

Development of an Electronic Book on Information Technology for Students at Chongqing College of International Business and Economics, China

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Abstract

The objectives of this study were (1) to develop an electronic book (e-book) on Information and Communication Technology (ICT) for students at Chongqing College of International Business and Economics and evaluate its efficiency based on the 80/80 criterion, (2) to compare the academic achievement of students learning through the e-book with those taught via traditional methods, and (3) to investigate students' interest and attitudes toward e-book-based learning. The research employed a quasi-experimental design with an experimental and a control group. The population consisted of 150 students, and a purposive sample of 80 students was selected and divided equally into two groups. The research instruments included the developed e-book, lesson plans, achievement tests, and an attitude questionnaire. Data were analyzed using mean, standard deviation, efficiency index (E_1/E_2), and independent samples t-test. The results revealed that the e-book reached an efficiency of $E_1/E_2 = 82.06/80.11$, exceeding the 80/80 criterion. Students in the experimental group achieved significantly higher post-test scores than the control group at the .05 level. Furthermore, students demonstrated a high level of positive attitude ($\bar{x} = 4.06$) toward the innovation. The study concludes that the e-book is a highly effective tool for enhancing ICT learning outcomes and fostering independent learning habits.

Keywords: Electronic Book (E-Book), Information and Communication Technology (ICT), Instructional Efficiency, Academic Achievement, Student Attitudes, Quasi-Experimental Design, Chongqing College

Introduction

The integration of electronic books (e-books) into higher education reflects broader shifts toward digital and self-directed learning environments. Early research on e-book technology emphasized its potential to support multimedia integration and interactive navigation beyond traditional print formats (Barker, 1992; Shiratudin et al., 2001). In technology-mediated learning environments, digital materials can enhance learner engagement and cognitive processing when designed according to sound instructional principles (Simon, 2002; Wilson, 2003).

From a cognitive perspective, multimedia learning environments must carefully balance visual, textual, and interactive elements to avoid cognitive overload while enhancing comprehension (HyunSeung, 2011). Moreover, constructivist approaches suggest that learner-controlled navigation and branching structures promote deeper conceptual understanding by allowing students to actively construct knowledge (Collis, 1991; Rinaldi, 1997). Therefore, the development of an ICT-specific e-book requires more than technological assembly; it demands theoretical alignment with principles of instructional sequencing, interactivity, and learner autonomy.

This study develops and evaluates an ICT e-book grounded in instructional design principles and examines its effectiveness through efficiency indices, achievement comparison, and attitudinal measures among students at Chongqing College of International Business and Economics.

Research Methodology

This study utilized a quasi-experimental research design with a non-equivalent pre-test and post-test two-group design (experimental group and control group), focusing on quantitative data collection and analysis. This design was selected to evaluate the comparative effectiveness of the developed ICT e-book against conventional lecture-based instruction while controlling for pre-existing group differences through pre-test score comparison (Cohen et al., 2018; Creswell, 2018). Both groups were administered a pre-test prior to the instructional intervention to establish baseline equivalence, and a post-test was administered after 18 hours of instruction to measure learning outcomes. The study addressed three research objectives: (1) evaluating the instructional efficiency of the e-book using the 80/80 criterion, (2) comparing academic achievement between the experimental and control groups, and (3) investigating students' interest and attitudes toward e-book-based learning.

Population and Sample: The target population consisted of all 150 first-year undergraduate students enrolled in the Information Technology course at Chongqing College of International Business and Economics during the first semester of the 2024 academic year, drawn from five intact classroom sections. Purposive sampling was employed to select 80 students from two sections that had comparable academic backgrounds and equivalent access to computer laboratory facilities. Pre-test scores were compared between groups using an independent samples t-test prior to the intervention; no statistically significant difference was found ($t(78) = 0.84, p = .40$), confirming baseline equivalence. The 80 selected students were assigned to an experimental group ($n = 40$, 22 female, 18 male) and a control group ($n = 40$, 21 female, 19 male). The experimental group learned through the developed ICT e-book, while the control group received conventional instruction using lecture-based delivery and presentation software over the same 18-hour instructional period.

Instructional Innovation: The researcher developed an ICT e-book using the Desktop Author program (version 3.0), following a systematic instructional design process grounded in Barker's (1992) e-book development model and Collis's (1991) evaluation framework. The e-book was organized into five thematic learning units: (1) Computer Principles, (2) Role of Computers in Society, (3) Technology Trends, (4) Data and Information Management, and (5) Information Systems. Each unit incorporated multimedia elements including text, diagrams, animated illustrations, embedded exercises, and pop-up feedback mechanisms. The e-book was designed with a non-linear "branching" navigation structure allowing students to access content in a self-directed sequence based on their interests and learning pace, consistent with constructivist principles of learner autonomy and self-regulated learning (Collis, 1991; Rinaldi, 1997). The completed e-book was reviewed by five subject-matter experts in educational technology and ICT instruction prior to the pilot study; all five units received mean appropriateness ratings above 4.00 on a 5-point scale, confirming content suitability and instructional alignment.

Research Instruments: Three research instruments were employed. (1) Nine lesson plans were developed for both the e-book and conventional instructional methods, each covering the same ICT content across the five learning units (18 instructional hours in total, 2 hours per unit with additional review sessions). All lesson plans were validated by three educational technology experts and received IOC values of 0.80 or above. (2) A 50-item multiple-choice achievement test (4 options each, total score = 50 marks) covering all five ICT content units was developed to measure students' academic achievement. The test was

validated for content validity through expert review ($IOC \geq 0.60$ for all items), then piloted with 30 students from a comparable course section. Item analysis yielded difficulty indices (p) ranging from 0.63 to 0.78 and discrimination indices (r) ranging from 0.22 to 0.38, both within acceptable ranges. The overall reliability of the test was confirmed using $KR-20 = 0.70$, meeting the minimum reliability threshold. (3) A 30-item attitude questionnaire using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) was developed to measure students' interest and attitudes toward e-book-based learning across three dimensions: cognitive engagement, affective response, and perceived learning effectiveness. The questionnaire was validated by five experts ($IOC \geq 0.60$) and piloted with 30 students, yielding a Cronbach's Alpha coefficient of 0.88, confirming strong internal consistency.

Data Collection and Analysis: All data were collected and analyzed using SPSS Version 26.0. A pre-test was administered to both groups prior to the intervention to confirm baseline equivalence. Both groups then received 18 hours of instruction across nine lesson sessions over nine weeks. The experimental group used the ICT e-book as the primary instructional medium, while the control group received conventional lectures delivered with presentation software. A post-test was administered to both groups upon completion of the instructional period. The efficiency of the e-book was calculated using the E_1/E_2 formula: E_1 represents the mean percentage score of students' in-process performance across all five learning unit exercises, and E_2 represents the mean percentage score on the final post-test. The standard criterion of 80/80 was applied. Academic achievement differences between the two groups were tested using an independent samples t-test at the .05 level of statistical significance, with Levene's test for equality of variances applied prior to interpretation. The attitude questionnaire was administered to the experimental group after the instructional intervention, and data were analyzed using mean and standard deviation, interpreted against a five-level scale (1.00–1.80 = Very Low; 1.81–2.60 = Low; 2.61–3.40 = Moderate; 3.41–4.20 = High; 4.21–5.00 = Very High).

Result

The findings of the study are presented in response to the three research objectives, incorporating both descriptive and inferential statistical outcomes.

1. Efficiency of the Electronic Book (E_1/E_2) — Research Objective 1: The analysis revealed that the ICT e-book achieved high instructional efficiency, meeting Research Objective 1. The process efficiency (E_1), calculated from students' mean percentage scores across all five in-unit exercise sets, was 82.06%. Unit-level E_1 scores ranged from 80.40% (Unit 3: Technology Trends) to 84.20% (Unit 1: Computer Principles), indicating consistently strong in-process performance across all content areas. The product efficiency (E_2), based on the mean percentage score of experimental group students on the final post-test, was 80.11%. The resulting efficiency index of $E_1/E_2 = 82.06/80.11$ successfully exceeded the 80/80 efficiency criterion established in the research hypothesis (Pantudhong, 1997), confirming that the developed ICT e-book is both instructionally efficient and suitable as a standalone learning material for higher education students.

2. Comparison of Academic Achievement — Research Objective 2: A statistically significant difference in post-test academic achievement was found between the two instructional groups, directly addressing Research Objective 2. Prior to the intervention, no significant difference existed between the groups' pre-test means (Experimental: $\bar{x} = 24.35$, S.D. = 3.41; Control: $\bar{x} = 24.78$, S.D. = 3.58; $t(78) = 0.84$, $p = .40$), confirming baseline equivalence. Following the 18-hour instructional intervention, students who learned through the e-book achieved a significantly higher post-test mean score ($\bar{x} = 40.06$, S.D. = 2.74) compared to the control group taught via traditional methods ($\bar{x} = 30.60$, S.D. = 5.09). An independent samples t-test confirmed this difference was statistically significant

($t(78) = 11.26, p < .001$, two-tailed), well exceeding the .05 significance level. Levene's test for equality of variances indicated unequal variances ($F = 9.43, p = .003$); therefore, the Welch-corrected t-test statistic was applied. The effect size was very large (Cohen's $d = 2.32$), indicating that the e-book produced educationally substantial gains in ICT achievement beyond statistical significance alone. The mean gain score of the experimental group ($\Delta M = 15.71$) was markedly higher than that of the control group ($\Delta M = 5.82$), further demonstrating the instructional superiority of the e-book approach.

3. Student Attitudes Toward the e-Book — Research Objective 3: Students in the experimental group expressed a consistently positive attitude toward e-book-based learning, addressing Research Objective 3. The overall attitude mean was 4.06 (S.D. = 0.75), classified as "High" on the five-level interpretation scale. At the dimension level, Perceived Learning Effectiveness yielded the highest mean ($\bar{x} = 4.28, S.D. = 0.61$, classified as "Very High"), followed by Cognitive Engagement ($\bar{x} = 4.11, S.D. = 0.68$, "High") and Affective Response toward ICT Learning ($\bar{x} = 3.98, S.D. = 0.82$, "High"). At the item level, students most strongly agreed that the e-book provides deeper knowledge of ICT ($\bar{x} = 4.70, S.D. = 0.52$), serves as an engaging medium that stimulates learning interest ($\bar{x} = 4.60, S.D. = 0.58$), and helps develop thinking skills ($\bar{x} = 4.53, S.D. = 0.61$). The lowest-rated item was "I feel confident using the e-book independently without teacher guidance" ($\bar{x} = 3.72, S.D. = 0.91$), suggesting that while attitudes were broadly positive, some students still valued instructor support during self-directed digital learning. These results collectively confirm that the ICT e-book was well-received by students and successfully fostered positive learning attitudes aligned with Research Objective 3.

Discussion and conclusions

The findings of this study confirm that the developed ICT e-book successfully addressed all three research objectives. With respect to Research Objective 1, the e-book exceeded the 80/80 efficiency criterion ($E_1/E_2 = 82.06/80.11$), demonstrating that the instructional materials meet the standard for effective and well-designed digital learning resources (Pantudhong, 1997). With respect to Research Objective 2, students in the experimental group achieved significantly higher post-test scores ($\bar{x} = 40.06, S.D. = 2.74$) than the control group ($\bar{x} = 30.60, S.D. = 5.09$), as confirmed by the independent samples t-test ($t(78) = 11.26, p < .001$, Cohen's $d = 2.32$). With respect to Research Objective 3, students demonstrated a high level of positive attitude toward e-book-based learning ($\bar{x} = 4.06, S.D. = 0.75$). Rather than viewing these outcomes merely as evidence of technological novelty, they should be interpreted through the lens of established instructional, cognitive, and constructivist learning theories that informed the e-book's design.

First, the efficiency outcome ($E_1/E_2 = 82.06/80.11$) reflects the effectiveness of structured instructional sequencing in the e-book's design, directly addressing Research Objective 1. The design aligned with systematic presentation of learning objectives, scaffolded practice, and cumulative reinforcement across five progressively complex content units. Such sequencing is consistent with principles of structured instructional design and staged cognitive progression (Rinaldi, 1997; Barker, 1992). By organizing ICT content from foundational Computer Principles through to advanced Information Systems, the e-book reduced conceptual fragmentation and facilitated cumulative knowledge building. The unit-level E_1 scores, ranging from 80.40% to 84.20%, indicate that students consistently engaged with and performed well across all five content areas, confirming that the instructional sequencing was both pedagogically appropriate and practically executable within the allocated learning time.

Second, the statistically significant improvement in post-test achievement (Experimental: $\bar{x} = 40.06$ vs. Control: $\bar{x} = 30.60$; $t(78) = 11.26, p < .001$; Cohen's $d = 2.32$), addressing Research Objective 2, can be interpreted through learner control and interactive

design mechanisms. Research on electronic books demonstrates that non-linear branching navigation enables students to regulate their own learning pace, revisit challenging concepts, and reinforce partial understanding through repeated practice, collectively enhancing mastery learning outcomes (Barker & Manji, 1991; Collis, 1991). Unlike the fixed, unidirectional pace of conventional lecture delivery, learner-controlled environments facilitate differentiated cognitive processing, allowing students with varying prior knowledge levels to engage with content at an appropriate depth and speed. The significantly larger mean gain of the experimental group ($\Delta M = 15.71$) compared to the control group ($\Delta M = 5.82$) further underscores that the interactive, self-paced structure of the e-book produced a qualitatively different learning trajectory than traditional instruction could provide within the same instructional duration.

Third, the positive student attitudes ($\bar{x} = 4.06$, S.D. = 0.75, overall “High”; Perceived Learning Effectiveness $\bar{x} = 4.28$, “Very High”), addressing Research Objective 3, align with multimedia engagement theory and cognitive design principles. When digital learning materials coherently integrate text, visuals, interactive exercises, and embedded feedback, they simultaneously increase learner attention, sustain motivation, and reduce cognitive disengagement (Simon, 2002; Wilson, 2003). The item-level attitude results—with highest scores for perceived depth of ICT knowledge ($\bar{x} = 4.70$) and stimulation of learning interest ($\bar{x} = 4.60$)—reflect that the e-book successfully created an affectively engaging learning environment beyond mere content delivery. However, the effectiveness of multimedia integration depends critically on cognitive balance. The structured layout, consistent visual hierarchy, and coherently paced interactive quizzes of the developed e-book minimized extraneous cognitive load while preserving germane load, enabling students to allocate available working memory toward genuine conceptual understanding rather than interface navigation (HyunSeung, 2011). The positive attitude results should therefore be interpreted as an outcome of effective cognitive and pedagogical design rather than mere aesthetic novelty. Moreover, the reinforcement mechanisms embedded within the e-book’s quizzes and pop-up feedback features reflect applied behaviorist principles that complement its constructivist architecture. Immediate, specific feedback on exercise responses functions as positive reinforcement for correct answers, strengthening accurate knowledge associations and increasing the likelihood of sustained engagement with subsequent content units (Rinaldi, 1997). For incorrect responses, corrective feedback directs students’ attention to specific conceptual gaps, enabling targeted remediation before progression. This combination of positive reinforcement and corrective guidance created a low-stakes, self-correcting learning environment that is particularly well-suited to independent digital study in higher education contexts where instructor supervision during self-directed learning sessions may be limited.

Importantly, the branching navigation structure aligns with constructivist perspectives on active knowledge construction. Allowing students to explore ICT content non-linearly and revisit units based on individual learning needs supports autonomy, self-regulated learning, and metacognitive awareness—competencies that are essential for sustained ICT skill development in professional contexts (Shiratudin et al., 2001). The lowest-rated attitude item (“I feel confident using the e-book independently without teacher guidance,” $\bar{x} = 3.72$) suggests that while the branching structure was positively received, some students still valued instructor scaffolding during self-directed digital learning phases. This finding indicates a productive avenue for future instructional design: integrating hybrid facilitation models in which instructor-guided sessions complement, rather than replace, the autonomous branching capabilities of the e-book, maximizing both learner agency and instructional support.

To synthesize these theoretical interpretations, the effectiveness of the e-book across all three research objectives arises from the deliberate interaction among three mutually reinforcing theoretical mechanisms:

1. Instructional sequencing (structured progression of content)
2. Cognitive optimization (balanced multimedia integration)
3. Learner autonomy and reinforcement (branching and feedback)

These three mechanisms collectively and synergistically explain why the e-book achieved instructional efficiency exceeding the 80/80 criterion ($E_1/E_2 = 82.06/80.11$), generated significantly higher academic achievement compared to conventional instruction (Cohen's $d = 2.32$), and produced consistently positive student attitudes ($\bar{x} = 4.06$) toward ICT learning. No single mechanism operating in isolation would be sufficient; it is their theoretical and practical integration within the e-book's design that produced these multi-dimensional learning outcomes.

In conclusion, this study successfully addressed all three research objectives. The developed ICT e-book demonstrated instructional efficiency surpassing the 80/80 standard ($E_1/E_2 = 82.06/80.11$), confirming Objective (1) Students learning through the e-book achieved significantly higher post-test scores than those taught via conventional methods ($t(78) = 11.26$, $p < .001$; Cohen's $d = 2.32$; Experimental $\bar{x} = 40.06$ vs. Control $\bar{x} = 30.60$), confirming Objective (2) Students demonstrated a high level of positive attitude toward e-book-based learning ($\bar{x} = 4.06$), with perceived learning effectiveness rated at a Very High level ($\bar{x} = 4.28$), confirming Objective (3) These outcomes collectively demonstrate that the ICT e-book represents a theoretically grounded and empirically validated instructional innovation whose success lies not in technological sophistication alone, but in its structured alignment of instructional sequencing, cognitive optimization, and learner-centered interactivity. This study contributes to the growing body of e-book research by empirically validating the theoretical synergy among instructional design, multimedia cognition, and autonomous learning within vocational higher education contexts in China, offering a replicable model for ICT instructional material development in comparable institutional settings.

Suggestion

1. Recommendations for Educational Practice:

Infrastructure Preparation: Schools and colleges should prioritize the preparation of computer facilities and high-speed internet to ensure that students can access e-books smoothly. The technical environment must be "e-book ready" to prevent delays that could hinder student motivation.

Shift in Teacher Roles: Instructors should transition from being primary information providers to "facilitators" who guide students through digital resources. Teachers should interact more frequently with students during e-book sessions to exchange knowledge and provide deeper contextual understanding.

Student Training and Accountability: Before implementing e-book learning, teachers must explain how to use the specific features of the program. It is also essential to cultivate a sense of "honesty and responsibility" in students, as independent learning requires high self-discipline to be effective.

Resource Portability: Institutions should consider making digital copies of e-books available for students to take home. This extends the learning environment beyond the classroom, allowing for continuous review and self-study.

2. Recommendations for Future Research:

Expansion Across Disciplines: Further research should explore the application of e-book-based instruction in other subjects beyond ICT, such as social sciences or humanities, to determine if the benefits of this model are universal or subject-dependent.

Longitudinal Studies: Subsequent studies should investigate the long-term retention of knowledge gained through e-books compared to traditional methods by conducting follow-up tests several months after the initial intervention.

Enhanced Multimedia Integration: Researchers should study the effects of incorporating more advanced multimedia formats, such as immersive 3D simulations or Augmented Reality (AR) within e-books, to further stimulate interest and cater to digital-native students.

Large-Scale Implementation: Future studies should consider larger and more diverse sample sizes (e.g., 1:100 field trials) across different provinces in China to enhance the generalizability of these findings.

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