.3)
	General	45(42.5)	53(50.0)	25(43.9)	27(47.4)	52(41.6)	60(48.0)	122(42.4)	140(48.6)
	Cannot	39(36.8)	32(30.2)	24(42.1)	18(31.6)	30(24.0)	28(22.4)	93(32.3)	78(27.1)
	Total	106(100)	106(100)	57(100)	57(100)	125(100)	125(100)	288(100)	288(100)
	Wilcoxon	11,180		2987		13,764		81,768	
	P	0.518		0.202		0.486		0.477	
11.The use of office software	Familiar	58(54.7)	60(56.6)	36(63.2)	33(57.9)	51(40.8)	64(51.2)	145(50.3)	157(54.5)
	General	47(44.3)	46(43.4)	20(35.1)	24(42.1)	71(56.8)	61(48.8)	138(47.9)	131(45.5)
	Cannot	1(0.9)	0	1(1.8)	0	3(2.4)	0	5(1.7)	0(0.0)
	Total	106(100)	106(100)	57(100)	57(100)	125(100)	125(100)	288(100)	288(100)
	Wilcoxon	11,348		3193		14,209		81,032	
	P	0.796		0.704		0.056		0.236	

The underlined sections in the table are the results that are highlighted in the Results section

hierarchical analysis was conducted. As can be seen in Tables 2, 3 and 4, the changes of information abilities obtained in students of different educational levels were different. In 5-year students, there were no significant changes in information abilities. In 7-year students, only the changes of borrowing books and of ability of evaluating the correctness of the information were statistically significant ($p < 0.05$). However, in the postgraduates, significant improvement can be seen in multiple aspects of all the three information abilities.

The evaluation of evidence-based medical record

The clinical application of evidence by students after the educational intervention is shown in Fig. 4 and Table 5. Overall, in the submitted evidence-based medical records, 56.1% (Grade A) of the students could clearly articulate the clinical cases they encountered; 51.8% (Grade A) of the students were able to clearly construct clinical questions using the PICO method based on their clinical cases, and 57.6% (Grade A) of the students could apply evidence to solve clinical problems. However, students remained relatively weak in "Acquiring evidence" and "Critical appraisal evidence", with only 36.1% and 13.2% achieving Grade A, particularly among five-year program students and graduate students. In terms of after-effect evaluation, only 10% of the students evaluated both self-evaluation and clinical effect, while most students evaluated the clinical effect alone. As to different educational levels, postgraduates were superior to other students in description of clinical case, constructing question and applying evidence, but inferior in acquiring evidence, critical appraisal and after-effect evaluation.

Discussion

In the context of this study, the change of students' IL was assessed comprehensively in three dimensions by integrating both students'subjective assessments and teachers'objective evaluations. First, it has been shown that the integrated EBM course could help improve medical students'IL in each of the three dimensions including information acquiring ability, information

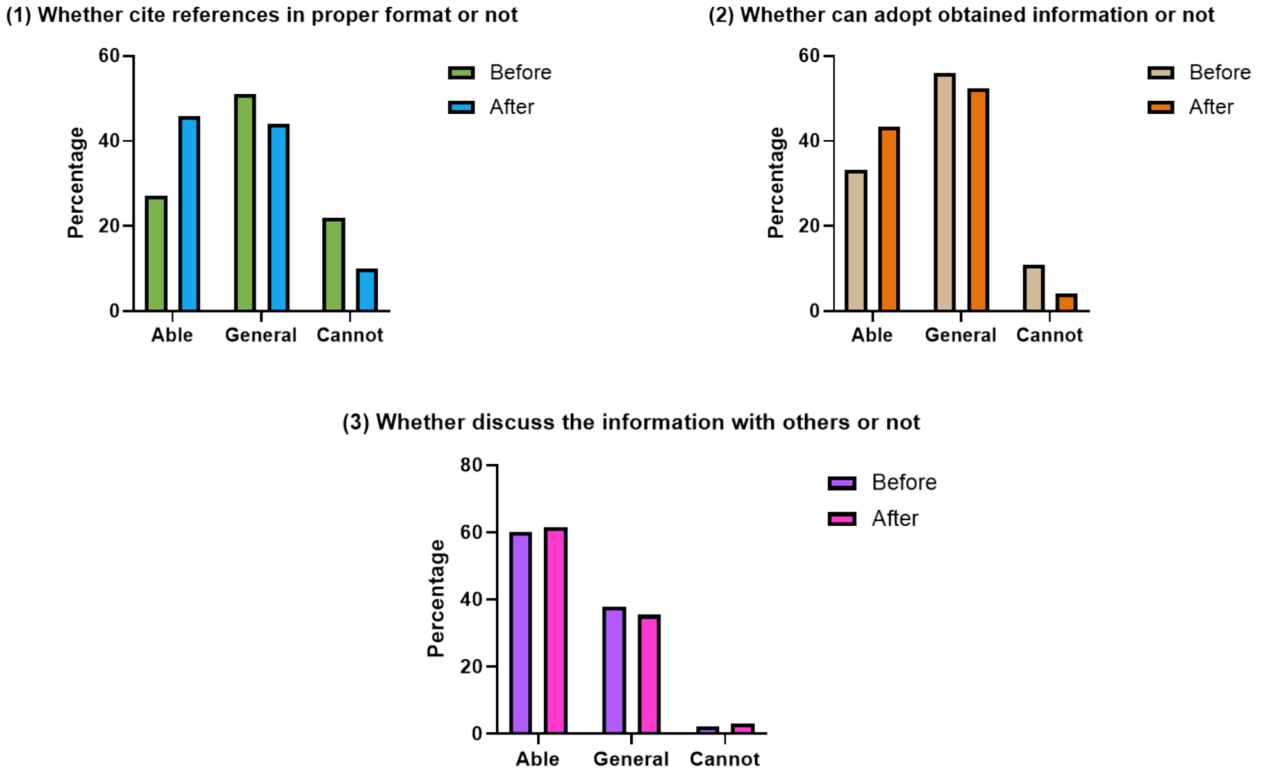


Fig. 3 Information utilizing ability

Table 4 Information utilizing ability

Items	Options	5-years (*N* = 106)		7-years (*N* = 57)		Postgraduate (*N* = 125)		Total (*N* = 288)	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
12.Whether cite references in proper format or not	Able	34(32.1)	44(41.5)	17(29.8)	20(35.1)	27(21.6)	68(54.4)	78(27.1)	132(45.8)
	General	54(50.9)	49(46.2)	30(52.6)	29(50.9)	63(50.4)	49(39.2)	147(51.0)	12.7(44.1)
	Cannot	18(17.0)	13(12.3)	10(17.5)	8(14.0)	35(28.0)	8(6.4)	63(21.9)	29 (10.1)
	Total	106(100)	106(100)	57(100)	57(100)	125(100)	125(100)	288(100)	288(100)
	Wilcoxon	10,837		3078		12,066		73,443	
	P	0.136		0.471		0		0	
13.Whether can adopt obtained information or not	Able	31(29.2)	39(36.8)	21(36.8)	26(45.6)	44(35.2)	60(48.0)	96(33.3)	125(43.4)
	General	64(60.4)	58(54.7)	28(49.1)	30(52.6)	69(55.2)	63(50.4)	161(55.9)	151(52.4)
	Cannot	11(10.4)	9(8.5)	8(14.1)	1(1.8)	12(9.6)	2(1.6)	31(10.8)	12(4.2)
	Total	106(100)	106(100)	57(100)	57(100)	125(100)	125(100)	288(100)	288(100)
	Wilcoxon	11,004		2937		13,930		77,537	
	P	0.760		0.101		0.015		0.002	
14.Whether discuss the information with others or not	Able	61(57.5)	57(53.8)	24(42.1)	30(52.6)	88(70.4)	90(72.0)	173(60.1)	177(61.5)
	General	42(39.6)	46(43.4)	31(54.4)	24(42.1)	36(28.8)	32(25.6)	109(37.8)	102(35.4)
	Cannot	3(2.8)	3(2.8)	2(3.5)	3(5.3)	1(0.8)	3(2.4)	6(2.1)	9(3.1)
	Total	106(100)	106(100)	57(100)	57(100)	125(100)	125(100)	288(100)	288(100)
	Wilcoxon	11,107		3032		14,988		82,696	
	P	0.548		0.300		0.968		0.818	

The underlined sections in the table are the results that are highlighted in the Results section

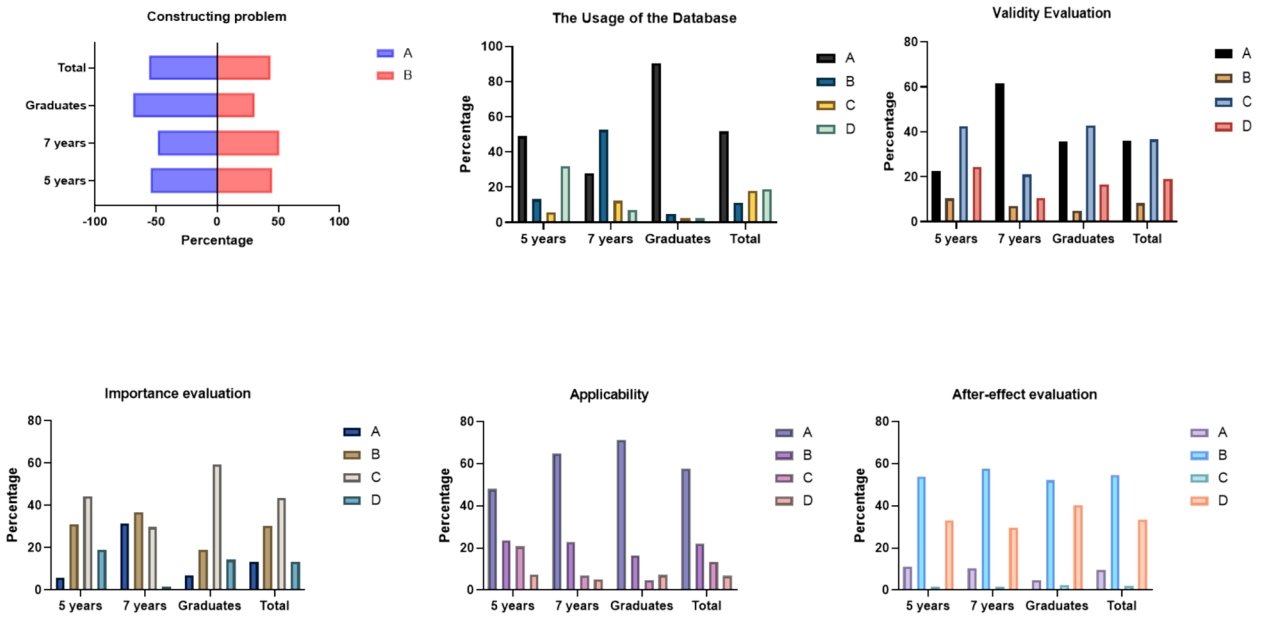


Fig. 4 The assessment of Evidence-Based Medical record

Table 5 The evaluation of evidence-based medical record

Items		A	B	C	D	Total
1.A description based on a clinical case	**5-years**	58(54.7)	48(45.3)			106(100)
	7-years	28(49.1)	29(50.9)			57(100)
	Postgraduate	29(69.0)	13(31)			42(100)
	Total	115(56.1)	90(43.9)			205(100)
2.Asking answerable clinical problem by PICO based the case	**5-years**	52(49.0)	14(13.2)	6(5.7)	34(32.1)	106(100)
	7-years	16(28.1)	30(52.6)	7(12.3)	4(7.0)	57(100)
	Postgraduate	38(90.4)	2(4.8)	1(2.4)	1(2.4)	42(100)
	Total	106(51.8)	23(11.2)	37(18.0)	39(19.0)	205(100)
3.Acquiring evidence	**5-years**	24(22.6)	11(10.4)	45(42.5)	26(24.5)	106(100)
	7-years	35(61.4)	4(7.0)	12(21.1)	6(10.5)	57(100)
	Postgraduate	15(35.7)	2(4.8)	18(42.8)	7(16.7)	42(100)
	Total	74(36.1)	17(8.3)	75(36.6)	39(19.0)	205(100)
4.Critical appraisal evidence	**5-years**	6(5.7)	33(31.1)	47(44.3)	20(18.9)	106(100)
	7-years	18(31.6)	21(36.8)	17(29.8)	1(1.8)	57(100)
	Postgraduate	3(7.1)	8(19.1)	25(59.5)	6(14.3)	42(100)
	Total	27(13.2)	62(30.2)	89(43.4)	27(13.2)	205(100)
5. Application evidence for clinical problem	**5-years**	51(48.1)	25(23.6)	22(20.8)	8(7.5)	106(100)
	7-years	37(64.9)	13(22.8)	4(7.0)	3(5.3)	57(100)
	Postgraduate	30(71.4)	7(16.6)	2(4.8)	3(7.2)	42(100)
	Total	118(57.6)	45(22.0)	28(13.6)	14(6.8)	205(100)
6.Post-effect evaluation	**5-years**	12(11.3)	57(53.8)	2(1.9)	35(33.0)	106(100)
	7-years	6(10.5)	33(57.9)	1(1.8)	17(29.8)	57(100)
	Postgraduate	2(4.8)	22(52.3)	1(2.4)	17(40.5)	42(100)
	Total	20(9.8)	112(54.6)	4(2.0)	69(33.6)	205(100)

The underlined sections in the table are the results that are highlighted in the Results section

processing ability and information utilizing ability. Second, this study found that the impact of the integrated EBM course in improving IL varied among medical students of different academic stages: no significant change of IL was observed in 5-year undergraduate students; While postgraduate students outperform 7-year undergraduates in IL. Although postgraduate students excel over other students in description clinical case, formulating questions and applying evidence, they fall short in acquiring evidence, critical appraisal evidence and post-effect evaluation.

There is a considerable amount of studies exploring the implementation of EBM courses within undergraduate medical curricula [25–31]. This study has yielded several new advances based on the previous research foundations: 1) This study focuses on undergraduate students (in the preclinical phase) and graduate students, exploring the differences between these two groups, distinct from prior research that primarily concentrated on undergraduate students [25, 26]. 2) This study integrates EBM education with IL education to enhance students'information literacy through EBM training, distinguishing itself from studies that focus solely on EBM education [28, 29] and aligning with some previous findings [25, 31]. Additionally, the course is designed for clinical medical students, ensuring that the research remains centered on solving real clinical problems while emphasizing the enhancement of students'clinical skills. In this study's course framework, students were asked to utilize authentic cases they encounter in clinical practice as learning materials. 3) Previous study has indicated that interprofessional approach should be considered in EBM education [26]. This study also adopts a multidisciplinary approach, with course design collaboratively undertaken by interdisciplinary experts, including clinical specialists, experts in EBM, information science specialists, and librarians. This collaboration ensures both the comprehensiveness and practicality of the educational program. 4) Currently, there are several well-established assessment tools for measuring attitudes, knowledge, and behaviors in EBM education [27]. Although these scales refine behavioral measurements and are designed for undergraduate students, they do not comprehensively meet the assessment needs for IL that we require. Also, attitudes and knowledge are precursors to behavior change; therefore, precise measurements of behavior can better evaluate the impact of education. Meanwhile, previous research [30] suggests that reasonable and effective assessment tools may be developed to address different evaluation needs. Hence, this study aims to more explicitly assess the three dimensions of IL.

Previous studies have indicated that an EBM course, implemented as an educational intervention, could modify the attitudes of students, enhance their knowledge and critical thinking abilities, as well as improve their self-reported critical appraisal skills [19]. This study further confirmed the impact of the integrated EBM course for improving medical students'IL. Furthermore, this study employed pre-course baseline assessments and post-course outcome evaluations as methods to investigate the enhancement of medical students'IL through the integrated EBM course. Simultaneously, by integrating students'subjective assessments and teachers'objective evaluations, the study aimed to conduct from multiple angles evaluation of the impact of the integrated EBM course on medical students'IL. In the context of this study, information literacy (IL) was categorized into three dimensions, and students'proficiency in IL was assessed from these perspectives, with the aim of conducting a comprehensive evaluation of the teaching impact. These methods all provide valuable experiences that could be drawn upon for future researches on the teaching impact of IL.

The reason why the integrated EBM course can enhance the IL may be that this course is designed based on the specific context of Chinese medical students. Not only is this integrated EBM course designed with a focus on competency-based teaching and assessment from the beginning [32], it is also targeted at the core competencies that Chinese medical students lack. According to "Global Minimum Essential Requirements" (GMER) released in 2002 by Institute for International Medical Education (IIME) [33], medical students should possess seven basic competencies: professional ethics, medical basic knowledge, communication skills, clinical skills, public health, information management, and critical thinking. In 2003, a survey of the core competencies of medical students in China showed that Chinese medical students are incompetent in communication, public health, information management, and critical thinking [34]. Our prior researches have confirmed that this integrated EBM course has shown significant impact in cultivating the core competencies of Chinese medical students [35], particularly in improving critical thinking skills [36]. Hence, it is foreseeable that the integrated EBM course would enhance the IL of Chinese medical students.

This study found that the impact of the integrated EBM course varied among students at different academic stages. The three dimensions of IL demonstrated significant improvement in the postgraduate students than the undergraduates. These results are consistent with previous study that postgraduate students outperform undergraduates in establishing personal information management systems [37]. According to our previous research [37], in terms of proactive planning

before acquiring and searching for information, postgraduate students exhibit significantly higher initiative and have a higher level of organization than undergraduates. This could be attributed to postgraduate students engaging in their field for a longer period, having a greater demand for professional information, and clearer objectives. This might also be the reason why postgraduates show significant improvement in all three dimensions of IL.

Strengths and Limitations

Our study employs a pre-and-post comparison method to assess the changes in IL among undergraduate and graduate medical students before and after an integrated EBM course. Simultaneously, the study conducted an evaluation of the impact of the integrated EBM course on undergraduate and postgraduate medical students'IL by integrating subjective and objective assessments. All of these methods may offer valuable insights and serve as a beneficial reference for the future researches on the teaching impact of IL.

This study also has some limitations: 1) Due to the course arrangements, it was not a randomized controlled trial; therefore, the scientific validity of the findings requires further validation through randomized controlled studies; 2) The results of this study are confined only to the intervention effects of an 8-week integrated EBM course. Moreover, the effects of education exhibit a delayed manifestation, so the impact of integrated EBM course on students' IL might potentially alter in the future; 3) Given the current situation where a standardized IL assessment scale is not available in China, we have resorted to using an alternative scale. Although we have conducted evaluations of its content validity and test–retest reliability, there are still some areas for improvement in terms of its overall reliability and validity. Therefore, it is important to acknowledge the potential limitations of the measurement results. 4) Another limitation of this paper is that the course was not tailored to different year groups. Our findings suggest that the challenges faced by postgraduate students may differ from those encountered by undergraduates. Therefore, in future research, separate courses could be designed for undergraduates and postgraduates to provide more targeted support for each group. Thus, future studies could longitudinally follow these students. Researchers could also conduct randomized controlled trials to further investigate the issues.

This study has its limitations as it was conducted 15 years ago. The rapid development of internet and AI technologies in the past 15 years, now deeply integrated into society, has significantly transformed information—related processes. Nevertheless, its execution when these technologies were less prevalent endows it with unique research significance: 1) Owing to the limited information acquisition methods and channels then, students were in a relatively closed information environment during the course learning. This implies that the change in IL was less likely influenced by confounding factors. Thus, the research findings are more relevant to the course, suggesting that post—class IL changes in students are more likely attributable to the course. To some degree, this offsets the lack of a concurrent control in the research design. 2)In the era of information and AI, information literacy (IL) has grown in importance. Despite seemingly enhanced access to information, individuals often struggle to navigate the vast data and may enter an information cocoon. This underscores the need to improve IL, particularly in discerning information authenticity and objective utilization. Consequently, the EBM course remains of practical significance for enhancing medical students'IL. 3)As students relied on paper resources and lacked AI tools then, analyzing the study can reveal the real situation of their IL and offer references for current medical education reforms.

Conclusion

The integrated EBM course intervention does contribute to the improvement of IL, but it still needs to be combined with other relevant education and more clinical practice to improve information ability. Further randomized controlled trials (RCTs) are needed for a more comprehensive and in—depth evaluation of the impact of EBM on IL. These findings assist us in promoting the integrated EBM course for medical students to enhance their Information Literacy (IL) in the future. Moreover, the discovery of different teaching effects among students at various academic stages from this study also suggests that we should develop more targeted teaching measures for students at different academic stages in the future.

Abbreviations

ACRL	Association of College and Research Libraries
EBM	Evidence-Based Medicine
GMER	Global Minimum Essential Requirements
IIME	Institute for International Medical Education
IL	Information literacy

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-025-07125-7.

Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions
JC made contributions to conception, design, and revision of the manuscript. CW drafted and revised the manuscript. YY made contributions to revised the manuscript. YLC made contributions to acquisition of data, analysis and interpretation of data. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study received approval from Sichuan University Medical Education Research and Development Center (00721) and Chinese Society of Medical Education, Chinese Association of Higher Education, Medical Education Committee (2012-KT- 2). Students were free to opt out of the study. The questionnaire is anonymous to protect student privacy. Participation did not impact students' evaluations. The study was approved by the Biomedical Research Ethics Committee of West China Hospital, Sichuan University (No: 2024–1344). The need for informed consent to participate was waived by the Biomedical Research Ethics Committee of West China Hospital, Sichuan University (No: 2024–1344).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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