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Journal of Education Technology in Health Sciences

Journal homepage: https://www.jeths.org/

Original Research Article

Utilization of e-books to enhance self-directed learning for clinical laboratory science specialists

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ARTICLE INFO

Article history:
Received 24-06-2023
Accepted 07-08-2023
Available online 22-09-2023

Keywords:
Continuing education
e-book
Independent learning
Professional development
Clinical laboratories sciences specialists (CLSs)

ABSTRACT

Background: Ongoing education plays a crucial role in enhancing the competence of clinical laboratories Sciences Specialists (CLSs). However, CLSs often encounter obstacles when trying to learn in involved clinical settings. To tackle these challenges and cater to the specific learning requirements of medical technologists, we developed a learner-centred electronic book (e-book) that fosters self-directed learning among them.

Materials and Methods: To assess the e-book's effectiveness as continuing education (CE) material for CLSs, a cross-sectional study was carried out at two medical centres in Riyadh. The e-book's content was tailored to meet the specific practice requirements and learning needs of CLSs. The study employed The New World Kirkpatrick Model, which includes four levels (reactions, learning, behaviors, and results), to evaluate the impact of the e-book on the participants' learning. A total of 280 medical technologists took part in the study, completing a questionnaire and a post-test, which provided valuable insights into their learning patterns, satisfaction with the e-book, and the learning outcomes they experienced after using it.

Results: After using the e-book, a majority of readers reported positive learning experiences and improvements in their learning outcomes, encompassing knowledge acquisition and changes in behavior. Furthermore, the e-book successfully presented a new continuing education (CE) activity and reached CLSs from diverse laboratory settings.

Conclusion: The affordable and learner-focused e-book efficiently addressed the obstacles to continuing education (CE) faced by CLSs. The interactive and flexible nature of e-learning was especially beneficial in enabling learners to actively participate in clinical scenarios related to laboratories. This research holds the potential to serve as a foundation for medical educators to develop e-learning model for CE.

1. Introduction

Continuing education (CE) plays a crucial role in enhancing the competence and expertise of healthcare professionals in the dynamic healthcare landscape.[1,2] Furthermore, it serves as a vital component of continuing professional development (CPD), fostering personal growth and driving improvements both at the individual and system levels. Contribution to healthcare[3,4] requires continuous professional development (CPD) through continuing education (CE) programs. Despite comprehensive training provided by healthcare educators, specialists still encounter learning barriers in complex clinical settings.[5,6] These barriers include overwhelming workloads,[5–7] challenges in adapting to various teaching styles and receiving irrelevant learning materials.[5,6,8] To improve CPD, CLSs must take responsibility for their CE requirements throughout their careers,[4,9] and educators should explore suitable

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https://doi.org/10.18231/j.jeths.2023.009

educational strategies to promote lifelong learning.[10,11] Studies have shown that effective educational programs can enhance CE learning effectiveness by engaging learners, capturing their attention, encouraging self-improvement, and targeting specific learning needs.[12–14] However, despite evidence supporting better learning facilitators, traditional educational meetings and teaching conferences are still widely utilized, even though they may be ineffective and counterproductive for healthcare professionals.[15–17] Relying heavily on lecture-based learning can lead to passive learning, fixed schedules, short attention spans, cognitive overload, and information redundancy. In the last two decades, self-directed learning (SDL) has emerged as a solution to overcome these learning barriers and foster the acquisition of new skills and knowledge.[18] SDL involves eight elements: a process initiated by the individual, potentially involving others, identifying learning needs, setting learning goals, finding necessary resources, choosing appropriate learning strategies, and determining methods to assess learning outcomes.[19] SDL encourages self-motivated learning after work, as it directly addresses clinical needs and consolidates job knowledge, motivating professionals to engage in regular learning. Evidence-based research indicates that digital learning promotes SDL, allowing professionals to conveniently access courses through digital devices in clinical settings, positively influencing their achievements.[20,21] Using emerging and habit-forming digital media in the digital age can enrich, extend, and advance learning across different environments. Recent research[22,23] suggests that building a digital continuing education (CE) program from the learner's perspective, with intuitive, readable, and enjoyable content, can effectively motivate professionals to engage in independent learning in complex work environments. Electronic books (e-books) have been found to be successful in increasing learners' motivation compared to traditional learning methods.[24,25] This is attributed to e-books' page fidelity, convenience, and interactivity, as they incorporate a combination of text, images, videos, animations, self-test questions, and other interactive activities. Being accessible and interactive on mobile devices, learners can actively engage with e-book content, which significantly improves their learning motivation and metacognitive abilities, ultimately enhancing their learning achievement.[24–26] Therefore, due to its flexibility, accessibility, interactivity, usefulness, enjoyment potential, and extensibility, the multimedia e-book holds promise as an effective learning tool for professionals working in complex clinical settings. The primary objective of this study was to optimize CLSs learning experiences and address their learning needs by developing a technology-enhanced CE program. Two research questions were explored: (1) Can an enriched e-book incorporating interactive multimedia elements and learner-centered content overcome learning barriers for medical technologists? and (2) What concerns must faculty members address to bridge learning gaps in CE for medical technologists?

To achieve these research goals, the study aimed to: 1) create an e-book that tackles learning barriers associated with traditional CE and promotes self-learning, 2) investigate if the utilization of the e-book overcomes learning barriers linked to traditional CE, and 3) assess the impact of the e-book on readers using The New World Kirkpatrick Model—an outcome evaluation model encompassing four domains: reactions, learning, behaviors, and results.[27,28]

2. Materials and Methods

2.1. Design of the research and the population

The research design involved a cross-sectional study conducted throughout January to December 2022, aimed at investigating the acceptability and practicality of implementing an e-book as a continuing professional development (CPD) program for CLSs in Riyadh. The e-book was structured to be released quarterly. Using convenient sampling, information was gathered from readers and CLSs who had access to the e-book through links provided as a part of the CPD initiative.

Participants in the program were informed that they would receive 1 hour of continuing education (CE) credit if they scored at least 80% on the post-test. Upon finishing the e-book, readers were invited to complete an anonymous online structured questionnaire and a post-test. To ensure privacy and obscurity, no personally identifiable information was collected.

This research was conducted at the Laboratories in two hospitals in Riyadh, the study included a total of 100 participants. The inclusion criteria required participants to be full-time CLSs working, while individuals employed as interns were excluded from the study. All 100 CLSs were provided with access to different editions of the e-book on a quarterly basis via email or links. Participants who completed the anonymous feedback questionnaire and post-test were considered as study readers.

2.2. The e-book design and learning

Context were created with a learner-centered approach, drawing insights from medical education research and input from CLSs. Flip PDF software version 4.1.10 (Flip Builder) was used to implement this design. This software facilitated the resizing of articles and figures to their final full-text and PDF formats, which were then converted to HTML5. The e-book editor allowed the incorporation of dynamic content, such as videos, audio, and links, providing an interactive learning experience. Readers could access learning materials simultaneously using hyperlinks that integrated multimedia information within the e-book.

Additionally, the e-book featured articles on knowledge application and information.

2.3. Data collection

The feedback questionnaire and post-test were accessible online for a duration of three months after each new release of the e-book. For instance, if the e-book was issued in January 2022, data from the feedback questionnaire and post-test completed between January and March 31 were collected to assess reader feedback and learning effects related to the January 2022 e-book. Each reader was allowed to submit data only once within the specified period. Data regarding the e-book were collected at four distinct time periods. To enhance learning in the laboratory, promote quality improvement, facilitate clinical consulting, enable clinical research, and foster problem-solving skills, various examples were collected, condensed, rewritten, and integrated into the learning context. These learning topics were tailored to meet the continuing competence program requirements for CLSS in Riyadh. To increase learner engagement in specific clinical scenarios related to Clinical Laboratory Sciences, the e-book included case-based learning with pictures illustrating pre-analytical, analytical, and post-analytical characteristics. These case examples were presented through interactive e-modules, creating a visualization-based and engaging clinical learning experience. All content within the e-book was available, ensuring accessibility to the target audience. The content was designed to be approachable, relevant to clinical practice, and of ideal length. Significantly, before the release of each e-book, the draft was reviewed by the mangers in the department, consisting of experts in laboratory.

2.4. Measurements of the outcome

As seen in Figure 1. The evaluation outcomes were assessed, which encompasses four domains or levels: reactions, learning, behaviours, and results. To gauge readers' perceptions, acceptance, and satisfaction with the e-book (Level 1: reactions), an anonymous structured questionnaire and a post-test comprising 10 multiple-choice questions were designed to assess the acquisition of knowledge (Level 2: learning) related to the content of the e-book. The change in behavior (Level 3: behaviors) was measured based on the number of readers who engaged with the e-book quarterly, as no previous e-book had been published before the program. To evaluate organizational changes (Level 4: results), the completion rate of 1 hour of CE credit was assessed after readers had used the e-book, as this CE credit was newly introduced in the organization. Additionally, the survey included questions about learning styles and demographic characteristics to analyze the e-book's effectiveness in meeting various learners' needs. The e-book was developed to address and overcome the learning barriers associated with traditional continuing education (CE) programs. Readers were encouraged to provide immediate feedback by using hyperlinks placed at the end of the e-book. The feedback questionnaire was carefully designed by the editorial board, with input from experts in laboratory education. To ensure its effectiveness, a pilot study involving 10 individuals was conducted in March 2023 to pre-test the survey questions for clarity and understanding. The same feedback questionnaire was administered to readers for each issue of the e-book, aiming to identify changes in reading behaviors and gather suggestions for future CE programs. Participants provided demographic information, shared their learning patterns, assessed the feasibility of using the e-book, expressed their satisfaction with its use, and reported on their learning outcomes after using it. The satisfaction measurements included seven questions rated on a 5-point Likert scale, along with an open-ended question to allow respondents to express their views on any topic related to the e-book. Additionally, a separate pilot study involving 10 individuals was conducted to pre-test the post-test survey questions. The questions in the post-test were designed by the editorial board and reviewed by experts in Clinical laboratory education. These post-test questions varied for each issue of the e-book but were carefully tested by the editorial board to ensure consistent difficulty levels across the different rounds, thus providing a reliable assessment for most CLSs.

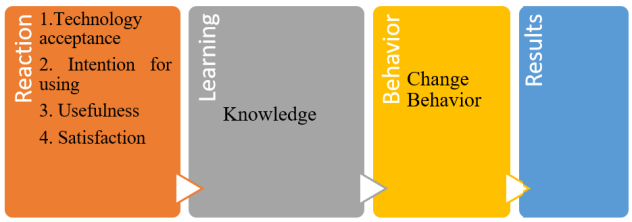

Fig. 1: The application of The New Model for evaluating the e-book's impact on continuing education (CE). This formal evaluation provided valuable insights into the effectiveness and relevance of the e-book in meeting the learning needs of CLSs

2.5. Statistical analysis

Data were statistically analysed using Microsoft Excel and SAS software version 9.4 (SAS Institute, Cary, NC, USA). For categorical data, results were presented in tables by using frequencies or percentages. Cochran–Armitage trend test was performed to determine the trends in binomial proportions across the levels of ordinal variables, whilst a chi-square test was performed to determine relationships between categorical variables. Correlation coefficient (phi) was used to measure the strength of the association between two categorical variables. Descriptive statistics

were conducted to analyse scores and responses, which were presented as proportions (%), means, and standard deviations (SDs). In all analyses, two-tailed $p<0.05$ was considered statistically significant.

3. Results and Discussions

A total of 100 CLSs were invited to participate in the study and complete the feedback questionnaire and post-test for each round. The response rates for different issues of the e-book in 2022 were 25.0%, 43.9%, 43.6%, and 40.0%, respectively. Demographic characteristics of the readers showed no significant differences between different issues of the e-book. Most participants were women with varied work experience, primarily specializing in clinical chemistry, clinical haematology, and microbiology. The majority of readers received continuing education from hospital or healthcare delivery systems and professional associations, with over 50% spending less than 30 minutes per week on educational activities. The main barriers faced by clinical specialists in continuing professional development (CPD) were lack of free time and information overload. (Table 1)

Reader satisfaction with the e-book program was generally high, with respondents reporting positive feedback on program organization, delivery modes, and learning stimulation. The responses indicated that the e-book content and layout stimulated their learning effectively, leading to overall satisfaction with the e-book. Some respondents particularly enjoyed the interactivity, convenience, and clinically relevant topics, while a few suggested a focus on general specialty-related subjects. Regarding the evaluation of learning effects on knowledge acquisition, readers achieved high scores on the post-test for each round, indicating successful learning outcomes after using the e-book. More than 70% of readers earned 1 hour of CE credit by achieving a score of at least 80% on the post-test in each round during the 1-year period. Additionally, an analysis of the associations between CPD participation frequency and readers' self-perceived barriers revealed a significant negative trend between participation frequency and language barriers for the readers of the 2nd issue. Regarding reader satisfaction with the e-book, responses from different rounds showed a consistent pattern. Despite some initial lower satisfaction reported in the first issue, the average responses for all seven items in each round were above 4, indicating positive feedback. Notably, the highest mean score was for the statement "The content and layout of the e-book stimulate my learning," and the mean scores for the statement "Overall, I am satisfied with the e-book" were higher than the average. This suggested that the e-book's educational content provided a favorable environment for continuing education (CE). In the feedback, some respondents expressed enjoyment of the e-book's interactivity, especially in clinical case scenarios, convenience, and the relevance of topics to clinical practice. However, a few respondents suggested focusing more on general specialty-related subjects. In evaluating the learning effects on knowledge acquisition, readers achieved high scores on the post-test in each round (89.0%, 71.4%, 82.8%, and 77.0%, respectively) after reading different issues of the e-book. Importantly, most participants mainly took courses provided by healthcare delivery systems, while more than 50% spent less than 30 minutes on educational activities per week. This data suggested higher reader engagement in this e-book program compared to previous CPD activities. Throughout the one-year period, more than 70% of readers achieved a score of at least 80% on the post-test in each round, successfully earning 1 hour of CE credit since the e-book was introduced as a new CE activity. In a further analysis of the associations between CPD participation frequency and readers' self-perceived barriers, a significant negative trend was found between participation frequency and language barriers among readers of the 2nd issue e-book. This trend suggests that readers who participated more frequently in CPD activities encountered fewer language-related barriers. (Table 2). The study did not find any significant relationship between participation frequency and language barriers among readers in different rounds. However, the frequency distribution revealed that readers facing language barriers tended to spend less time on Continuing Professional Development (CPD) programs. On the other hand, a larger proportion of readers believed that certain aspects of the e-book's learning facilitators could help them overcome their specific learning barriers. These facilitators included the efficiency of conducting research, and relevance to clinical practice (Table 3). The strength of the relationship between readers' self-perceived barriers and the corresponding learning facilitators in the e-book was assessed using the phi correlation coefficient. Except for the facilitator most readers who had self-perceived barriers were more likely to report benefits from the corresponding facilitators, such as "efficiency for researching," and "relevance to clinical practice." This indicates a positive correlation between the perceived barriers and the potential benefits of the e-book's learning facilitators among readers in different rounds, it was possible to identify connections between specific barriers and the corresponding facilitators, even though this correlation was not consistently present in every round.

The primary objective of the research was to develop an e-book that could effectively address the learning obstacles typically associated with traditional Continuing Education (CE) for CLSs. Furthermore, to encourage self-learning among these professionals. To the best of our knowledge, this was the first attempt to create a high-quality e-learning model tailored specifically for specialists at a low cost. Since the e-book was made available online for free, the only expenses incurred during its

Table 1: The participant responses to the e-book from the survey

Items of the Questionnaire	*Mean (SD)			
	First Issue (n=60)	**Second Issue (n=90)**	**Third Issue (n=90)**	**Forth issue (n=80)**
1. I am satisfied with the contents and layout of the e-book	4.01 (0.86)	4.10 (0.81)	4.14 (0.70)	4.08 (0.63)
2. It is convenient and attractive to use 3C to read the e-book)	4.01 (0.89)	4.14 (0.79)	4.17 (0.69	4.12 (0.64)
3. I am satisfied with the contents and layout of the journal articles in the e-book	4.03 (0.85)	4.09 (0.75)	4.15 (0.64)	4.07 (0.58)
4. It is convenient and attractive to use 3C to read the journal articles in the e-book	4.01 (0.90)	4.11 (0.79)	4.20 (0.69)	4.13 (0.63)
5. Overall, I am satisfied with the e-book)	4.06 (0.83	4.15 (0.76)	4.18 (0.66)	4.13 (0.61)

Responses based on a 5-point scale (1=strongly disagree, 5=strongly agree)

Table 2: Correlations between participants engage in (CE) and the continuing professional development (CPD)

Perceived barriers	**Frequency of practicing continuing education per week (min) N (%)**			
Readers of dissimilar e-books				
Lack of free time	15–30	31–60	>60	p trend
1st issue (n=60)	13 (39.4)	13 (39.4)	2 (6.1)	0.5593
2nd issue (n=90)	26 (44.1)	13 (22.5)	7 (11.9)	0.7509
3rd issue (n=90)	29 (45.3)	16 (25.0)	5 (7.8)	0.4068
4th issue (n=80)	25 (51.0)	17 (34.7)	2 (4.1)	0.8809
Offered courses in English only				
1st issue (n=60)	17 (37.0)	18 (39.1)	3 (6.5)	0.6397
2nd issue (n=90)	33 (49.3)	18 (26.9)	12 (17.9)	0.1883
3rd issue (n=90)	35 (42.7)	25 (30.5)	9 (11.0)	0.1174
4th issue (n=80)	37 (54.4)	18 (26.5)	6 (8.8)	0.7202
Courses not related to clinical fields				
1st issue (n=60)	9 (31.0)	14 (48.3)	1 (3.4)	0.5169
2nd issue (n=90)	20 (42.6)	8 (17.0)	4 (8.5)	0.0383
3rd issue (n=90)	18 (39.1)	12 (26.1)	8 (17.4)	0.1565
4th issue (n=80)	18 (39.1)	12 (26.1)	8 (17.4)	0.1565

Table 3: The relationships between participants believe in utilizing e-books fortheir continuing professional development (CPD)

Perceived barriers	**Save time for researching**	**Relation to clinical fields**
Readers of different e-books		
Lack of free time		
1st issue (n=60)	0.047 (-0.186~0.281)	-0.143 (-0.374~0.088)
2nd issue (n=90)	0.305 (0.134~0.475)	-0.013 (-0.190~0.162)
3rd issue (n=90)	0.328 (0.148~0.507)	-0.022 (-0.199~0.155)
4th issue (n=80)	0.005 (-0.180~0.190)	-0.177 (-0.349~ -0.005)
Offered courses in English only		
1st issue (n=60)	-0.001 (-0.234~0.234)	0 (-0.234~0.234)
2nd issue (n=90)	-0.183 (-0.365~ -0.001)	-0.177 (-0.349~ -0.005)
3rd issue (n=90)	0.099 (-0.075~0.273)	-0.103 (-0.278~0.072)
4th issue (n=80)	0.010 (-0.174~0.195)	-0.269 (-0.441~ -0.097)
Courses not related to clinical fields		
1st issue (n=60)	-0.221 (-0.456~0.015)	0.145 (-0.087~0.377)
2nd issue (n=90)	0.094 (-0.081~0.270)	0.084 (-0.091~0.260)
3rd issue (n=90)	0.079 (-0.094~0.252)	0.183 (0.003~0.362)
4th issue (n=80)	0.030 (-0.153~0.213)	0.348 (0.152~0.543)

production were related to the authors' work and the editing process. Furthermore, the evaluation of the e-book's learning outcomes was conducted using The New Model, which consists of four levels: reactions, learning, behaviors, and results. In the current wor, we discovered that the e-book had impacts at all four levels of learning, which expands on previous studies that only examined the lower levels.[23,24] The e-book was successfully integrated as a new Continuing Education (CE) activity, reaching CLSs from various laboratory backgrounds. A key finding of our study was that the majority of readers had positive learning experiences and improved learning outcomes, including increased knowledge acquisition and behavioral changes, after using the e-book. Unlike previous investigations that generally assessed the effectiveness of e-learning,[29–31] our study specifically evaluated whether the e-book could lead to effective learning outcomes in the field of laboratory Sciences. Additionally, we explored different learning facilitators associated with the e-book, demonstrating how this innovative educational approach could have diverse effects on participants' learning experiences. One notable result from our study was the inverse relationship between information overload and the frequency of CPD participation. To address this, we ensured that the e-book's articles contained the latest information in a concise and easily digestible format, which was well-received by readers, leading to positive feedback and high scores on corresponding questions. This approach aligns with cognitive load theory, which recommends presenting information concisely to minimize cognitive strain. Findings on e-learning education were consistent with previous studies,[29–31] showing that it can yield results comparable to traditional CE at Kirkpatrick's Levels 1 to 3. However, e-learning has an advantage in clinical settings due to its ability to overcome access barriers for healthcare professionals under various circumstances, leading to more effective achievement of organizational goals.[32–34] One significant factor contributing to positive changes in organizational impact was that the e-book did not require participants to possess high levels of information technology literacy. Additionally, offering the e-book for free likely increased participants' commitment to the program and positively influenced participant attrition. Importantly, similar to a study in Chile,[34] our e-learning CE activity was implemented systematically and successfully achieved Kirkpatrick's four levels of organizational change as part of the CE program. Furthermore, our study identified language barriers as significant obstacles hindering non-native English speakers from accessing updated knowledge in CPD programs. The study found a significant negative relationship between language barriers and CPD participation frequency. Language barriers are a common challenge faced by non-native speakers, including healthcare professionals in various regions such as Asian countries,[35,36] Oceania,[37] and several European countries.[38–40] These language barriers pose significant obstacles to healthcare professionals' ability to engage effectively in learning. As a result, it is appropriate to offer language support to professionals stressed with language barriers in the short term. However, in the long term, further research and discussions are necessary to find a more comprehensive solution to address this issue.

4. Study Limitations

Our study has certain limitations. It was designed as a cross-sectional study without a control group, which prevented us from assessing the effectiveness of our e-learning model in comparison to traditional methods. Moreover, we did not endeavor to determine if our model was more effective than other approaches. Instead, the primary focus of this study was to develop a low-cost e-learning model for medical technologists and investigate how they perceived the e-book.

5. Conclusion

A cross-sectional analysis, revealed the successful utilization of a low-cost and learner-focused e-book in overcoming various learning obstacles for CLSs in Continuing Education (CE). The interactive and adaptable nature of e-learning proved particularly beneficial in encouraging learners to actively participate in clinical scenarios related to laboratory Sciences. Given the growing prominence of e-learning, our findings hold the potential to guide educators in constructing e-learning framework tailored to meet the needs of professionals in CE.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Cite this article: Al Mohsen Z, Alqassab HA. Utilization of e-books to enhance self-directed learning for clinical laboratory science specialists. *J Educ Technol Health Sci* 2023;10(2):35-41.