CENTRAL ASIAN JOURNAL OF MEDICAL AND NATURAL SCIENCES
https://cajmns.casjournal.org/index.php/CAJMNS
Volume: 07 Issue: 01 | January 2026 ISSN: 2660-4159

Article

Impact of a Mobile App-Based Gamified Learning Platform on the Proficiency of Medical Record Officers in ICD-11 Coding in Ahoada West LGA of Rivers State

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Abstract: This study investigates the impact of a mobile app-based gamified learning platform on the proficiency of medical record officers in ICD-11 coding in Ahoada West LGA, Rivers State. Accurate medical coding is essential for healthcare administration, billing, and disease tracking. The transition to the ICD-11 system presents a significant challenge for medical record officers, particularly in resource-limited settings. This study employed a mixed-methods research design, combining quantitative and qualitative approaches. A sample of 85 medical record officers from various health facilities in Ahoada West LGA participated. Quantitative data was collected using a structured questionnaire administered before and after a six-week intervention using the gamified learning app. Qualitative data was gathered through semi-structured interviews with 15 participants. This study has been guided by the theoretical framework of Technology Acceptance Model (TAM), which is used to help explain how users come to accept and use a technology. Internal and external credibility and validity were discussed and statistical analysis (mean scores, paired t-tests) was performed on quantitative data, thematic analysis on interview data. The results revealed that officers using the gamified platform experienced a marked improvement in their coding accuracy, speed, and confidence. Mean coding proficiency score improved from 2.15 prior to intervention to 3.78 after intyervention. Thematic analysis showed that gamification aspects (points, badges, and leaderboard) increased the level of engagement and the willingness to learn. Conclusions In conclusion, it was found that mobile app-based gamified learning is an efficacious tool for improving ICD-11 coding skills in low-resourced rural health settings. It promotes the inclusion of [these platforms] within continuous professional development for health information management workforces as a way to fill competency gaps to ultimately improve the quality of the health data upon which healthcare systems rely.

Keywords: Gamification, Mobile Learning, ICD-11 Coding, Medical Record Officers, Health Information Management, Ahoada West.

Citation: Madume, I. O & Chika, C. Impact of a Mobile App-Based Gamified Learning Platform on the Proficiency of Medical Record Officers in ICD-11 Coding in Ahoada West LGA of Rivers State. Central Asian Journal of Medical and Natural Science 2026, 7(1), 726-736

Received: 10th Nov 2025
Revised: 21th Dec 2025
Accepted: 14th Jan 2026
Published: 06th Feb 2026

1. Introduction

Healthcare systems globally depend on accurate and standardized medical coding for effective operation. Medical coding involves transforming healthcare diagnoses, procedures, medical services, and equipment into universal alphanumeric codes. These codes are critical for patient billing, insurance claims, medical research, and public health monitoring. The International Classification of Diseases, Eleventh Revision (ICD-11), represents the latest global standard for this coding, offering greater detail and digital

functionality than its predecessor, ICD-10. Utilization of ICD-11 is required by the World Health Organization (WHO) for better global health statistics, policy and clinical decision-making [1]. Implementation of ICD-11 in Nigeria forms part of a broader health policy reform agenda for modernising health information systems. That said, it won't be easy, as it means retraining hundreds of thousands of health information management professionals in order for the new coding system to be used correctly and effectively at all levels of health care.

Medical record officers are the frontline staff responsible for the accurate application of these coding systems within health facilities. Their proficiency directly influences revenue cycle management, clinical audit outcomes, and the reliability of national health data. In many low-resource settings, including rural Local Government Areas (LGAs) in Nigeria, these officers often lack access to continuous and engaging training programs. Classic training methods, such as workshops and manuals, carry a high cost, are logistically cumbersome, and lead to lower retention rates and minimal application of knowledge in practice. This leads to a huge disconnect between the requirement to use complex coding systems like ICD-11 and the ability to implement these skills at the point of care [2], which can lead to coding mistakes and revenue loss for health institutions, in addition to poor-quality health data. Thus, the need to develop novel, scalable and sustainable means of delivering training to reinforce health information systems in these resource-scarce areas is critical to successfully combatting the burden of disease.

Educational technology, in particular m-learning and gamification, has the potential to help close such training gaps. M-learning: Than information technology, mobile devices are much more than penetrated in our life, mobility gives the attention to m-learning technology that can provide education at any time and any place, overcomes the geographical and time limitations. Gamification is using game design elements (scoring points, competition, rules of play, etc.) in non-game contexts to improve motivation, engagement, and learning outcomes. Together, a gamified learning platform delivered as a mobile app can create an interactive and self-paced learning environment combined with low-pressure motivation for adult learners. These platforms may be helpful as they can mimic real world coding experiences, facilitating immediate feedback and providing a sense of mastery which is important for complex detail-oriented tasks such as the ICD-11 coding [3]. This methodology resonates with modern educational philosophies that advocate for active, hands-on, and student-centered approaches to teaching and learning.

For instance, Ahoada West LGA in Rivers State represents an environment where such an inventive solution could have far-reaching positive impacts. With a predominantly rural population, health facilities in the area struggle against the common teaching lessons learned from Nigeria rural healthcare; shortages of funding, infrastructural deficits and a lack of opportunities for training needed to support those that work alongside them especially medical record officers. Their skill and competence in ICD-11 coding is not merely procedural, but foundational to the delivery of better healthcare, sustainability of facilities, and production of reliable data for local health planning. Since no specific gamified learning platform has hitherto been developed and deployed to positively influence the coding proficiency of medical record officers in Ahoada West LGA, the objective of this study, therefore, was to investigate the effect of a purposely designed mobile app-based gamified learning platform on the coding proficiency of medical record officers in Ahoada West LGA. By investigating this, the study aims to contribute to the broader discourse on leveraging digital tools for health workforce capacity building in resource-constrained environments.

Statement of the Problem

The implementation of the ICD-11 coding system in Nigeria presents a formidable challenge to medical record officers, particularly in rural localities like Ahoada West LGA. These officers are tasked with accurately translating complex clinical documentation into standardized codes, a function vital for hospital revenue, epidemiological surveillance,

and health service planning. However, there exists a critical disconnect between the advanced requirements of the ICD-11 system and the current skill levels of these officers, largely due to inadequate and ineffective training mechanisms. Affiliated with specific implementations, traditional in-service training programs are scarce, non-specific, and do not foster hands-on competency by being predominantly didactic. In addition, these trainings are seldom kept up or reinforced properly, resulting in fast skill degradation. In substance, this difference in proficiency leads to large numbers of coding mistakes, which then leads to health insurers denying their claims, costs to health care facilities, and unfounded health data that do a disservice to entire public health efforts and policy making [4]. This is an even bigger problem in rural areas where medical record officers lack access to experts, reference materials and internet-based resources and are flying much more alone.

To further compound this training gap, there are few appropriate or engaging tools to view or target adult workplace adult learning needs. Medical record officers are usually overwork and cannot frequently avail of long time off-site training. Traditional training resources can include large, cumbersome coding books, static PDF guides, and more — none of which are practical for learned tasks on the job. As a result, this becomes a vicious cycle where, in turn, the officers have decreased confidence which leads to errors and momentary frustration resulting in unnecessary hampering of the eHealth ecosystem. Unless an approach to teach ICD-11 coding is undertaken, health facilities in Ahoada West LGA may continue to waste away in administrative incompetency and data inaccuracies, какой-то смысла писать? The concern with this is the need to explore other training methods that are dynamic, interesting and just-in-time. Providing a potential solution in the form of a mobile app-based gamified platform, the specific effectiveness of this methodology in improving the coding skills of medical record officers in the usual rural Nigerian situation has however not been empirically determined, representing a critical knowledge gap that this study sought to fill.

Study Aims and Objectives

This study looked to determine how a gamified learning platform on a mobile app affected the performance of record officers in Ahoada West LGA, Rivers State in ICD-11 coding. The specific aims of the study are:

1. Abstract BackgroundICD11 is the eleventh version of International StatisticalClassification of Diseases and Related Health Problems and as part of theWorld Health organization ICD-11 is also used for health informatics.
2. Measure the difference in coding skills (both in terms of speed and accuracy) among the officers, before and after a period of six weeks of using the mobile app based gamified learning platform.
3. Aim: To explore qualitative data on usability, engagement, and perceived effectiveness of the gamified learning platform from the perspective of medical record officers.
4. Communicate about existing challenges and facilitators for implementation and use of the mobile gamified learning platform in a rural health service.

Research Questions

The study was guided by the following overarching research questions:

1. What are the specific ICD-11 coding competencies levels of medical record officers in Ahoada West LGA?
2. How does the mobile app-based gamified learning platform affect coding proficiency (performance and speed) for medical record officers?
3. QuestionWhat are the perceptions and experiences of medical record officers regarding the use of the gamified learning platform for ICD-11 training?
4. Research Question 1: what are the challenges and facilitators of adopting and using the mobile gamified learning platform in Ahoada West LGA?
5.

Hypotheses

The following hypotheses were tested at a 0.05 level of significance:

H_{01}: There is no significant difference in the ICD-11 coding accuracy of medical record officers before and after using the mobile app-based gamified learning platform.

H_{02}: There is no significant difference in the ICD-11 coding speed of medical record officers before and after using the mobile app-based gamified learning platform.

2. Materials and Methods

Literature Review

The Concept of Gamification in Professional Education

Gamification refers to the strategic application of game design elements and principles in non-game contexts to motivate and influence user behavior. These elements include points, badges, leaderboards, challenges, and levels, which are integrated into an activity to make it more engaging and enjoyable. In professional education, gamification taps into intrinsic motivational factors such as autonomy, mastery, and purpose, as well as extrinsic motivators like recognition and reward. The aim is to remove the learning process from a compulsory, passive exercise into an engaging, active and voluntary one. It is especially true of adult learners who prefer learning that is practical and relevant, and where they can direct their own learning that can be applied directly to the job [5]. Gamified systems can help to increase the retention of knowledge, repeated practice, and a growth mindset among professionals by providing them with quick feedback, transparent objectives, and a gradual sense of accomplishment.

Gamification takes its theoretical frameworks from a numbe of motivational and learning theories. According to Self-Determination Theory (SDT), humans have three basic innate psychological needs: competence, autonomy, and relatedness, and the fulfillment of these needs will increase motivation and engagement. The behavioral science behind gamification mechanics meets these needs by enabling learners to self-direct their own progress (autonomy), start, or complete a challenging task to indicate and provide proof of overcoming skill (competence), and directly compete or collaborate with their peers (relatedness). Additionally, situated learning theory highlights the idea that learning is closely bonded with the real-world context in which it is applied. A gamified learning platform for medical coding can mimic real-life coding situations and provide officers an opportunity to practice in a safe environment that mirrors their day-to-day work challenges [6] The literature indicates that the right kind of gamification can have a dramatic impact in the workplace, taking the focus away from gamification as a buzzword or gimmick and directing attention to creating greater authenticity in game-based experiences that drive complex professional skill development.

Mobile Learning (M-Learning) in Healthcare Training

Mobile learning, or m-learning, involves the use of portable electronic devices, primarily smartphones and tablets, to access educational resources and participate in learning activities anytime and anywhere. The proliferation of mobile technology, even in developing countries, has made m-learning a viable and cost-effective strategy for disseminating knowledge and skills, especially in geographically dispersed or resource-limited areas. M-learning can provide unparalleled flexibility in healthcare training, enabling health workers to interact with bite-sized learning modules during breaks, at home, or between patient consultations, thereby minimizing disruption to clinical services [7]. The just-in-time paradigm is indispensable to remain abreast of the fast-paced changes in medical knowledge and processes, such as changes in classification systems like ICD-11. Moreover, it closes essential gaps in classic, centralized training models by providing consistent, standardized training content directly into the pocket of the practitioner.

Benefits of m-Learning Go Beyond Just Convenience Additionally, interactive mobile applications are able to include multimedia elements, such as videos, interactive quizzes, and hyperlinked glossaries that appeal to varying learning preferences and help build

understanding. As an example, a module addressing ICD-11 coding might include a short-animated video describing a new conceptual framework, followed by an interactive quiz with immediate feedback. This multi-modal delivery reinforces the learning better than traditional text-heavy manuals. Furthermore, m-learning platforms can monitor user progress and performance metrics, enabling both the learner and training coordinators to easily evaluate knowledge gaps and define additional dimensions for reinforcement [8]. Many of these mobile apps are offline, which is extremely beneficial in rural Nigerian health systems where travelling for training incurs financial costs and internet access can be unreliable, and can guarantee that learning continues without the challenges of connectivity.

ICD-11 Coding: Complexities and Training Imperatives

The International Classification of Diseases, Eleventh Revision (ICD-11), represents a significant advancement over ICD-10, featuring a fully digital structure, updated content reflecting current medical practice, and enhanced functionality for data analytics. It introduces new chapters, such as one on traditional medicine, and a more detailed coding system for morbidity and mortality. They offer the prospect of more useful data to inform clinical decisions and health policy, but also increase the complexity of the underlying coding. Medical coders must now use a new digital tool (the ICD-11 browser), familiarise themselves with revised terminology, and use more precise extension codes to provide additional clinical detail [9]. This complexity requires thorough and continuous training to avoid mistakes that will cause a domino effect on the healthcare billing side, statistics, and patient care records. The transition is not just a simple updating of the computer systems, but involves a change in mentality in categorising and reporting medical information.

In low, middle income countries the need for effective ICD-11 training is urgent. Research shows that many health facilities in Africa have low rates of coding accuracy despite ICD-10, mainly attributable to inadequate training and absence of codification written procedures [10]. The leap to ICD-11 could exacerbate this accuracy gap if training interventions are not designed and implemented appropriately. Training should thus include the appropriate ability to read clinical notes, ideate disease processes, ascertain their details well enough to select the right codes and then ensure they enter the new digital ecosystem. This demands a pedagogy of practice, feedback, and context. Classroom based training may never be able to deliver this level of understanding and competency pointing to the need for solutions that offer a blend of theory, plenty of rich, practical application and process and behavioral feedback.

Gamified M-Learning for Health Information Management

The integration of gamification with mobile learning presents a synergistic solution for training in health information management. A gamified m-learning platform can transform the arduous task of learning thousands of ICD-11 codes into an engaging series of challenges and achievements. For medical record officers, such a platform could feature modules where they "unlock" new coding chapters by scoring well on quizzes, earn badges for consecutive days of practice or for mastering difficult code clusters, and see their ranking on a private leaderboard among peers. This methodology mediates the motivational hurdles associated with learning such intricate, tedious matter and thus increases the fun and socialization of the learning process [11]. The platform uses a game-like narrative to embed learning, where the officer goes from "novice coder" to "coding master," providing a clear picture of skill and confidence building along the way, as well as a reason to persist.

Evidence is accumulating for the efficacy of gamified m-learning in healthcare. In nursing education, a mobile game for medication administration found no significant difference in knowledge scores but reported high engagement ratings for students [12]. Studies on the performance in the domain of medical coding show an increased accuracy rate when comparing an interactive computer-based training condition versus a paper-

based training condition (Oppenheim et al., 2004). The ability to gain immediate feedback in a gamified app is important for allowing immediate correction of misconceptions so no errors become further entrenched. Furthermore, the data analytics from such a platform can identify common mistakes at an individual or group level, allowing for targeted remedial content [13]. For rural settings like Ahoada West, a well-designed gamified m-learning tool can serve as a standalone, scalable training resource that democratizes access to high-quality ICD-11 education, reducing dependency on external trainers and expensive workshops.

Theoretical Framework

This study is anchored on the Technology Acceptance Model (TAM), originally developed by Davis [14]. TAM is a widely used theoretical framework for understanding and predicting user acceptance and usage of information technology. The model posits that two key beliefs—Perceived Usefulness (PU) and Perceived Ease of Use (PEOU)—directly influence a user's attitude toward using a system, their behavioral intention to use it, and ultimately their actual system use. Perceived Usefulness is defined as the degree to which a person believes that using a particular system would enhance their job performance. Perceived Ease of Use refers to the degree to which a person believes that using the system would be free of effort [15]. In the context of this study, the mobile app-based gamified learning platform is the technology in question. The study investigates whether medical record officers perceive the app as useful for improving their ICD-11 coding proficiency (PU) and whether they find it easy to navigate and interact with (PEOU). We expect these perceptions to impact their engagement with the platform, which in turn should impact the outcome variable: actual improvement in coding skill.

In this respect, the Technology Acceptance Model (TAM) framework is particularly relevant for assessing the effect of the gamified learning intervention. For one, it enables the exploration of the user experience factors that shape the link between the deployment of the technology and the learning result. So, for example if a really experienced officer does not find the app user friendly, then they are unlikely to engage with it over time and hence the never potential impact on skills. Second, the model helps in understanding the drivers of sustained use beyond an initial trial period. The gamification elements are hypothesized to positively influence both PU and PEOU by making the learning process more engaging (thus increasing perceived value) and by breaking down complex coding tasks into manageable, game-like steps (thus reducing perceived difficulty). By employing TAM, this study can systematically analyze not just the final proficiency scores, but also the psychological and experiential pathways through which the gamified app influences learning behavior and outcomes among medical record officers in a rural setting.

Methodology

This study employed a mixed-methods research design, combining a quasi-experimental one-group pretest-posttest approach with qualitative phenomenological inquiry. The design was chosen to comprehensively capture both the quantitative changes in coding proficiency and the rich, subjective experiences of the participants using the intervention. The study was conducted across primary and secondary health facilities in Ahoada West LGA, Rivers State. Participants The target population was all 112 medical record officers of these facilities. The final sample included 85 officers who were enrolled using both purposive and convenience sampling, providing them with an Android smartphone (which was required for the app) and were willing to undergo the six-week intervention. The intervention consisted of gamified learning modules delivered through a purpose-built mobile application ("CodeMaster NG") on the basics of ICD-11 coding and the rules and exercises on coding in specific chapters.

In the first stage, Quantitative data was collected through a self-administered questionnaire comprising 3 parts: demographic data, a 20-item ICD-11 coding proficiency test (which was used for both pretest and posttest) and a section on perceptions of the app (using a 5-point Likert scale). After the intervention, we conducted

semi-structured interviews with 15 purposively selected participants to explore their experiences in-depth. Experts in health informatics and medical education validated the quantitative instruments, which were subjected to a pilot test to ensure reliability (Cronbach alpha = 0.87). Interview guides were similarly validated. Pretest data collection happened in week one, followed by six weeks of using the app where officers were instructed to use the app for 30 minutes per day, and posttest and interviews occurred during week eight. Result Part Existing in part 1 of test hypotheses, Quantitative data was analyzed using SPSS version 26, using descriptive statistics (mean scores, standard deviation) and inferential statistics (paired sample t-test). Qualitative interview data was audio-recorded, transcribed, and analyzed using thematic analysis to identify, analyze, and report patterns (themes) within the data.

3. Results and Discussion

Data Analysis

Research Question One: What is the baseline proficiency level of medical record officers in Ahoada West LGA in ICD-11 coding?

Table 1. Mean Score Showing Baseline ICD-11 Coding Proficiency (Pre-Test)

S/N	Proficiency Indicator	Mean Score ($\bar{x}$)	Std. Deviation	Remark
1	Accuracy in assigning diagnosis codes	2.10	0.75	Low Proficiency
2	Accuracy in assigning procedure codes	1.95	0.82	Low Proficiency
3	Understanding of ICD-11 structure	2.30	0.68	Low Proficiency
4	Speed of code lookup and assignment	2.25	0.71	Low Proficiency
5	Confidence in using ICD-11 digital tool	2.15	0.80	Low Proficiency
	Overall Mean Proficiency Score	**2.15**	**0.75**	**Low Proficiency**

Table 1 Baseline Performance of Medical Record Officers (Before Intervention): Interpretation An overall mean score of 2.15 on a scale of 1 to 5 (1=Very Low, 5=Very High) suggests a low ICD-11 Coding capacity. All sub-indicators such as accuracy for diagnoses and procedures, knowledge of the framework, speed of coding and confidence are scored at the "Low Proficiency" level (mean scale scores 1.50 - 2.49). This discovery highlights a critical need for targeted training interventions, which was used in gamified learning platform, and confirms that there is a significant skills gap among the officers before the introduction of the gamified learning platform.

Research Question Two: What is the impact of the mobile app-based gamified learning platform on the coding proficiency of medical record officers?

Table 2. Mean Score Showing Post-Intervention ICD-11 Coding Proficiency (Post-Test)

S/N	Proficiency Indicator	Mean Score ($\bar{x}$)	Std. Deviation	Remark
1	Accuracy in assigning diagnosis codes	3.85	0.52	High Proficiency
2	Accuracy in assigning procedure codes	3.70	0.58	High Proficiency

3	Understanding of ICD-11 structure	3.90	0.48	Very High Proficiency
4	Speed of code lookup and assignment	3.65	0.61	High Proficiency
5	Confidence in using ICD-11 digital tool	3.80	0.55	High Proficiency
	Overall Mean Proficiency Score	**3.78**	**0.55**	**High Proficiency**

Table 2 shows the levels of proficiency following the six-week intervention with the "CodeMaster NG" app. Mean Scores on each of the five EUAs increased substantially, with the Overall mean jumping to 3.78, within the "High Proficiency" band (3.50 – 4.49). There is significant improvement across all indicators measured. Greatest improvement was in 'Understanding of the structure of the ICD-11' (mean=3.90), indicating the application seemed to be successful in communicating the conceptual organization of the new system. Relatively high scores on accuracy, speed and confidence showed that the progress from game-based learning had successfully translated onto the practical skills and confidence of medical record officers.

Research Question Three: Interactive Version of the Research Questions With Explanations.

The analysis of the interview transcripts identified four main themes on the nature of feedback given through in-game communication: Increased Engagement and Motivation, Practical and Contextual Learning, Satisfaction and Progression, and Social Interaction and Competition. Over all sessions, participants described the game-like components as making the experience "fun" and "something to look forward to" in stark contrast with the monotony of study methods. Earning points for completing and reviewing modules and receiving badges for accuracy streaks carried over into their informed writing session. However, in one of the first officer comments, "The 10 in a row cardiology codes badge felt like a big win; it motivated me to be more focused". Quick follow-up of each quiz was mentioned as an important thing, which can help instantly correct mistakes and reinforce the right knowledge. Participants commended the platform's design that provided coding scenarios based on simulated patient cases because it increased knowledge transfer by making the learning relevant to their day-to-day work. Despite being anonymous, the leaderboard promoted a healthy level of competition and peer comparison, leading many to log in more frequently to try and rise higher up in the ranks. Nonetheless, a few participants were cautious regarding the technology in the beginning; though they quickly became comfortable with the intuitive interface.

Fourth Research Question: What are the challenges and facilitators affecting the acceptance and utilization of the mobile gamified learning platform?

Analysis identified a number of facilitators and challenges. Mobile learning facilitated their schedules as officers were able to practice while in transit to and from work or during quiet times on the job; the app was visually appealing and easy to navigate; and it was relevant content, related to their immediate job requirements. Use of local clinical examples (e.g., common cases of malaria, hypertension) within the app exercises was identified as a key element of the app that helped improve relevance and comprehension. Significant challenges were also identified. The major limitation were poor internet services in some areas of the LGA, which sometimes made it impossible to download new modules or sync progress, but the app was effective as it had an offline mode for most core activities. Some officers with older smartphone models noted app crashes or sluggishness from time to time. In addition, the recommendation of 30 minutes a day was cited as a barrier as some officers were under heavy workload pressures and found it difficult to set aside this time consistently each day. Nevertheless, overall responses were that the strengths of the platform vastly outweighed the weaknesses and that participants would love more modules of this kind and on this platform.

Test of Hypotheses

Hypothesis One (H_{01}): There is no significant difference in the ICD-11 coding accuracy of medical record officers before and after using the mobile app-based gamified learning platform.

Table 3. Paired Samples T-Test for Coding Accuracy (Pre-Test vs. Post-Test)

Test Phase	N	Mean Accuracy Score	Std. Deviation	t-value	df	p-value
Pre-Test	85	2.03	0.78	25.74	84	0.000
Post-Test	85	3.78	0.55			

Interpretation: The results of the paired samples t-test presented in Table 3 show a statistically significant difference in coding accuracy scores before (M=2.03) and after (M=3.78) the intervention. The obtained t-value is 25.74 with 84 degrees of freedom, and the p-value is 0.000, which is less than the alpha level of 0.05. Therefore, the null hypothesis (H_{01}) is rejected. This indicates that the use of the mobile app-based gamified learning platform led to a significant improvement in the ICD-11 coding accuracy of the medical record officers in Ahoada West LGA.

Hypothesis Two (H_{02}): There is no significant difference in the ICD-11 coding speed of medical record officers before and after using the mobile app-based gamified learning platform.

Table 4. Paired Samples T-Test for Coding Speed (Pre-Test vs. Post-Test)

Test Phase	N	Mean Speed Score	Std. Deviation	t-value	df	p-value
Pre-Test	85	2.25	0.71	18.92	84	0.000
Post-Test	85	3.65	0.61			

Interpretation: Table 4 displays the results for the test of the second hypothesis. The mean score for coding speed increased from 2.25 in the pre-test to 3.65 in the post-test. The calculated t-value is 18.92 with 84 degrees of freedom, and the associated p-value is 0.000, which is below the 0.05 significance threshold. Consequently, the null hypothesis (H_{02}) is rejected. This provides strong evidence that the gamified learning intervention had a statistically significant positive effect on the speed at which medical record officers could look up and assign ICD-11 codes.

Discussion of Findings

The findings of this study demonstrate a substantial positive impact of the mobile app-based gamified learning platform on the ICD-11 coding proficiency of medical record officers in Ahoada West LGA. The quantitative data reveals a dramatic shift from low baseline proficiency (mean=2.15) to high post-intervention proficiency (mean=3.78). This marked improvement in both accuracy and speed, confirmed by the statistically significant results of the paired t-tests, underscores the effectiveness of the gamified m-learning approach. These findings coincide with previous literature promoting interactive, technology-mediated learning for healthcare skill gain. Experimental work assessing the efficacy of simulation- and game-based learning in medical education also often demonstrate superior knowledge retention and skills performance to passive learning [13]. The sizeable improvement in "understanding of ICD-11 structure" indicates that the app broke down the complex new framework into more manageable interacting elements to allow for conceptual understanding to occur, which is crucial for accurate coding. The qualitative findings are greatly informative about the "how" and "why" of the quantitative success. The first two themes of Enhanced Engagement and Motivation and Sense of Achievement and Progression correspond very closely to the core mechanics of gamification, aimed at activating intrinsic motivators. The fact that participants described the learning process as being 'fun' and that they were motivated to seek out badges suggests that the principal learning platform managed to change a more voluntary, fun task of professional upskilling, to a less voluntary fun task of professional upskilling. This is consistent with the principles of Self-Determination Theory, where game elements

satisfy needs for competence and autonomy [5]. Furthermore, the theme of *Practical and Contextual Learning* highlights the importance of situated learning. By using simulated, locally-relevant patient cases, the app bridged the gap between abstract code learning and real-world application, thereby enhancing the transfer of knowledge to the workplace. This addresses a critical shortfall of traditional training noted in similar settings [10].

The challenges identified, especially unstable internet and workload pressures, are not peculiar to this intervention but rather systemic issues in the rural Nigerian healthcare delivery system. Nevertheless, the lack of internet zapped some of the functionality of the app, but because it was designed in part for use outside of high-resource contexts, the offline functionality saved the day. Despite faced challenges in rolling this out, the overwhelmingly positive reception, imply that the perceived usefulness and ease of use (tangible key TAM constructs) must have had significant value. Officers could live with some small tech hiccups because they actually saw the tool as valuable to doing their job. The high demand for sustained access suggests promise for continued use, an important factor for sustaining proficiency gains. It also underscores the significant shortfall in institutional support for ongoing professional development, as officers mostly had to lead their own learning, albeit facilitated by a very powerful tool. This echoes the need for systemic integration of such digital solutions into official training curricula and support frameworks for health information management personnel.

4. Conclusion

In conclusion, the use of a gamified learning platform accessible via a mobile application is a highly effective intervention to significantly improve the ICD-11 coding skills of medical record officers in a rural Nigerian setting. The intervention: resulted in significant improvements in coding accuracy and speed ($p < 0.01$), taking officers from a state of low baseline proficiency to high proficiency. The gamification features effectively increased engagement, motivation, and knowledge retention, and mobile delivery allowed for training that is flexible, accessible, and delivered in-context. The results confirm that carefully designed digital learning resources are capable of bridging essential cognitive skills gaps in low-resource settings and provide a scalable model for on-going continuing competence development. In Ahoada West LGA, as elsewhere in Nigeria, there is an urgent need for innovative, technology-based approaches to developing a robust health workforce that will be able to respond to contemporary health information systems demands. For example, implementing platforms like these is also fraught with implementation challenges (e.g., connectivity, workload, etc.) — but with some ingenuity in their design and institutional support, we can increase the effectiveness of such platforms.

Recommendations

According to the findings of this study, the following recommendations are proposed:

1. We recommend the formal endorsement of the validated mobile gamified learning platform, "CodeMaster NG", by the Rivers State Ministry of Health and the Health Information Management Registration Board of Nigeria as an integral part of the compulsory continuous professional development programs for medical record officers within the state, especially within rural LGAs where professionals are less likely to be able to access conventional continuing professional development programs.
2. Healthcare facility administrators can promote an enabling environment for digital learning by providing dedicated protected time during normal work hours for officers to use these learning platforms, viewing this time as part of officer development.
3. For educational tools going to rural contexts, app developers and instructional designers should foreground strong offline capabilities and low-data-use features. Future versions of the platform may have additional modules for

complex coding scenarios, audit trails, and an admin dashboard to allow managers to track employee progress.

4. Investing in digital infrastructure around health facilities, including internet access (especially broadband and wireless), is important to enable the deployment and optimal use of digital health and training technologies.20 For implementation at scale, government and donor agencies can pilot initiatives in consultation with service providers and mobilize capital investments in targeted areas, to provide appropriate infrastructure.21
5. Future studies need to validate the retention of acquired coding skills via gamified platforms over time as well as the relationship between better coding competence and some of the key health system results including hospital revenue cycle performance and quality of routine health data.

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