

Exploring healthcare providers perceptions of gamified self-regulated learning experiences on smartphone devices

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Abstract

There is an urgent need for more and better-trained health workers in Sub-Saharan Africa (SSA). A lack of training opportunities significantly contributes to the poor quality of neonatal care outcomes in this region. Smartphone-based learning shows potential to address this training need. However, before widespread adoption can happen, it is important to obtain input from healthcare providers who will be future users of this technology. This study explored the perceptions of healthcare providers on how to enhance the design and implementation of more engaging learning experiences on smartphone-based gamified learning, which is a largely under-researched topic in low resource settings. It also explored how healthcare providers perceived such contextualised learning experiences could influence their self-regulatory learning (SRL) efforts as they embark on bridging their knowledge gaps. We used Nominal Group Technique and semi-structured interviews to explore how healthcare providers perceived their learning experiences using gamified smartphone-based learning with a particular focus on how the platform could support SRL.

We found that the provision of highly contextual feedback that elaborates on the consequences of action, inaction or erroneous action optimises healthcare providers SRL experiences and improves both their engagement and effort regulation. For this to be effective at scale in SSA contexts, a theory of change that validates healthcare providers learning by building confidence in the knowledge gained and that transfers to a routine clinical setting would be necessary. We posit that the context-reflective, co-designed conceptual model emerging from this study could support uptake of smartphone-based self-regulated learning platforms and aid in making gains in patient outcomes in SSA.

Introduction

The global need for more and better-trained health workers is well established [1]. Sub-Saharan Africa (SSA) contributes to over 24% of the global disease burden but only has 3% of the global health workforce [2, 3]. Severe workforce shortages, coupled with a lack of training opportunities, are significant contributors to the poor quality of maternal and neonatal outcomes in the region [1]. Globally, 2.9 million newborn lives are being lost each year [4]. Thirty eight percent of global neonatal deaths occur in SSA, the majority of which are within the first 24 hours of life [4]. Half of these deaths are attributable to a lack of adequate training for healthcare providers, making training a critical intervention to reduce avoidable neonatal deaths [5, 6]. The costs of face-to-face training in the SSA region are prohibitively high [7] and efforts to extend training are further constrained by the socio-economic, political and institutional landscape [7, 8].

Within SSA, solutions to address the demand for relevant, more accessible training tend towards one-off volunteer-based short courses which are often offered unpredictably [8]. Recently, learning delivered through smartphone devices has shown potential to address healthcare providers' training and knowledge gaps [9]. The development of these interventions have, to date, been technocentric in nature and their implementation often too reliant on transfer and diffusion models [10] which are not always

pedagogically-driven [11]. They often do not target healthcare providers' learning experiences in a contextually-cognisant, goal-oriented manner, which is essential to achieving desired learning outcomes [12]. There is also a lack of evidence on how theory-driven novel digital-based learning approaches targeting healthcare providers from low-income countries (LICs) support contextually appropriate self-directed learning [13].

SSA healthcare providers' control over their learning is underpinned by learning theories such as the self-regulated learning (SRL) theory. SRL is the ability of an individual learner to regulate their thinking, emotions, and actions to enhance learning goals achievement [14, 15]. SRL theory posits that the learning process is initiated and directed by individual learners instead of relying on educators [16, 17]. The main principle of SRL is that students who are better at regulating their learning processes will learn more effectively [18]. How LIC-based healthcare providers using smartphone-based learning interventions might effectively plan, monitor and evaluate their learning processes and outcomes remains largely unexplored [13, 19, 20]. Given that healthcare providers tend to actively engage in SRL so long as learning addresses their contextual and self-efficacy needs [19, 20], and SRL is highly informed by context and socio-cultural factors [21], generating evidence on the implementation of smartphone-based SRL for healthcare providers in SSA -which remains largely unaddressed- is necessary for enhancing learning outcomes [13, 22].

There is a clear research gap in understanding how smartphone-based platforms for supporting clinical training can be implemented in a socially-embedded manner for SSA. From an evidence synthesis of health professionals' use of digital education, there is a renewed call for more research evaluating novel forms of individualised digital-based learning on learning behaviours especially from SSA [13]. Moreover, understanding on how learners' SRL experience can be made more engaging, contextually-relevant, and adaptive to their learning needs, would be useful in enhancing uptake of such forms of learning [8, 9, 23].

One such novel form of learning is the use of gamified digital learning platforms designed to engage learners by integrating mechanics such as scoring, levels, achievements, immediate feedback loops and time pressure [22]. Gamified approaches seek to bridge the gap between what healthcare providers know and how they practice by facilitating repeated exposure to the learning process and thereby producing intended learning outcomes [24]. The increased exposure to learning processes is achieved through leveraging the motivational effect and the instructional principles contained in the gamified approach [25] when it is informed by SRL theories [18].

Although the instructional potential of game-based learning is recognised, there persists a lack of evidence to guide adaptive learning design, and support assessment [26]. Little is known on what design and evaluation features of gamified digital learning might enhance SRL experience across different learning contexts [27–29] more so for clinical training in SSA. Additionally, current frameworks that attempt to map pedagogical patterns to game-play features (e.g. badges, achievement and leader boards, difficulty level etc.) offer little evidence on how to evaluate adaptive game-play impact on the users' learning experience [26, 30].

The key challenge of how a gamified mobile training intervention might be better designed to support healthcare providers self-regulated learning of neonatal emergency-care management in SSAs still remains, which is the purpose of this study. This is because research on gamified learning in contexts like those of SSA is still in its early days and how to link this with SRL is even less well-developed. Additionally, while the effect of adaptive learning mechanism on learning outcomes has been evaluated and SRL behaviors of healthcare providers from SSA have been empirically determined and linked to learning gains [31, 32], how they perceive gamified learning on smartphone devices to influence their learning has not yet been well elucidated upon in existing research.

The objectives of this study are to explore (1) the perceptions of healthcare providers on how to enhance the design and implementation of more engaging learning experiences on smartphone-based gamified emergency care training, and, (2) how healthcare providers from LICs perceive such contextualised learning experiences to influence their SRL efforts as they embark on bridging their knowledge gaps [33].

Methods

The intervention being piloted

The clinical training intervention being co-designed is **Life-saving Instruction For Emergencies (LIFE)**, an Android™ smartphone and low-cost Virtual Reality (VR) platform which is being developed to train healthcare workers in low-resource settings to manage neonatal clinical emergencies on low-cost smartphones [34]. It uses a scenario-based teaching approach where the components being assessed emphasise the tenets of neonatal critical care with early recognition of neonates who need immediate care. This is achieved by using game-like training techniques to reinforce the key steps that need to be performed by a healthcare worker to manage an emergency, an approach commonly referred to as serious gaming [24, 35].

Consequently, it follows a specific ordering of clinical care-giving algorithms with each learning task being timed. The learner starts a scenario which provides background information to the learning task, and on each learning task, they must provide input either through multiple choice quizzes, selection of items necessary for the learning task, or performing on-screen interactive tasks (e.g. navigating to equipment, switching on machines, etc.) as illustrated in detail in supplementary 1 of the appendix.

On each incorrect attempt by the learner, feedback is provided with an option to read more information if required. The learner must repeat each step in the quiz until they successfully respond before being able to proceed. The end of the scenario is signalled by a crying baby and a congratulations screen indicating that the baby is now breathing, with a breakdown of scores by quiz provided. The scenario model is adapted from the validated Emergency Triage, Assessment and Treatment plus admission care (ETAT+) face-to-face training approach [36, 37]. ETAT+ content has already been used in face-to-face training with over 5,000 healthcare workers and 2,000 medical students across Eastern and Southern Africa, and East Asia [36, 37]. LIFE is designed to be accessible at scale by healthcare providers, functions off-line on low-

end smartphone devices, and provides self-regulated training opportunities akin to continuous professional development at very low marginal cost.

The simulated scenarios were designed using an iterative user-centred design approach with continuous feedback from new and old cohorts of study participants around training content, platform interactivity, user experience and design parameters for future consideration. So far, it has been tested with three different cohorts of student nurses and doctors in Kenya and the UK.

Study design, setting, and participants and timelines

This qualitative study was conducted in three phases. The first phase used Nominal Group Technique (NGT) - a structured small-group consensus method [38] which is illustrated further in supplementary 2 of the appendix. NGT was used because it is well-suited for (1) building consensus among study participants for the purposes of idea-generation and (2) determining priorities of proposals for the design and implementation of more engaging learning experiences, (3) research questions geared towards informing learning experiences design [39] and (4) aiding development of solutions that are testable using rapid-change cycles (e.g. regularly updated smartphone application content and user-interface design) [40]. NGT was used to address the first research question whose aim was to build consensus with healthcare providers on how to enhance the design and implementation of more engaging gamified learning experiences.

The second phase was complimentary to the first and was carried out within a week of phase one and sought to evaluate whether the perceptions of healthcare providers were consistent across varied levels of seniority, training and experience. It consisted of brief semi-structured open-ended interviews and its purpose was to corroborate and validate the findings from phase one (illustrated in supplementary 3 of the appendix). The third phase consisted of semi-structured open-ended interviews (illustrated in supplementary 4 of the appendix). Phase three's purpose was to evaluate how the contextualised smartphone learning experiences influenced healthcare providers' perceived SRL efforts. To overcome the challenge of having different types of participants in phase two from phase one, who might have very different learning needs, phase three participants was representative of participants in phase one and two. The research in this study was designed to produce insights that can be used to enhance SRL experiences design with deliberate repeated practice on smartphone-based gamified platforms; It was not designed to evaluate the repeated use of the technology on learning outcomes, which we have reported in detail elsewhere [31, 32]. A breakdown of the study participants in each phase is illustrated in Table 1.

Table 1: Summary of the Qualitative Research Phases

Phase	One	Two	Three
Method	Nominal Group Technique	Semi-Structured Interviews	Semi-Structured Interviews
Time	Apr 2018	Apr 2018	1 st Feb 2019 – 31 st Jul 2019
Cadre	In-training paediatric nurses	Consultant and in-training paediatricians	Senior nurses, junior doctors, and in-training nurses
Location	Regional paediatric training centre (Nairobi)	Annual national paediatric conference (Mombasa)	Regional hospitals and medical training centres (Nairobi)
Level	Actively practicing	Actively practicing	Students, actively practicing
Recruitment	Medical training institution, local hospitals	Annual medical conferences	Professional paediatric social network managing the ETAT+ [41] course, peer referrals, regional clinical meetings, local hospitals
Date	April 2018	April 2018	February - July 2019

The selected participants varied by cadres and expertise to reflect different experiences at different levels of speciality training in neonatal emergency care (Table 1). In the first phase, participants were recruited from amongst practising nurses from different hospitals in the region undertaking advanced paediatric training at a private paediatric teaching hospital in Nairobi. In the second phase, all recruited participants were paediatricians drawn from different parts of the country attending the annual national Kenya Paediatric Association (KPA) conference. The third phase consisted of participants who were medical and nursing students and practising junior doctors and nurses. In this phase, these participants represented hospitals and medical training institutions in Nairobi County and its environs.

The participants in all the phases were selected using both convenience and purposive purposeful sampling techniques. They were identified to ensure a range of participants with varied training experience, covering both rural and urban areas, and a variety of the geographical location of clinical practice (i.e. rural and urban), hospital resource settings (i.e. private and public) and level of training. All study participants had completed at least one learning scenario in LIFE before being included into the qualitative study. Different sets of participants and methodological approaches was used to generate situated and contextually rich data about learning that would serve to corroborate, validate, contrast or expound on items generated from the NGT phase (phase one).

Data collection and analysis procedures

Phase one of the study – the NGT phase - took two hours. Using the neonatal resuscitation module within LIFE, the NGT's single purpose was to generate and prioritise ideas around how-to better design LIFE to support and motivate personalised learning. This would be derived from healthcare providers' insights about their learning experiences. The procedures adopted are outlined in detail in supplementary 2 of the appendix. Data collection in the second phase was through semi-structured interviews, which were conducted with specialist paediatricians. These were analysed in juxtaposition to NGT analyses results, to highlight the varying views based on clinical cadre and experience. Each interview in phase two took between 20–25 minutes and was conducted in a designated space within the conference area. Data collection in the third phase was also through semi-structured interviews, each interview lasting 30-40 minutes. The NGT and interviews were all conducted in English.

TT facilitated phase one NGT with the help of NM, and CW. Phase two and three interviews were conducted by TT with CW aiding in participant recruitment. All interviews were digitally recorded and transcribed by a transcription service and checked for accuracy by TT. During the process of transcription, all participants were anonymised by assigning interviewee codes. The audio recordings and transcripts were stored in a password protected computer.

Because the individual in-depth interviews in phase three were being continuously interpreted together as the new interviews were occurring, questions that were not effective at eliciting perceptions and experiences related to clinical training were suppressed in favour of new ones. Thematic analysis [42] informed by SRL theories [43] and linked to the research aims was applied to the NGT and interview data after cross-checking and discussions with members of LIFE team.

SRL theory informed the analysis of the qualitative data but was not linked to the design of interview guides. SRL theory informed the analysis of how the immersive and interactive experiences that engaged the healthcare providers kept them motivated to continue learning. While we posit that LIFE provides SRL training opportunities, rather than explain the nature of SRL within the gamified platform, the analysis in this study focused on how healthcare providers perceptions of their learning experiences using LIFE aligned with SRL processes that have been explained in elsewhere in related studies [31]. This is because LIFE was designed to provide opportunities for autonomy and independence that can help set the phase for regulatory action and thinking. We did not explicitly ask about SRL experiences, so that the participants' level of knowledge of SRL concepts would be rendered inconsequential to the responses they provided.

Results

Baseline characteristics of the qualitative study phases

For phase one, the target was a cohort of nine study participants attending a continuous professional development nursing course. This cohort had only female nurses but the gender disparity is not unusual as more than 75% of nurses in Kenya are female [44]. Their median age and median experience in years was 34 and 6 respectively (Table 2). In phase two, five participants were interviewed, all of whom were paediatricians or paediatricians-in-training, including three females and two males (see Table 1–2 for group characteristics). In phase three, 19 participants made up of junior doctors, in-charge paediatric nurses, and nursing students were interviewed by TT. The median age of participants in this phase was 25 years with three years of experience. Across all the phases of the qualitative study, participants were drawn from seventeen different health facilities' paediatric units and departments spanning private clinics to public referral hospitals, geographically representing different regions of Kenya and reflective of the various professional cadres.

Table 2
Summary characteristics of study participants

Research Phase	Clinical Cadre	Institutions represented	N (% Female)	Age (years)	Experience* (years)
				<i>Median (IQR)</i>	<i>Median (IQR)</i>
One	Sub-speciality nurses in-training	8	9 (100%)	34.5 (30–38.75)	6 (3–8)
Two	paediatricians	4	5 (60%)	32 (31–33)	8 (7–8)
Three**	Senior nurses, junior doctors, and students	5	19 (52.6%)	25 (23.5–33.5)	3 (2–7.5)
Total		17	33 (66.7%)	31 (25–35.5)	5 (2–8)

*Note: *Experience reflects cumulative years of front-line service, including internship. ** 4/19 of these participants were junior doctors.*

- **Results from Nominal Group Technique.**

From the silent phase and item generation phase detailed of Nominal Group Technique (NGT) in supplementary 2 (appendix), the participants went through the listed items, discussing with and asking for clarification from each other, with the facilitator (TT) summarising the generated items as listed in Table 3. The participants tended to express their learning experiences using the app in a manner unlinked to specific in-app feedback design instruments even though that was what they were being asked to do. An example of this is item C, G or I in Table 3, where phase one participants attached value to how LIFE influences their cognitive processes. Additionally, during NGT, we felt that the brevity in the descriptions of the items generated by the participants was purposely done to avoid in-depth interrogation by their peers.

Table 3

Summary of design components derived through consensus from item - generation phase of the Nominal Group Technique.

Option	Description
A	Promote challenge using almost similar multiple-choice options
B	Accommodate differences in actual workplace practice in the scenarios
C	The timer adds pressure, anxiety, [<i>*viewed positively, to be retained as a feature</i>]
D	Give immediate feedback due to the "urgency" of the learning scenario [<i>*as opposed to providing delayed feedback at the end of the scenario</i>]
E	Improve the utility of feedback to help remember the correct answer [<i>*e.g. by adding more information links</i>]
F	Give immediate correct answer on first error screen but weight the final score when feedback message is provided to the wrong entry.
G	Sharpen <i>critical</i> thinking when playing the game [<i>*in reference to use of feedback messages in error dialogues, providing hints etc.</i>]
H	Add emojis to make enjoyable [<i>* e.g. When reflecting LIFE's evaluation of learner's progress</i>]
I	Challenging, if it's the learner's first time interacting with [<i>*ETAT+</i>] materials
J	Give a rationale for more <i>task</i> information. [<i>*Helps to build learner's appreciation of task importance</i>]
K	Add continuation to scenarios [<i>*quantity of training content</i>]
L	Cascade challenge and complexity level of the content
<p><i>Note: * Clarification added through discussions with study participants. **Two options (Give more demonstration of tasks; Reduce navigation difficulty;) were not discussed due to accidental omission by the session facilitator.</i></p>	

The identified thematic areas from the NGT discussions that generated Table 3 are expounded upon from the next section, and in juxtaposition to results from phase two and three analyses, for purposes of comparison and contrast. Participants in phase one ranked the items listed in Table 4 in order of decreasing priority, based on which items they were most inclined towards, impressed with, or would recommend being included (i.e. voting phase of NGT).

From the voting phase, each cell in Table 4 in rank columns represents the number of participants who voted for that item at that rank position. Given that there were 12 items to be voted upon, and participants were limited to only voting for their top 10 items, row-wise sums of the item votes could be less than or equal to the total number of participants. The weighted average rank, given as the sum of the ranks adjusted for the votes per rank, was calculated as illustrated in Eq. 1.

$$WeightedRank = \frac{\sum (row(cellwisevotes * rankposition))}{row(sumofvotes)} (1)$$

Table 4
Weighted rank of items generated from the voting phase of Nominal Group Technique

Item	Item description*	Rank										Average Weighted Rank**
		1	2	3	4	5	6	7	8	9	10	
F	immediate corrective feedback on first incorrect try	1	1	1	2	1	0	1	0	0	0	3.71
J	Task rationale with more information	2	2	0	2	0	0	1	0	1	0	3.75
G	Sharpening critical thinking using feedback	2	1	0	2	1	0	1	1	0	0	4
I	Challenging Content	0	2	1	0	1	0	1	1	0	0	4.5
C	Task timing	1	1	2	0	0	1	1	2	0	0	4.75
D	Immediate feedback due to learning task urgency	2	1	0	1	1	0	2	1	1	0	4.89
E	Improved feedback utility	0	1	0	1	1	2	0	2	0	1	6.13
A	Promote challenge using almost similar multiple-choice options	1	0	0	0	1	1	1	0	2	0	6.17
K	Add continuation to scenarios	0	0	2	0	1	2	1	0	0	2	6.25
L	Cascade challenge and complexity level of the content	0	0	1	1	1	2	0	0	3	0	6.38
B	Scenarios accommodate differences in workplace practice	0	0	1	0	1	0	0	2	1	0	6.6
H	Add emojis to make enjoyable	0	0	1	0	0	1	0	0	1	5	8.5

Note: *The item description provided as shorthand of descriptions given in Table 9.2.1. **The average weighted rank is given as the sum of the ranks adjusted for the votes per rank, with the formula provided in Eq. 9.3.1

The next sections of the results analyse responses from all the qualitative study phases through a thematic lens [42, 43], reflecting how experiences within different cadres and levels of speciality training in neonatal emergency care might map onto personalised training using LIFE. The themes identified from semi-structured interviews with participants are discussed in the following sections and are linked to Winnie Hadwins' SRL model [43].

Learning task definitions, elaboration and performance imperatives

Nursing and student participants interpretation of the aims of learning tasks within LIFE implied that from the game features provided within an assessed task, their attention was skewed towards performance (as indicated by their fixation with final score), rather than task elaboration. Specifically,

time spent on a task appeared to be intrinsically associated with the urgency of the learning task, considered inseparable from performance goal. This correlates with the high rank item F (*Immediate corrective feedback*) in Table 3.

"...As you begin, it took a little bit of time because you had to read the explanations and the questions...So, at the end of it you find that your resuscitation took a bit of a long period. And even as you start the game, you know at the end you are being timed which again I think is a good thing because again with resuscitation, you are dealing with life and death and you have a very short period of time, so your interventions have to be really correct and they have to be timely..." LIFEEXP12

However, paediatrician participants in phase two tended towards downplaying time as a task strategy and instead, sought to use feedback to inspire goals linked to refining skill competencies. In phase two, timing was perceived to be relevant when conditioned on pre-existing learner knowledge or practice and is dealt with in a later section of this paper. This would be more reflective of the rank of item I in combination with item C (*Task timing*) in Table 3.

"...timing should not be [there], but when you have the pop-up message telling you 'this is a life-saving procedure, you need to move, you need to make a decision, you need to make a step' it's good enough..." KPA002

In contrast, perceptions of phase three participants combined the emphasis of elaboration of the learning task together with its time-linked consequences.

"...Ideally, as nurses, ...you need to know because if you mess, if you do not do the right things at the right time the first time, most of the times you will mess up with those children. So, it is good to understand, 'why do I have to do this?'" LIFEEXP06

Learning task elaboration (a "More information" button within the LIFE app) and as indicated by item J (*Task rationale*) in Table 3 was highly valued among the participants in phase one and three, hinged on the perception of LIFE not as a game first, but as a learning tool. This is illustrated in the quotes below.

"...They [feedback messages] are explaining why you should do that so I found it quite educative because there are times when you are not even sure, 'why would I need to do this?' but they are able to elaborate it further. If they tell you it is a neutral position, why should the head be in a neutral position? Then they explain to you why. 'Why would I use this kind of mask rather than this other one?', you know..." LIFEEXP06

However, phase two participants preferred a standardised learning process that was not seeking within-game tasks elaboration as the preferred emphasis of the game. Given that phase two participants were paediatricians, they would have been exposed to ETAT + hence their agreement on this. They argued for elaboration of the learning goals to be articulated either before or after, but outside the LIFE game itself. This might be attributable to the differences in the level of training, prior experience and specialisation in the participants between the phases.

“...I think you can gauge how much people have internalised if you’ve given the talk and now use their scores and what mistakes they make to like correct things at the lab. So, I feel like it can still be used even without the ETAT setting, if you were just given like a CME or something. Like do a talk and then tell them, ‘Okay fine I want you to play this game’, then give them their scores at the end, you go like, ‘I realised that this are some of the few things that were hard to clear...’ I feel like it’s giving that talk before and giving them the goals of the game and what you expect them to achieve...” KPA003

Additionally, phase two participants appeared to be in agreement that an unintended consequence of tasks being elaborated in similar fashion to traditional educational tutorials diminishes the gaming experience, which is explained further in the *Games and engagement* results sub-section. Healthcare providers perceive limited internalisation of learning where there is no elaboration. The elaboration being referenced here not only emphasises the expected goal of the learning task being taught but also a nuanced breakdown of the consequences of [in]action or erroneous action.

Context of practice, cognitive adaptations and goal setting

Phase one and three participants perceptions on how LIFE might encourage personal evaluations were arguably a result of reflections on (1) context of resources and frontline work encountered so far, and (2) the cognitive effort put in weighing options available predicated on prior knowledge.

“... You know down there in the villages, things like a resuscitaire are not available and they actually have to do the resuscitation on a desk and not on a resuscitaire because the hospital doesn’t have a resuscitaire. Or even if they are available, they are not working. A normal resuscitaire should have a warmer at the bottom and the warmers are not even working in the hospital...” LIFEEXP03

“... Stimulate critical thinking... you think about resuscitation materials... I compare with what sometimes is practiced at place of work, like tickling the babies’ feet so I was like ‘I would like to tickle it also’...” NGTCONV

“... We have the scenario, like this is a new-born resuscitation, this is the flow chart, this triggers you, if at all you have done this before, it triggers you because you have the three Ss like shout for help, prepare your setting, wash your hands and all that then examine. So, when you are coming to the game itself like the scenario, when it comes to the choices you are like ‘this is off, this is off...’. But the way [LIFE] answers are, all the enticing ones are there: ‘this looks good, I will do this’. Then you are like ‘Oh! it is not correct’...” LIFEEXP11

Learning content relatability appears to influence self-evaluation of learning progression given a contextualised framing of learning objectives. Admittedly, it is worth noting that such necessary equipment for providing quality healthcare might not be readily available in typical rural facilities, but there is a need to keep the app in line with what should be done so as to continually reinforce best practice [45]. Curiously, the typical learning task strategies especially utilised by participants who had limited prior knowledge of task was use of guesstimation (educated guess) approach as illustrated below.

"... Yeah maybe one or two I guessed, and got... I eliminated the wrong and I arrived on the right..." KPA002

But guesstimation, when linked to the need for elaboration earlier addressed can be viewed as learning by understanding what not to do. Healthcare providers evaluated this learning strategy to be successful if it produced perfect conformity to the clinical care guidelines as evidenced in the quotes below.

"... [The score] represents the kind of management I am doing. Because if you do not score well that means the care you are giving is not right... let's say you have scored 20%, what is going to be the outcome of this baby? You are going to have a baby with severe cerebral palsy. You are managing in terms of, you know... to come out with somebody who is alive and not having any major complications..." LIFEEXP01

"...I think scoring 70% means you never understood the full training. It doesn't mean you can't provide all the care, because even scoring that 70% is still actually part of the training. But a person who scores 100%, there is a tendency for this person to be better trained as compared to the person who is scoring 70. But it doesn't mean that the person who is scoring 70 cannot take part in resuscitation..." LIFEEXP03

Even in the gamified smartphone-based training linked to clinical scenarios, there is limited perception of internalisation of learning where performance is not 'automatic' (i.e. characterised by very quick response to the learning task) and have a perfect score. Performance, while being regarded as not being exclusively constitutive of knowledge mastery, cannot be dissociated from the perception of knowledge mastery. Healthcare providers concern for patient outcomes was heightened by how they perform, but they do not consider this to be representative of their knowledge mastery, which they implicitly referred to as not being directly observable i.e. latent.

Phase two participants made a distinction of whether personal learning goals needed to be set based on (1) previous exposure to ETAT+, and (2) the number of previous plays on LIFE. These they argued, would mitigate any negative effects stemming from learner's first experience with ETAT + content, and once acclimatised to LIFE and ETAT+, focus on implications of erroneous knowledge on clinical outcomes. Where there was no previous knowledge of the content, the emphasis was on an exploratory learning approach, with goal-setting exercises building on previous rounds of play.

"...For beginners, maybe no, but [maybe] if someone has either played it before or has done it before. I feel like because you, you know the sequence, you'd be like, 'Okay fine the next step is I want to do it in less time' ... for the purpose of this learning, it, it wouldn't be that useful...doing the game the second time, I think that will improve on your time and like improve on your skills. Yeah maybe it will be useful for those people, for first-timers it is discouraging..." KPA 003

"...Well for me, I think getting a perfect score, translated to how well I understood the scenarios... like I was reminding myself what I had forgotten about ETAT+. So for me the motivation was other than the high score, whenever I scored higher than I did initially, I was like 'Wow, I think I am getting better', you know? it is like I am beginning to showcase whatever I have learnt in that particular scenario and putting it into

practice now, like ‘...how well had I gotten the concept and how well I’m replicating it in the scenario now...’ LIFEEXP10

At a global level, LIFE’s goal-oriented imperative of saving lives at birth was well understood and internalised by the participants in all the qualitative study phases in general, with the clear intended consequence being building confidence to provide care.

“...If I had a life, in front of me that means I would have gotten it wrong when I’m doing an emergency procedure that I need to know, so that was scary... I know it’s more of goal-oriented, to have more confidence, you need to pass, you need to get better...” KPA002

These strategic learning adaptations informed by personalised learning goals which constantly evolve based on perceptions of knowledge mastery have implications on the type of instructional support expected and to what end. We expound on this in the next section.

Feedback and motivation, and transfer to practice

Feedback is the key mechanism for maintaining high SRL behaviour by allowing learners to monitor their engagement and attainment of their learning goals [46]. In LIFE’s case, it served to highlight the extrinsic motivation for learning, which healthcare providers understood to be the adequate management of the neonatal emergency cases. It also unearthed self-efficacy concerns from healthcare providers’ reflections:

“... I am a healthcare worker, how do I miss that, how do I get that wrong in resuscitating a new-born? But it’s good it’s there because it helped me know, ‘you are wrong on this one’. But on the other hand, ... I think I’m very bad if I can get a wrong on this...” KPA002

They perceived their self-efficacy concerns to be inseparable from their extrinsic motivation linked to a higher game score. Feedback needed to build up motivation for personal goal achievement at the individual learning task level in addition to encouraging the global goal of perfect automatic performance. This was reflected in phase one by items **D** (*Immediate feedback due to the learning scenario "urgency"*) and **E** (*Improved feedback utility*) in Table 3.

“Q: Having played it, in terms of the type of feedback you got from LIFE, what would you like to see?”

A

Maybe for them [the feedback messages] to say what I could do better, Okay, the overall point of the game was that we did it and the baby cried, I don’t know if it’s possible for them to, to say maybe he should have bagged faster, is there an option for that?...” KPA001

“...maybe it’s to say that ‘you’ve gotten at least X right ...It’s essential that you get this one also right...’ A way to imply that ‘Yes, you’re wrong, still, but try... we need you to improve’. What is the motivation after I get the wrong things? That’s what I’m thinking, what is the motivation? ...” KPA002

"...you can just give feedback at the end of it and tell me 'at this phase went wrong and this was supposed to be the answer' and then after revising something and then you go and start doing it, after getting where you went wrong, I will try and remember. Instead if you are done with this step and it tells you immediately... you feel stupid. Personally, I felt so stupid and I was like 'you don't know this thing?'"
LIFEEXP02

This illustrates how the corrective feedback messages (a) motivate individual learners to *keep reflecting in and on their action* and (b) might encourage healthcare providers to apply what they learn through LIFE in routine hospital settings as illustrated in the comments below.

"...[LIFE] is better than nothing because when we see that and when you call your consultant over the phone because you can be doing a resuscitation and you are like 'this child is actually not responding to the bagging that I am actually doing', once they talk to you over the phone and tell you that you need to actually give thirty breaths per minutes, if you have actually gone through the [LIFE] app ...like three times probably you would have seen the messages somewhere, and it would be better than that someone who has never heard about thirty breaths per minutes..." LIFEEXP03

"...But you know, at first before I played the game, I could have killed so many babies, but right now actually I am so confident, so I can handle it..." LIFEEXP02

Within gamified learning, targeted approaches leveraging on heightened learner emotions are needed to enhance learner engagement [47]. Through such targeting, gamification makes it easy to repeat cycles of game play, evaluation and reflection on learning performance, and adapting the learning strategy for next iteration, free from associated real-life risks associated with clinical learning content.

"...Because I understand that with such games, some of them actually they are more intense in the fact that they tell you that the baby has died... I've seen it before in other games and I would think when on emotional level it's somehow useful, you would want to save the life again. You know, through applications and games, it's the only time you can revive, resurrect someone to try and save them again..."
KPA004

"... You know when you play it [LIFE], it gets so interesting and then you are just like 'why did I get 75 and I want to get to 100?'... That was my goal! And then the more you play it and the more you want to hate it, but the more you are learning from it. And the more it gets easier..." LIFEEXP02

The reflection and adaptation within the repeated learning cycles are exemplified in the previously mentioned 'guesstimation' strategy where healthcare providers with partial understanding of care giving procedures try to deduce the gap in their knowledge by a partial elimination mechanism when responding to learning tasks, or reflect on their experience in routine clinical practice. Healthcare providers perceive their smartphone based SRL to be limited when their individual motivation for reflective learning is not targeted by the platform nor does learning address confidence and courage to act in the routine clinical

setting. This perception of limited learning reflects on their views of whether they are acquiring knowledge mastery (despite good performance) through SRL using gamified platforms.

It is peculiar that this subsection was barely mentioned in phase one, except as primarily intended to produce better scores instead of better capacity to respond to personal growth areas in delivering emergency care. These differences might be partially attributable to differing level of experience mediated by specialisation training, or due to the methodological differences between phase one NGT and the complimentary phases two and three.

Game experience and engagement

As a gamified smartphone-application, healthcare providers provided their views on the trade-off between content, design, and provision of supplementary learning resources in enhancing the game experience. In this regard, while phase one participants would want more task elaboration, phase two participants reflected on its perceived negative impact on the gamified experience.

"... You don't want to go so far from being in the game and actually is a bit of a game and a massive scientific quiz and research and information overload. Because people can get information from books and things...keep the game as a 'this is how we resuscitate babies, lets practice doing it, let's get into a routine, this is the protocol to follow', not digging so much in to the science behind it..." KPA005

"...I feel like if you added anything it would be too long, and someone would get bored in-between, but it would be a tough balance to add something and still keep people interested..." KPA003

However, the effort healthcare providers applied in learning tended to be low due to perceiving the platform as not requiring utmost serious-mindedness while using it. This could be attributed to a limited experience of immersion while using LIFE [47]. Such a learning posture towards gamified learning might hamper its acceptability as a novel modality of teaching if does not target to deeply immerse the learners [47].

"... You know like the way I was playing it, at first, I was playing it while watching movies but now like when someone tells you play this game there is a qualification you will do it with a lot of seriousness in it... I would play it with a lot of care and a lot of concentration..." LIFEEXP02

"...Probably I would have been keener because I told you that in one of the scenarios, class was going on and I was just here [playing it]. So, I wasn't concentrating, so probably I should have been keen and taken it as more of life and death situation. As opposed to treating it as just a game. So, I think if I would have been keener... I would have been more meticulous..." LIFEEXP10

"...I think there will be some initial resistance from people trained on mannequins and real babies...people saying, 'is this [form of] paediatrics training better?' ..." KPA005

Effort regulation will produce higher goal attainment where gamified platforms such as LIFE ensure heightened keenness and sombreness of healthcare providers learning through it. Additional incentives to

foster such postures towards SRL behaviours need to be further explored.

From the key findings, internalisation of the learning task would be maximised in the presence of feedback that elaborated on the consequences of [in]action or erroneous action. Such internalisation would be in response to learning content that was relatable due to its reflection of the clinical context and would help foster an engaging learning journey. Healthcare providers perceived themselves to have not internalised the learning content where their performance was not perfect nor were their responses to the learning tasks automatic. They also perceived achieving a perfect score as not being fully constitutive of knowledge mastery. Heightening the keenness and emotions of healthcare providers while learning was perceived to lead to enhanced learning and optimised effort regulation [47]. From the study participants, the validation that they had met their learning objectives was when they perceived that their courage to act in a routine clinical setting had been enhanced from the confidence in the knowledge gained produced in a healthcare provider. These key findings, which represent how the interviewed healthcare providers perceive SRL to be linked to their personal learning objectives, are illustrated by Fig. 1.

Discussion

Summary of findings

The qualitative research sought to explore the perceptions of Kenyan healthcare providers on the use of a gamified smartphone-based application platform (LIFE) for emergency care training in their context of clinical practice. Specifically, the interest was in how they perceived such platforms might be better implemented to enhance more engaging and fruitful self-regulatory learning experiences. The study participants were geographically from diverse regions of Kenya and included different clinical cadres involved in paediatric care at different levels of practice, experience and seniority.

The qualitative research highlighted differences in focus between participants in the different phases of the studies; for example, healthcare providers with less clinical domain specialisation concentrating on the time-mediated performance and learning task-elaboration while those with more domain-specialisation being more concerned with minimising risk on clinical outcomes associated with erroneous knowledge.

From the key findings, internalisation of learning task would be maximised in the presence of feedback that elaborated on the consequences of [in]action or erroneous action. Such internalisation would be in response to learning content that was relatable due to its reflection of the clinical context and would help foster an engaging learning journey. Learning was perceived to be limited (or not achieved) where performance was neither automatic nor perfect; However, achieving performance objectives was also not regarded as being fully constitutive of knowledge mastery (Fig. 1).

Comparison to other studies

We have initiated the implementation of the recommendations from previous studies to “...find a point where the intrinsic and extrinsic motivation of the players can converge...” [25] by starting to generate insights into self-regulated learning experiences necessary for improving gamified learning in clinical training. Such insights address a gap in research evidence from studies that involve healthcare providers from low-income countries [13, 22]. With scarcity of comparable evidence, we provide theory-informed considerations for enhancing learning experiences design and implementation of digital clinical education, specifically in the Global South [24]. Typical studies looking into the effectiveness of gamified digital clinical training do not highlight how learning theories inform their implementation or provide a framework for interpreting findings [22]. We provide theoretical underpinning for understanding how healthcare providers from SSA perceive (1) Their learning; (2) Interaction with the learning platforms that enhances their SRL, and (3) The theory of change for how their SRL-linked learning gains might be positioned for transfer to routine clinical practice. We offer a more nuanced explanation of the healthcare professionals’ learning behaviours linked to related evaluation studies reported elsewhere [31, 32], unlike previous studies in this area [13, 22]. We also have sought to thread the needle in this topic by providing a baseline conceptual framework that can inform the design and evaluation of similar interventions in contexts like Kenya.

Implication of findings

We have highlighted differences in focus between participants in the different phases of the studies, with healthcare providers with relatively less clinical domain specialisation concentrated on the time-mediated performance and learning task-elaboration, while those with more domain-specialisation were concerned with minimising the risk associated with erroneous knowledge (and clinical outcomes) and standardising knowledge. Self-regulated learning in gamified digital platforms within this context ought to cater for differentiated goal-achievement orientation by using novel and elaborative feedback mechanisms. However, these novel feedback designs while helping to support learners to diagnose, recognise, recover from errors, and ensure adherence to emergency-care standards [48], should not minimise the ‘game’ experience lest they render the platform to be similar to traditional learning tools which minimises the posited benefits of gamified learning on learner engagement [49].

Such novel elaborative feedback designs need to be underpinned by a clear theory of change of how at the learning-task level, motivation to continue learning is enhanced [49], and at the transfer-to-practice level, how such motivation might produce the intended action. These theories of change also need to highlight how they intend to create and maintain heightened keenness in healthcare providers SRL experience, while being cognisant of the learning content and context. This will aid in minimising flippancy in self-directed use of gamified digital platforms.

Another key implication of measurement in learning, even on gamified digital platforms, is being able to distinguish knowledge from performance, and in efforts to satisfy the healthcare providers interest in both, give an indication of both. The learners (who are healthcare providers in our case) make this distinction since they do not consider perfect performance to be wholly constitutive that they have grasped the concepts well. Informing them how they perform might not suffice if they cannot reconcile

how they perceive their knowledge. Change in healthcare provider's practice behaviour might not be observed until they are confident to act. Different approaches to building this confidence -whether through feedback messages, provision of a fully immersive VR experience which can move them closer to real-life experience, prompts for practical action linked to performance, or knowledge mastery approximation- ought to be considered.

Strengths and limitations

A key strength in our research is the use of methodological triangulation to validate and strengthen findings. This was further increased by using varied participants with differing experience, specialisation levels and expansive geographical representation. However, the lack of gender diversity is a limitation of this study. For phase two, while every effort was made to include more participants, limited conference time made it difficult to recruit. This was further exacerbated by the conference environment having moderate to extreme noise levels depending on the time of day making it difficult to conduct longer interviews. As a result phase two semi-structured interviews lasted between 25–35 minutes. Given that findings across phases cohere, any bias due to interview length, and number of recruited participants is likely to be minimal and we conclude saturation is achieved as evidenced by convergence of themes across phases [50]. It is also difficult to track impact on healthcare providers' clinical practice behaviour or effect on patient outcomes due to lack of availability of high-quality patient outcome data from routine clinical setting linked to the providers who used LIFE platform.

Conclusions

The use of gamified learning on digital platforms for clinical training in SSA contexts like Kenya ought to provide feedback elaborating the consequences of [in]action or erroneous action, which is hinged on relatable contextualised learning content. This would optimise learning experiences and heighten engagement and effort regulation of healthcare providers while learning. Use of theory of change that validates the self-directed learning of healthcare providers by building confidence in the knowledge gained and produces the courage to act in a routine clinical setting is necessary if self-regulated learning is to be effective in SSA contexts. We posit that the context-reflective conceptual model emerging from this study will encourage further development of smartphone-based self-regulated learning platforms and aid in making gains in patient outcomes in SSA.

Declarations

Ethics approval and consent to participate

This study was approved by the Scientific and Ethics Review Unit of the Kenya Medical Research Institute (KEMRI), (#3444). It was also approved by the Central University Research Ethics Committee (CUREC), University of Oxford (#ED-CIA-18-106). Individual consent for access to recording the interviews and collecting de-identified demographic data was acquired from participants.

Availability of data and materials

Data are available from the KEMRI's Data Governance Committee after successful application to KEMRI's Scientific and Ethics Review Unit for researchers who meet the criteria for access to confidential data.

Competing interests

The authors have declared that no competing interests exist.

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Author contributions

TT conceived the initial idea for the study with the assistance from NW and CP. NM, and CW helped in facilitation the study data collection and management. TT wrote the first draft manuscript with assistance from NW and NM. ME, NM, and CP then significantly contributed to a revision of the final manuscript for intellectual content and structure. All authors approved the final version prior to final submission.

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Figures

Figure 1

Illustration of the perceptions of self-regulated learning on gamified scenario-based training on digital platforms of the study participants

Supplementary Files

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- [Appendix.pdf](#)