Digitizing Development: Enablers and Inhibitors of Mobile App-Based Population Census Adoption

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1 Introduction

Digital transformation has created countless opportunities and approaches for training and data collection [1], supporting developing countries' agendas to analyze population and housing dynamics [2]. The challenging nature of data collection in these regions , such as the lack of accurate, updated district maps and poor telecommunication networks, has opened possibilities for computer-assisted personal interviewing (CAPI) [3]. Even though the paper-and-pencil interviewing (PAPI) remains the most commonly used household surveys in developing countries [4]. Previous censuses have been marred by long data entry and processing time, poor handwriting or field officer errors and the potential loss of surveys through paper destruction [5, 6]. CAPI can significantly improve quality of data, reduce processing time and address most of PAPI's limitations [7].

Previous national housing surveys (NHS) and population and housing censuses (PHC) implemented in 1960, 1970, 1984, 2000 and 2010 in Ghana relied on PAPI and face-to-face instruction to train trainers and field officers. However, the Ghana Statistical Service (GSS), a body that oversees the efficient production and management of quality data for Ghana, introduced motivational information tools like gamification elements to complement face-to-face training and digital census as essential features of the 2021 PHC. However, there were challenges with access to ICT resources, not to mention the uneven access to ICT in different populations, districts and households [8].

The general presumption is that for Ghana to get good economic, educational, health and international comparison data, ICT and advances in artificial

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intelligence should be prioritized [9]. In this regard, the use of digital censuses is to ensure efficient data collection, management and processing. The introduction of the geographical positioning system (GPS) is to capture the coordinates (location) of all structures to ensure complete coverage. Notwithstanding the novelty of ICT in PHC, this study examines the experiences of trainers and field officers whose training, performance and ease of use of digital census are critical to the success of collecting data on the socio-economic, demographic and living conditions of persons living in Ghana [10].

This study aims to propose a framework for empowering digital census implementation. This framework will focus on successful training programs for data collection and the ongoing use of digital censuses for population and housing data collection. The chapter begins with a brief overview of Ghana's population censuses. It then identifies challenges faced in online training and digital census adoption during the 2021 PHC based on experiences of rural trainers and field officers. The study also explores potential concerns identified in the literature regarding digital census adoption and training delivery methods, including gamification. The underlying research question guiding this investigation is: How effective are online training, face-to-face instruction and digital census adoption in the context of Ghana's 2021 population and housing census. Limited research currently exists on integrating Information and Communication Technologies (ICT) into PHC. This study aims to contribute to this gap by sharing the benefits achieved, challenges encountered, and potential solutions to inform improved planning and implementation of future censuses.

1.1 Digitizing Development—Ghana 2021 PHC

The Government of Ghana invested GHS521 million (approx. $43.4 m) to ensure the success of the 2021 population and housing census as recommended by the United Nations (UN). Since 1981, Ghana has been conducting population censuses at approximately ten-year intervals. Currently, five censuses after independence have been conducted, with 2010 being the latest. The 2010 population and housing census recorded a total population of 24.7 million. Following the census sequence, Ghana was supposed to conduct its PHC in 2020, but due to the novel COVID-19 pandemic, the exercise was rescheduled for the first half of 2021, with June 27, 2021 as the census night.

The rationale for the periodic censuses in Ghana is to update the socio-demographic and economic data and further ascertain the population's structural changes over the last decade. The census gives a sense of the total number of persons and housing types in every village or town in Ghana. Such information is essential for government and local planning of educational, health and other social service needs. Therefore, the GSS adopted three phases for the census process—the pre-enumeration (planning stage), enumeration (data collection stage) and post-enumeration phase (data processing, post-enumeration survey and dissemination stage). To streamline the collection of quality data from the enumerator end, a data scenario was developed (see Fig. 1).

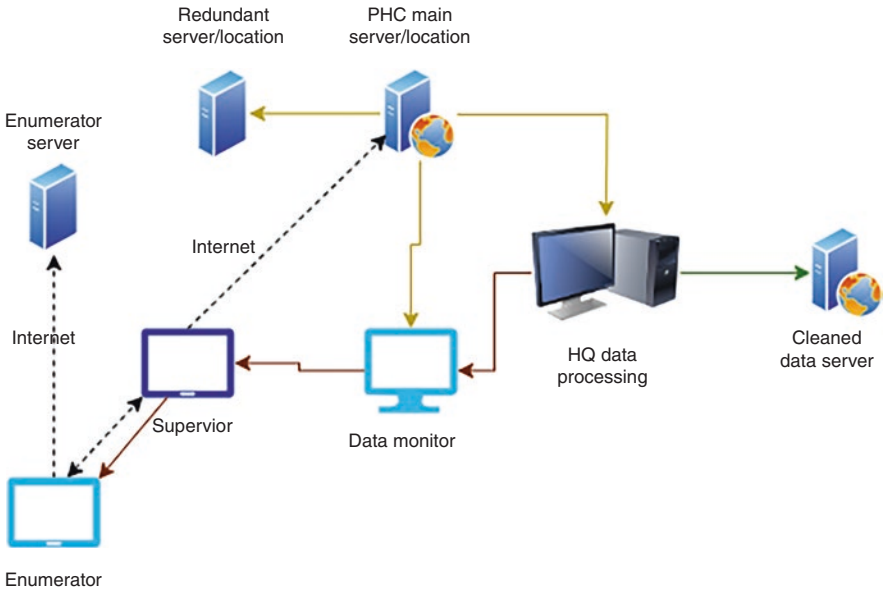

Fig. 1 Adapted data collection and reporting scenario [10]

This secure data flow model (Fig. 1) ensures quality census data collection: after supervisors transmit data, it's monitored, cleaned, and stored in designated servers for current use, backup, and historical analysis by central processing teams.

To commence the national exercise, the GSS set up a three-tier trainer of trainer groups, namely master trainers, national trainers and regional trainers at all levels of the sixteen regions of Ghana. In this regard, the master trainers train the national trainers, who train the regional trainers and finally, the regional trainers train the field officers (supervisors and enumerators). For the objective of this study, the regional trainers and the enumerators are the focus since they fall within the category of rural areas facilitators.

1.2 Digital Census Enablers in National Surveys

Digital technologies are now deployed for training purposes in developing countries. However, research suggest that participants in online training programs in these regions are more likely to withdraw or not complete their training compared to their counterparts in developed countries [11]. This can be attributed to a lack of motivational features within the online systems that could encourage continued engagement [12, 13]. Studies have shown greater improvement in training outcomes with face-to-face training sessions compared to online-only approaches, even though both methods can lead to sustained learning over time. Despite these mixed findings, blended learning, which combines online and traditional training methods,

is considered to be the most effective approach [14]. Recognising this, and faced with the challenges of COVID-19 pandemic, the PHC adopted online training platforms with CAPI capabilities as a promising alternative.

Based on the contrasting views on online and traditional training methods, this study sought to investigate participants' experiences at the 2021 PHC in Ghana. Potential concerns examined in the literature on online training include high cost, basic IT skills, acceptance of e-training by field officers and poor internet connection [15]. To enhance the capabilities of online training, practitioners and researchers in the last decade have introduced game design elements as a major component of online technologies. Due to the researchers' interest in gamification, the capabilities of the online system for PHC were explored further to examine its characteristics for motivation. The next section focuses on the gamification elements introduced by GSS to the online training, specifically the badges. During the COVID-19, online training has gained popularity in most training sessions in Ghana.

Gamification is a new concept, and developing countries are still coming to terms with its application and benefits [13]. Gamified online training is beneficial for engaging and motivating learners, but its effectiveness for meeting desired outcomes is contextualized and details mixed results [16].

Gamification uses game elements and features like badges, points, rewards, scores, and instant feedback to promote training. This practice motivates learners to accomplish a task and engage in the activity. Aside from the motivational powers of gamification, it provides feedback on learner assessment for formative purposes and helps assess successful training outcomes [17]. Through learner assessment, gamification reveals the merits and shortcomings of the game design element deployed to the users.

Gamification was incorporated into Ghana's PHC Field Officers Training to enhance field officers' training performance and engagement. However, only a few online training programs have incorporated gamification elements to assess and encourage training in Ghana, especially as a formative assessment for research and data collection [13]. Hence, a knowledge gap exists in the literature as regards the effect of using gamification for assessment. The present study examines the first-time involvement of gamification elements (i.e., badges and points) in population and housing census training of field officers in Ghana. Figure 2 shows forty-one

Fig. 2 Ghana 2021 PHC online training—41 gamification badges upon completion

badges that trainers must attain before successfully passing out to the next phase (face-to-face training).

2 Mixed-Method Design

This study adopted a mixed-methods approach [18]. Initially, the study was to qualitatively survey the views of regional trainers and field officers towards the acceptance of online training tools for PHC. However, after interviewing and categorizing the participants' responses, we identified constructs similar to the works of [19]. The identified constructs were examined quantitatively to determine the use of online training tools such as CAPI tablets for PHC.

2.1 Methodology—Qualitative & Quantitative Approach

A qualitative narrative inquiry approach was used to investigate the national and regional trainers' and enumerators' experience with the gamified online training and the practical CAPI session for the population and housing census, especially those in rural areas in Ghana. It should be noted that the national and regional trainers only had online training before face-to-face training with the CAPI—the reason being that GSS would consult them for future survey training. Hence their depth of statistical training was important. The enumerators, on the other hand, experienced only face-to-face training for the PHC. The central phenomenon in a qualitative study is the idea, concept or process being studied. Accordingly, the researcher learns more from the participants by exploring their experiences and critical incidents. Consequently, the data was collected through interviews.

Quantitatively, to have a homogeneous group of participants for this study, we contacted the 40 respondents who partook in the earlier interview. All 40 participants contacted, responded and returned their questionnaires (24 online and 16 paper-based). The study employed purposive sampling to recruit participants based on 2021 PHC experience. Consequently, the 40 participants are justified since they effectively capture the variations and perspectives of the census within Ghana.

Table 1 indicates the participants' profiles. The survey instruments were adapted from the [20] scale, while items on organizational influence were adopted from the [21] studies. Some of the constructs of UTAUT identified under the technological, individual, environmental and administrative context of this study form part of grounding proposed solutions to existing literature on technology adoption models and, hence, testing of the constructs.

Instruments

The researcher used interviews to understand the behavioral changes of the participants in the PHC. A semi-structured guide that comprised the guiding research

Table 1 Demographic characteristics of respondents

Category	Frequency
Gender	
Male	22
Female	18
Total	40
Occupation	
Teaching	10
Nursing	10
Unemployed	15
Self-employed	2
Retired	3
Total	40
Role in census	
Census Technical officers/advisors	7
Regional and district census officers	10
Field supervisors	6
Field enumerators	15
Monitoring	2
Total	40

questions was used to interview participants. Open-ended questions were used, which afforded the respondents space to provide their broad perspectives on the subject. The scope of the interviews was recurring themes from literature in general and those relevant to Ghana.

Population and Sampling

Ten (10) regional trainers and field officers (supervisors and enumerators) were taken from two rural areas of the Eastern region of Ghana. All trainers and field officers assigned to the Eastern rural areas of Ghana formed the target population. Twenty (20) of the trainers and field officers were thus randomly selected to join the study. The trainers were basically from universities—some indicated teaching assistance and trained teachers, while the supervisors and field officers were professionally engaged in teaching, national service personnel, and trained nurses. The majority of the enumerators were unemployed graduates from universities, polytechnics and training and vocational colleges, while others were self-employed.

Procedures

The approval to commence research on the subject matter was approved by the district census officers, and their views on the research items were incorporated. Trainers and field officers were randomly contacted during the census period from May 20 to June 25, 2021. The study's objective was sent to the randomly selected respondents to seek their consent to be part of the study. An appointment was scheduled for each participant to give their consent to the study. The interview was conducted via voice call.

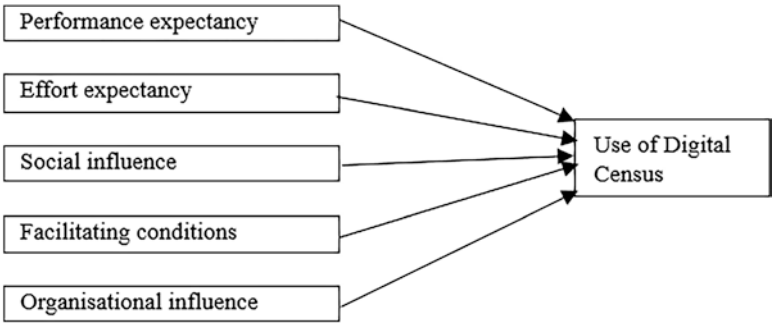

Fig. 3 Proposed Conceptual Model

Identified Constructs

Based on the identified constructs synonymous with the unified theory of acceptance and use of technology (UTAUT) [19], the study proposes the following model (see Fig. 3) as the antecedent of online training and digital census use. Thus, assessing the identified constructs further aims to extend the UTAUT model by integrating organizational influence to examine the determinants that affect field officers' intention to use CAPI tablets and online training for PHC. The constructs identified include perceived ease of use and usefulness, facilitating conditions, social influence, and organizational influence as well as field officers' behavioral intention to use tablets in data collection.

Performance expectancy: several studies confirm that users are likely to adopt technology if they perceive it as useful and promoting favorable outcomes [22]. Further, in the context of innovation or new technology adoption, extant literature confirms the positive relationship between performance expectancy and behavioral intentions [23]. In this regard, we hypothesize that:

H1: Performance expectancy will influence field officers' behavioral intention to use online training and tablets during PHC.

Effort expectancy: users prefer technologies with maximum benefits and are easy to use with less effort [19]. According to [24], effort expectancy is a strong predictor of behavioral intention to use innovation or new technologies in various individual or organizational contexts. Thus, we hypothesize that:

H2: Effort expectancy will influence field officers' behavioral intention to use online training and tablets during PHC.

Social influence is how an individual is influenced based on peer-group decisions to use a particular innovation. Extant literature supports social influence's impact on users' behavioral intention to use new technologies [24]. In this regard, we hypothesize that:

H3: Social influence will impact field officers' behavioral intention to use online training and tablets during PHC.

Facilitating conditions: The trainees asserted that internet access and other training resources were essential to the success of PHC in Ghana. Thus, this study proposes the effect of necessary resources as a condition for conducting a successful PHC. Extant literature supports the relationship between facilitating conditions and users' behavioral intent to use new technologies [25]. We, therefore, hypothesize that:

H4: Facilitating conditions will influence field officers' behavioral intention to use online training and tablets during PHC.

Organizational influence: Extant literature emphasizes how organizations influence results and users of new technologies [26]. Field officers similarly reported that the GSS expected them to be proficient in computerized data collection. This study introduces the concept of organizational influence as a novel construct within the UTAUT model, specifically addressing the context of technology adoption in Ghana. Investigating organizational influence in census emphasizes the importance of ensuring data integrity and accuracy and also improves the census process in building trust in government agencies. According to [26], competency increases the performance of users or employees in the data collection. In this regard, we hypothesize that:

H5: Organizational influence will impact field officers' behavioral intention to use online training and tablets during PHC.

Figure 3 shows the proposed model for field officers' intentions to use online training and tablets during PHC.

3 Results and Discussion

This section discusses the online training experience of regional trainers with game elements and their experience with computer-assisted personal interviewing in the 2021 population and housing census in Ghana. Almost all the indicators for effective CAPI use and the barriers identified in the literature review were found in the Ghanaian context of PHC. Table 2 shows a summary of the interviews conducted, which indicate the salient constructs for mapping future PHC. The study findings suggest that online training with gamification elements was ineffective for training compared to the in-person and interaction sections in Ghana's PHC. The trainers revealed a lack of cultural elements of the badges though getting the badges was a sign of accomplishment, reward and dedication to learning the PHC manuals online.

Further, the field officers' experience with the CAPI improved the previous censuses conducted in Ghana. The CAPI practical was effective and easy to collect data, though there were challenges generating the GPS with the CAPI.

Table 2 Qualitative groupings and sub-categories of the interview

Categories	Sub-categories (enablers)	Identified constructs	General Challenges
Effectiveness and barriers to gamified online training	Game elements Cost Household name (social interactions) Traditional and online training with ease	Perceived ease of use and usefulness of online training and digital technologies [19]	*Technological and environmental contextual challenges*
Effectiveness of digital census	User friendly Social interaction Reduced data collection time Organizational need	Attitude towards digital census for data collection and training Social influence Organizational influence to use [19, 26]	*Individual and technological contextual challenges*
Barriers to digital census use (listing of structures)	Digital census Asset Exposure myth Limited training on digital census Internet and GPS access Digital census and tablet challenges	Adoption of online training and digital census [19]	*Administrative contextual challenges*

Data Analysis I—Qualitative Analysis
The data was analyzed and transcribed using NVivo 11.0 and grouped into categories and sub-categories. To ensure transcription accuracy, the interviews were played severally and analyzed and transcribed verbatim. Also, to ensure confidentiality, the researcher used pseudonyms for each respondent. Table 1 shows the demographic characteristics of the participants.

3.1 Effectiveness of the Online Training

Game Elements Though the trainees felt a sense of accomplishment with the introduction of badges in the PHC training, the game elements were not tailored to meet their level of motivation. The game elements failed because a one-size-fits approach was used without considering the user characteristics. The future application should consider the user players and the kinds of game elements they feel accustomed to.

> Well, the game elements or badges that were displayed on the 2021 PHC Field Officers Virtual Training Platform did not motivate me that much. I liked it as an accomplishment badge, but the pictures on the badges did not communicate to me. I felt badges should be cultural to depict hardworking individuals in Ghana. [“Eunice” – Regional Trainer]

> Whenever I received the badge, I felt satisfied. However, I felt annoyed at the initial stage when I saw the number of completions of my colleagues. There were 40–45 tasks to be completed, and within three days, some trainees had completed more than 30 readings and assignments. I felt pressured initially, but it propelled me to catch up. ["Silas" – Regional Trainer]

> Sincerely, I did not feel any connection with the rankings and the badges awarded to me. I sometimes download it for downloading sake. However, seeing the badges was a sign of relief that I am drawing close to completing the field officer's manual. ["Patty" – regional Trainer]

Cost Data for the virtual learning was a significant challenge for the participants. The cost of the data bundle per day for training was too much for the trainees.

> OK, what I can say about the data is that it is very expensive. Online training is more expensive than one can imagine. Though GSS decided to prefinance the data used per day, the amount was too small. They initially agreed to pay GHS50 but ended up paying GHS40 (approximately $7/day). Interesting, we spend 7 hours online per day, can you imagine? ["Moses" – Regional Trainer]

Social Relatedness (Household Name) Most trainers felt a sense of relatedness and household-relatedness in online training, which affected their training and gave them a sense of belonging.

> The online training was one of the most memorable social learning I have experienced in my life. We hardly knew ourselves during the first three days though we were all from the same district (from the Eastern region of Ghana). Nevertheless, as time progressed, some household names became popular. They almost answered every question and raised their hands in all Zoom meetings (we used the household name because population and household census- PHC- brought us together). The fun of hearing some names made us know the image or personality behind every voice. One can imagine the joy and social relatedness when we met at the face-to-face training. In all, it positively affected my training behaviour and made me want to learn always as a team. ["Joshua" – Regional Trainer]

Traditional and Online Training Most of the trainers preferred the two-week traditional mode (face-to-face) of training over the two-week online training sessions because of its effectiveness and high-level of participation.

> There is no way I can compare the power of traditional learning to online learning. Online training was difficult and distracting. I wish you lived with me – so much intrusion and family check-ups. When we camped at Koforidua for the face-to-face training, I spent more than two weeks on the online platform, with no practical experience. However, it did compliment the face-to-face teaching, such that most of the terms were not new to me. ["Felix" – Regional Trainer]

> Online training is too much work. I barely focused throughout the period. There was "dumsor" (light-out) while I was due to present at a point in time. The factors that prevent online learning are too much for us to adopt. At one point, I connected and left the phone while receiving a visitor. They had to call my phone to answer the question posed by the facilitator. [Foster – Regional Trainer]

> During the Zoom meetings, I had many internet disruptions. I barely completed a day successfully without the internet, not messing up the meeting. I am in a typical rural area, so I blame the organizers for considering all trainers as staying in the Greater Accra capital. ["Irene" – Regional Trainer]

3.2 Effectiveness of the Digital Census and Gamification

Most of the enumerators and supervisors indicated that the CAPI is very easy and fast for collecting data compared to the PAPI. Though some of them participated in yearlong surveys, this was their first time conducting a population and housing survey with CAPI.

User Friendly An ample number of field officers quickly learned how to use the CAPI and navigate the tablet without difficulty because the features were like their smartphones. Other officers stated the convenience of using the CAPI instead of the PAPI.

> The digital census has made this year's PHC easy and faster as compared to the PAPI in previous censuses because it was straightforward to handle and use. This 2021 census is my third as an enumerator. My Android phone has similar features, so I did not expect challenges handling it. However, taking GPS is challenging because you might excuse yourself during the interview to take coordinates or information. Just imagine leaving the room during the interview to collect the information outside….It sometimes creates an awkward moment and a sign of mistrust. ["Patience" – Enumerator]

> For convenience's sake, handling the digital census is way better and easier than the PAPI. I can recall my experience in the last census – 2010, where I listed almost 400 structures. So, that should tell you the number of questionnaires I was handling throughout the month. I do not think we will ever go back to PAPI for a national assignment again, maybe for small surveys like sanitation and agriculture. ["Mercy" – Enumerator]

Social Interaction Most of the enumerators felt bonding and interaction among the facilitators and trainers when using the CAPI for practice. The interaction between enumerator-enumerator and supervisor-enumerator positively affected the effectiveness of the digital census use

> You know, during the face-to-face training, our facilitators grouped us into eleven groups – each group was ten trainers to begin the digital census practice. Out of the ten, one was made the supervisor who assigned us the enumeration area, and I felt that was the beginning of our social bond with digital census. Sometimes, you will hear a colleague making a joke about digital census exposing him because he could not fully cover my assigned area. Moreover, since we were all recruited from this district, bonding and establishing good working relationships with the digital census was easier. In all, it was a friendly exercise, and the same thing is what we are facing now at the Listing stage of the 2021 PHC. ["Pauluto" – Supervisor]

Table 3 Psychometric Properties ($n = 40$)

Construct	Loadings range	CA	RhoA	CR	Ave	VIF	Disc. validity
Performance Expectancy (PE)	0.765–0.813	0.706	0.886	0.929	0.814	1.15	Yes
Effort expectancy (EE)	0.794–0.910	0.885	0.866	0.918	0.789	2.45	No
Social Influence (SI)	0.807–0.921	0.866	0.755	0.856	0.665	1.39	Yes
Facilitating conditions (FC)	0.834–0.893	0.750	0.736	0.826	0.617	3.34	Yes
Organisational influence (OI)	0.738–0.792	0.790	0.850	0.897	0.745	5.06	Yes
Behavioral intention	0.865–0.950	0.828	0.895	0.934	0.825		Yes

Reduced Data Collection Time Majority of the field officers indicated that the PAPI would have consumed more time to complete the volume of questions. However, CAPI is robust enough to include built-in skip patterns and filters. For example, it skips fertility questions when a male responds.

> My first time using it, but I find it very useful and user-friendly with good skip patterns and auto-fill features. Digital census makes the work of an enumerator easier and helps us input much data within the shortest time. New data can also be aggregated and checked daily for consistency. The response time to input information on the digital census is swift, but the questions are many in this year's PHC. [“Nana” – Enumerator]

3.3 Data Analysis II—Quantitative Approach

The researcher employed the partial least squares using the SmartPLS to test the research hypothesis [27]. PLS is the most preferred statistical technique for small-to-medium-sized samples and a powerful tool for estimating the path coefficient and model parameters under non-normality conditions [28].

3.3.1 Measurement Model

The first stage assessed the reliability and internal consistency, as well as the convergent and discriminant validity. As shown in Table 3, the factor loadings of each item are significant, indicating that the values are all above the minimum threshold of 0.70 [29, 30]. Also, Table 3 indicates that the average variance extracted values are all above the minimum acceptable value of 0.5 [29]. We assessed the reliability of the indicators using Cronbach alpha and composite reliability, and all the coefficient values were above the minimum threshold value of 0.70. The collinearity assessment was estimated using the variance of inflation factor (VIF). A VIF value of 5 or less shows no collinearity issue [27]. Table 3 shows that among the constructs, only organizational influence is slightly above the threshold of 5.

Table 4 Path co-efficient and effect sizes

Path	Path Coefficient	*P*-value	STDEV	f^2	Supported
PE→BI	0.159	0.045	0.079	0.395	*H1: supported*
EE→BI	0.068	0.153	0.057	0.031	*H2: not supported*
SI→BI	0.781	0.010	0.302	0.021	*H3: supported*
FC→BI	0.114	0.042	0.056	0.009	*H4: supported*
OI→BI	0.549	0.000	0.056	0.015	*H5: supported*

3.3.2 Structural Model

The significance of the path coefficients is determined by the p-values, which represent the prediction of specific endogenous constructs by specific endogenous constructs. The R^2 value was 0.623, indicating a 62% prediction of the endogenous variables. This implies that performance expectancy, effort expectancy, social influence, facilitating conditions and organizational influence jointly explained 62% of the variance for behavioral intention for a digital census. Since R^2 values of 50% are considered high in behavioral and technology adoption studies [19], 62% indicates a good model's predictive power for a digital census in a developing country. The effect size was also determined using f^2. The *f^2 values less than 0.02 proved there is no effect, while 0.02, 0.15 and 0.35 indicate small, medium and large effect sizes, respectively.*

The structural model generally predicted an acceptable fit since the standardized root mean square residual (SRMR) of 0.078 was below the required threshold of 0.08 [27]. The significant values shown in Table 4 indicate that four hypotheses were supported out of the five independent variables. The four supported factors are PE, SI, FC and OI, with *p*-values below the 0.05 threshold. Consequently, EE was rejected with a *p*-value greater than the 0.05 threshold. In other words, performance expectance, social influence, facilitating conditions and organizational influence significantly predicted behavioral intention to use online training and CAPI tablet for PHC. On the contrary, effort expectancy did not predict behavioral intention in PHC. The empirical data of the PLS approach also confirms that social influence (β =0.781; P = 0.01) and organizational influence (β =0.549; P = 0.00) are predominant factors that drive field officers' digital census intention.

The empirical result regarding the determinant of field officers' intention to use online training for the census is that performance expectancy leads to technology adoption. This means that Ghanaians who tend to partake in PHC focus on the perceived usefulness and favorable outcomes of the digital census. In other words, when government statisticians and agencies responsible for PHC consider users perceived usefulness of the digital census, Ghanaian field officers are more likely to consider the CAPI and thus promote the collection of quality data. The results also indicate that effort expectancy does not have a significant direct effect on online training behavioral intention for PHC.

As expected, our findings from Table 4 strongly indicate that social influence is positively related to behavioral intention to use. Thus, this study is consistent with

previous literature on technology adoption [25]. Consequently, the results can infer that a high degree of intention to use digital census and online training is formed when Ghanaians develop social relatedness and influence during the training. The greater the social influence during the training, the more digital tools and online training use intention among the field officers.

Findings of the PLS-SEM analyses also indicate that internet access and other training resources are essential facilitating resources that drive field officers' intention to use digital technologies in the census. In this regard, agencies responsible for PHC should provide all available resources on and off the field for the enumerators to avoid initial technology rejection. Finally, organization influence on digital census increases the likelihood of field officers' behavior intention to use digital technologies in PHC. This means that managers of PHC would have to develop strong organizational influence and attitude toward digital technologies in collecting data and also in training the field officers.

3.4 Barriers to Digital Census Transformation

Technology Asset Exposure Myth One of the major challenges mentioned by the enumerators is how the interviewers want to withhold information, especially when capturing data with the digital census. According to 45% of field officers, some households withheld information because they believed that they would be taxed or found out in the future if they provided accurate information to the officers. In Ghana, most people are conservative with their items to invade taxes and other responsibilities, which affect national surveys. For example, to evade higher electricity bills or fear of being exposed to the actual bills to pay, some interviewers would not list all the electrical gadgets in their household.

> My experience has been good so far. As you may know, using the digital tool makes work easier but scares some interviewers, especially when taking the GPS location. In taking the GPS, we must move to an open space to get the required threshold of 5. However, when that happens, the respondents feel you are capturing them for tax collection (examples of these locations are stores, bars, clubs, churches etc.). I think some information is withheld in typical rural areas where we cannot control what they think or know. ["Sandra" – Supervisor]

Limited Training on Digital Census Tools Field officers complained about the limited time for the training, especially the field practice. While some accepted the two-week training as effective, others said the time was too short to learn all the nineteen chapters of the PHC and include field practice and economic survey questions.

> I hope you see the Field Officer's Manual. The facilitators were good at covering the full manual, but other groups might find it difficult to download all these materials for effective learning and practice. The disadvantage is that when the enumerator is not taught enough to

> understand the software, it becomes a disaster as quality data and complete coverage might be a challenge. Secondly, the training time frame was very short as I said, which most people could not understand enough. What you feed the system is what you will get. We know most trades in Ghana, like foodstuff sellers and dressmakers, regarding economic activities, but it was not easy to find them. It would have been prudent to have checkboxes ticked, and then move on, but that was not the case. Going through that long procedure to look for their professions is not a joke, my brother. But in the end, we provided respondents with the right professions. [“Kwame” – Enumerator]

Internet and GPS Access Accessing the internet for syncing with headquarters and getting a suitable GPS threshold of five was one of the significant challenges mentioned.

> I presume you know the challenges with poor internet unless you are new in our district. The two main telecommunications that work best here are MTN and Vodafone. However, in my area, MTN has the best internet access. Unfortunately, I subscribe to Vodaphone, so I struggle very much during data synchronization with HQ unless I move to Kade (the district’s capital). But with the GPS reading, some of my enumerators have complained to me, but I have no solution but to report to the district census officer. These are our main challenges in getting quality data. [“Madison” – Supervisor]

Digital Census Challenge The respondents provided general challenges to the technology adoption and tablets used for collecting the data, which included screen misfunctioning, poor GPS coordinate reading, slow app and frequent app errors.

> My main barrier is that at times the screen turns out not working and as such slows work at times. It comes when it pleases, but I am told to come for a new one. [“Vera” – Enumerator]

> The best thing about the digital training is the about is the filters. Though it brings out errors, it sometimes does not detect some errors that it is understood to detect. Making it slow and confusing and also generating the GPS was a bit of a headache. [“Millicent” – Enumerator]

> The technology makes the work much easier and user-friendly, but many times runs very slow even after restarting it. Taking GPS coordinates is another hell of a time, sometimes over ten times before being able to read accurately. [“Sammy” – Enumerator]

> The application runs slow at your peak time. Also, I realized that GPS reading is a bit of a challenge when it is getting late. Overall, the use of the system is a good experience, but there's a difficulty when correcting unintentional mistakes. [“Michael” – Enumerator]

> The technology has made the work simple and smart... but my problem is when you mistakenly select "yes household population" and move forward, it will not allow you to come back and choose option No. I mean, the No will not appear again. For that, do you have the right to delete such a structure and redo it? You answer for me. [“Rich” – Supervisor]

> One thing I realized during the listing stage is that when two Enumerators in one EA are notified of an error in the system by the data management team, it is difficult to identify the error. Funny enough, our supervisor could not see the error either. So, how then do you know the error to correct? [Judith – Enumerator]

3.5 General Challenges That Impact Digital Census Transformation

Political Interference and Poor Recruitment Sixty percent of the participants indicated that the selection of field supervisors and enumerators did not follow laid-down procedures. Though assessment tests were conducted on three occasions, none of the tests were used for selection, as revealed by enumerators. Regional trainers revealed that they submitted a qualified field officer list to the district census officer. However, most of the qualified candidates were removed from the shortlist for the exercise. Thus, due to the limited competence of some field officers, poor total coverage and poor-quality data were recorded. There is a need to promote transparency in publicly reporting on census methodologies, standardized recruitment process and potential limitations.

Financial and Remuneration Constraints Four out of five census officers indicated that the inadequate financial package could affect the entire exercise, which ultimately may affect the quality of data collection. There were a series of petitions concerning the remuneration package addressed to the secretariat. Field officers, i.e., supervisors and enumerators, were paid approximately GHS 2520 and GHS 2950 (approx. $ 215 and 252) for the exercise. Establishing a union can give enumerators a collective voice in negotiating better wages and working conditions.

Software Upgrade One in five field officers reported that the digital census did not have the latest CSEntry version, which slowed the exercise. This issue distorted training sections since all participants needed to be on the same page. There is a need to implement software version control practices for future data collection exercises.

Based on the respondents' views, four categories were identified, namely: technological, individual, environmental and administrative context. Table 5 shows a summary of identified barriers and strategies for effective online training.

3.6 Effective Adoption of Digital Census in National Surveys

What to Consider When Integrating Digital Census in Training and Collecting Data

During our interaction with regional trainers, supervisors, and enumerators, we identified several issues discussed in Table 5, technological, individual and environmental, that need to be solved to achieve effective digital census integration in training and collecting data. Based on our research output, we make seven recommendations to any country or institution interested in integrating digital censuses and digital technologies into training and data collection for massive national surveys (target of 30 million population and more).

Table 5 Summary of barriers and strategies to effective digital census

Category (enablers)	Barriers/Inhibitors	Strategies
Technological context	Issues with online learning Poor internet connection or Poor motivation for learning online Unmotivated game design elements Poor communication between trainees and instructors Limited access due to tablet and manual sharing Software requirement	Embracing acceptance of online training by field agents to improve self-efficacy. Collaborative online training improves the learning experience Online training personalization (a tailored approach based on users' experience) Update CSEntry software before training Improve the IT procurement process
Individual Context	Poor reporting to training Stress in combining census training with other work, e.g. private and public teachers Difficulty adjusting to CAPI training and learning style Practical concern Lack of essential accessories to promote learning Inadequate trainers' skills	Prior digital literacy for field officers Incentives and rewards as motivation Provide funding and data support Conduct a needs assessment survey among trainees and district facilities Keep an updated record of field officers and trainers Competent-based assessments and training Review and assessment of district census officer and statistical products
Environmental context	Family interruption during training (district level) Knowledge gap in training and field practice Bribery for selection as enumerator Poor transparency in the selection Power interruption Long hours of sit-down training	Field supervisor, support and evaluation Ensure open channels of communication among administrators, community leaders, trainers and field offices Reduce travel time Digital transformation agenda Integrating tradition and emerging technologies into systems Forms processing capabilities
Administrative Context	Limited training opportunities Poor organization and administrative issues Untimely delivery of training materials Faulty tablets for training Education and residential concerns Discriminatory resources in many census centers at the district level	Provide sufficient training devices and materials to enhance practical training sessions. This is important because some field officers reported sharing tablets during the training. Keep a record of trained field officers for future survey activities Infrastructure and technical support Encourage blended learning Quality control checks Improve organization census reporting

1. Identify the field officers early and their familiarity with the digital census
2. Address environmental challenges to training per district or regional level, e.g., access to electricity, internet and classroom
3. Trainers should be highly familiar with the digital census and modules
4. The national census team must ensure closer work with the district IT coordinators
5. Ensure the digital census is an integral component of the training and of sufficient in number for trainees
6. Describe key features and functions of the CAPI tablet on the first training day (why digital census) in data collection and how to achieve complete coverage with digital census)
7. Tablet distribution should be done carefully, especially at the local level to avoid infrastructure limitations

4 The Mixing of Results: Model for Enhancing Digital Census Transformation

By conducting a mix of qualitative and quantitative results, we identified important themes that have the potential to enhance digital census research and practice. The first theme identified is the *digital census capabilities* (technology, i.e., online training) with the intended goals for the census activities. Providing enough details of the digital census functionalities to dispel the one-size-fits-all approach of online training systems. This study has shown that identifying the characteristics and capabilities of the field officers (FO) is essential to a successful census. Thus, future

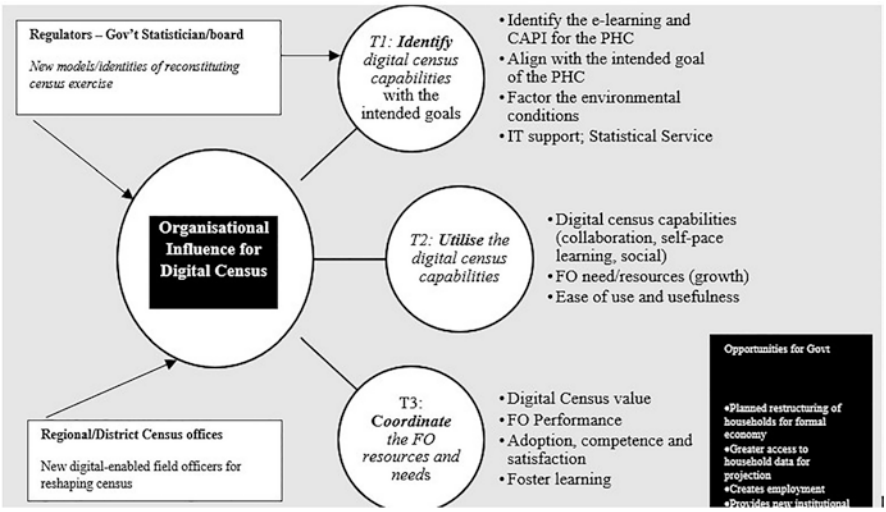

Fig. 4 Proposed model for enhancing digital census

census programs need to investigate the various capabilities of the field officers and the learning system to reinforce the intended purpose of conducting PHC. It is also important to consider the country-level environment and the quality of field officers recruited. The second theme is to *utilize the digital census capabilities* and tools to initiate field officers-centric training approaches. This provides the field officers with the autonomy to develop training in different forms, such as interpersonal skills, self-paced training and self-awareness. The third is to *coordinate the field officers' resources and need*s and the objective of implementing a digital census. Thus, there should be an appropriate interplay between the source materials and how they can successfully achieve the goal of PHC. As shown in Fig. 4, this is a proposed model for enhancing digital census training in a developing country context.

5 Conclusion

The study investigated the behavioral enablers and barriers of the digital census in Ghana by validating a research model and conducting an in-depth analysis. A qualitative and quantitative approaches were used to examine the issue of digital census. Qualitatively, the study found general challenges in household surveys to include political factors and poor remuneration, financial and remuneration constraints, issues with software upgrades and GPS access. All in all, the barriers and strategies can be classified into individual, technological, environmental and administrative contextual factors. Quantitatively, the study found performance expectance, social influence, facilitating conditions and organizational influence as significant enablers of field officers' intention to use digital census for PHC or NHS in a developing country.

The digital census's introduction into the PHC has shown promising signs of collecting quality data. Most of the supervisors and enumerators revealed the effectiveness of the CAPI compared to the PAPI. However, future digital census use for PHC should address the challenges outlined in this study to achieve complete coverage.

5.1 Theoretical and Practical Implications

Theoretically, this study extends the adoption model by integrating organizational influence, which is an important determinant in examining the case of online training and data collection tools for national assignments. Thus, the relationship between organizational influence and behavioral intention has not been considerably studied. Consequently, the results of this study enhance existing knowledge in technology adoption by confirming the significance of integrating the user's attitudes and beliefs in online training and closing the digital divide in developing

countries. Additionally, the findings from this study contribute to the advancement of prior research on online training by empirically testing the role of performance expectancy, effort expectancy, social influence and facilitating conditions in Ghanaian field officers' online training intentions. The research explains 62% of the variance in users' intentions. This confirms the study's robustness of the UTAUT model [19] in a developing country context.

Practically, in developing countries, our study identifies performance expectancy, social influence and organizational influence as the most significant predictors of field officers' intention to use online training and CAPI tablets to collect quality data and ensure complete coverage. Thus, our study presents some important strategies for other emerging countries that want to conduct population and housing censuses through digital technologies that are still in their infancy in developing countries. Specifically, we have shown that organizational influence can boost technology acceptance for national activities in the case of rural and urban dwellers in Ghana. This study also indicates that social influence and organizational influence are predominant factors driving individual digital census use.

Limitation

The generalization of the study is difficult due to the small sample size. The study focused on regional trainers' views of the in-person and online training and supervisors' and enumerators' perspectives on the use of CAPI in Ghana's 2021 population and housing census without including the voices of regional census officers, district census officers and district data officers managing the entire exercise. Further, the study participants were from two rural areas in the eastern region of Ghana, while Ghana has 16 regions with many field officers taking part in the census.

5.2 Future Direction and Recommendation to Achieve Effective Future PHC/NHS

Based on the analysis and review of relevant sources in this study, a recommendation is proposed for future household surveys in developing countries. We realized that recommendations for future PHC/NHS should cover best practices for more effective use of the CAPI system in NHS at different stages. Hence, the following key recommendations:

(a) *Embrace online self-enumeration*: As developing countries continue to improve internet penetration, a secure and user-friendly online platform for citizens can enhance the quality of data collection throughout the year. Furthermore, logistical complexity and cost will be reduced, and this online activity boosts overall participation and empowers individuals with increased convenience. More IT literacy programs are needed to address the digital literacy gaps and ensure technology access in rural areas.

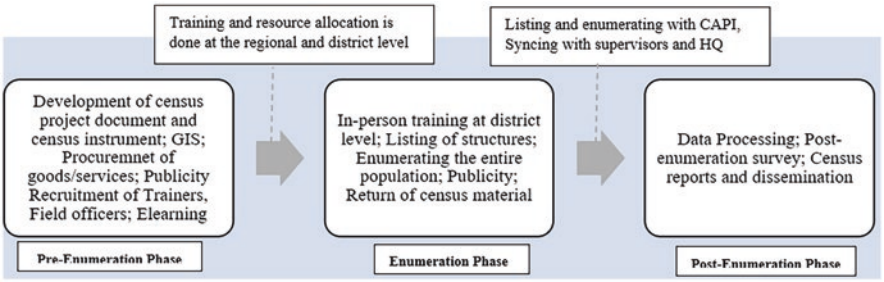

Fig. 5 Adapted Proposed Framework

(b) *Offline functionality*: Inasmuch as enumerators are resourced with mobile technology for data collection for enhanced accuracy, priority for offline functionality should be critical, especially for rural areas in developing countries. Implement offline functionality for places with limited connectivity and safeguard data security.
(c) *Leverage real-time data analytics for deeper insights:* The governing statistical services must invest hugely in advanced analytics to extract valuable and real-time insights from census data. The problem with developing countries is the delay in generating predictive trends to inform resource allocation and support evidence-based decision-making for all sectors of the economy.

5.2.1 Framework for Unlocking Digital Population Census

As shown in Fig. 5, the recommendation framework for census entails three phases: the *pre-enumeration phase*—development of project documents and census instruments, procurement of goods and services, publicity, and recruitment; the *enumeration phase*—listing of structures, enumerating the entire population, publicity and return of census materials; and *post-enumeration phase*—data processing, post-enumeration survey, census reports and dissemination. At the heart of this exercise is the resource allocation at the regional and district levels.

With the huge amount of money and resources allocated to training national and regional trainers, the statistical bodies should retain these trainers for future NHS. Employing their services will reduce costs and ensure the continuity of training modules. However, the GSS must issue a training certificate and accomplishment to the trainers—to certify them for future programs. The same ideology can be applied to the supervisors and enumerators at the regional and district levels.

Future national surveys and PHC virtual platforms should incorporate gamification elements that have cultural meaning and motivate users. This can be achieved when designers systematically examine the user characteristics, considering the context of the learners. Adopting one-size-fits-all game elements, which have been the case for most gamified systems, is a recipe for failure. Ghanaians are intrinsically attached to some game design elements, and designers and instructors must

identify them and incorporate them systematically into the intended outcomes. Lastly, this study calls for future research to explore the gender differences in the perception of digital censuses and examine the role of artificial intelligence (AI) in the data collection for achieving more efficient, accurate and inclusive results [9, 31]

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