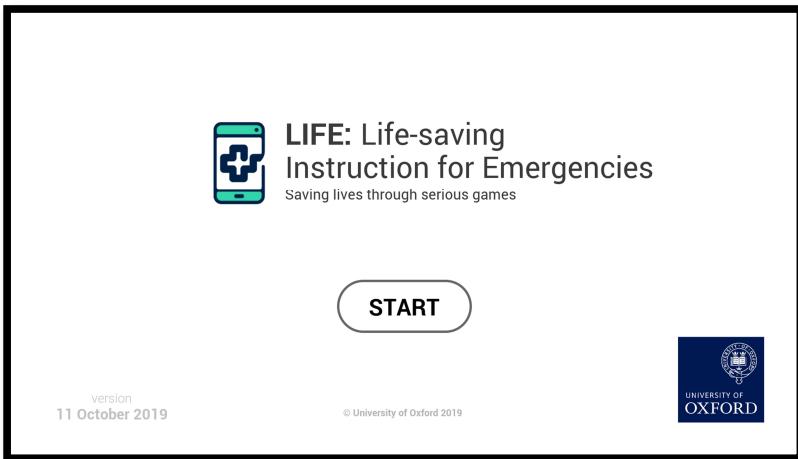


Appendix

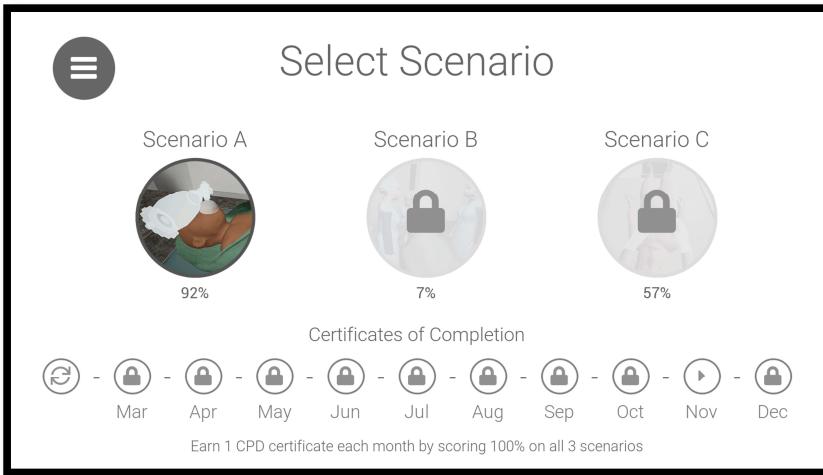
Supplementary 1: LIFE learning platform

This study utilises the Life-saving Instruction For Emergencies (LIFE) platform. LIFE is a smartphone-based clinical training intervention; an Android-based application developed to train healthcare providers from low-resource settings to manage neonatal and paediatric clinical emergencies [1]. The LIFE app is a gamified platform intended for use with low-cost smartphones to provide training in the care of very sick neonates with plans of expanding it to include other clinical care scenarios. It evolves scenario-based teaching where the components being assessed emphasise the tenets of paediatric critical care with early recognition of children 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 [2, 3]. Whereas game-based learning approaches involve the design of fully-fledged (serious) games, LIFE uses gamified learning approaches which focus on augmenting or altering an existing learning process to create an experience that learners perceive as game-like [4]. The LIFE app uses scenario-based teaching, where the components being assessed emphasise the tenets of paediatric critical care, including early recognition of children who need immediate care. Consequently, it follows a specific ordering of clinical care-giving algorithms, with each learning task being timed.

When the learner initiates the smartphone app, after tapping on the start button, they get a choice of learning scenarios. The user may select a scenario, and background information on the scenario which relates to the learning context and clinical care being trained on is provided (Supplementary figure 1 – 3).



Supplementary Figure 1: LIFE start screen



Supplementary Figure 2: Screenshot of example of scenario selection in LIFE



Supplementary Figure 3: Navigation task provided with scenario background information

The learner navigates to the next learning task by “tapping” on the *next* button on the smartphone (illustrated on the bottom right of Supplementary figure 4). Learning interactions on the LIFE smartphone application are primarily through finger press. There are three main types of learning interactions within LIFE:

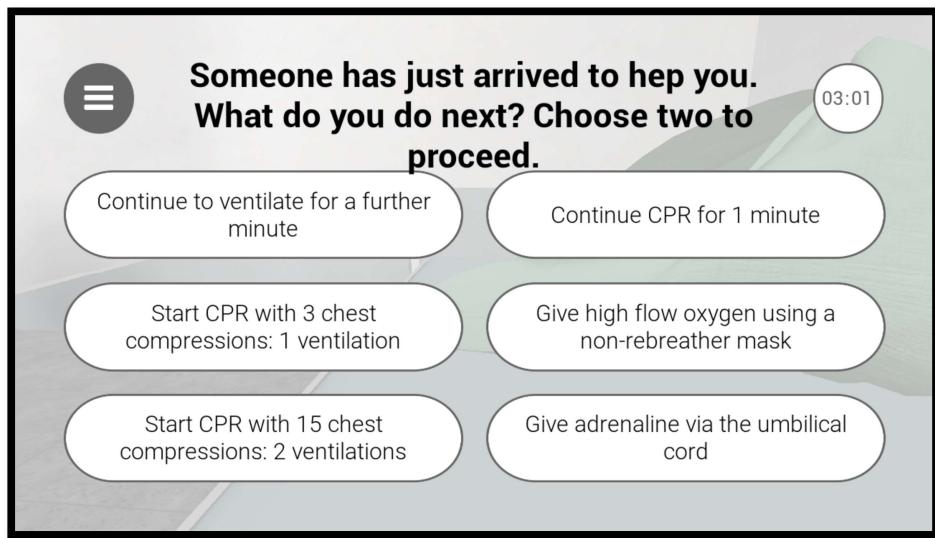
- a. Navigation interactions, where the learner must “navigate” the learning space to locate medical equipment, tools or patients, similar to a first-person game (Supplementary figure 4),



Supplementary Figure 4: Navigation interaction using on the smartphone device

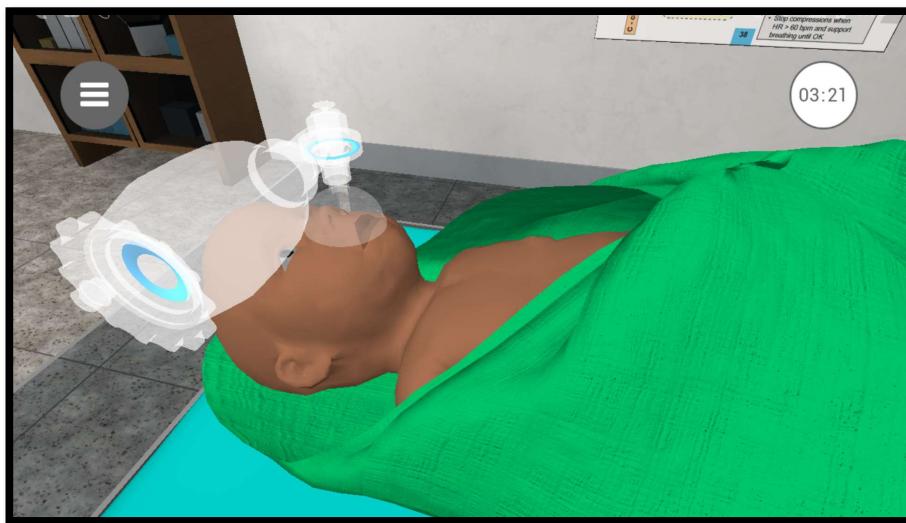
- b. Multiple choice questions where the learner gets to choose the next steps in the clinical care

giving process or identify the clinical criteria needed for decision (Supplementary figure 4).



Supplementary Figure 5: Multiple choice question illustration

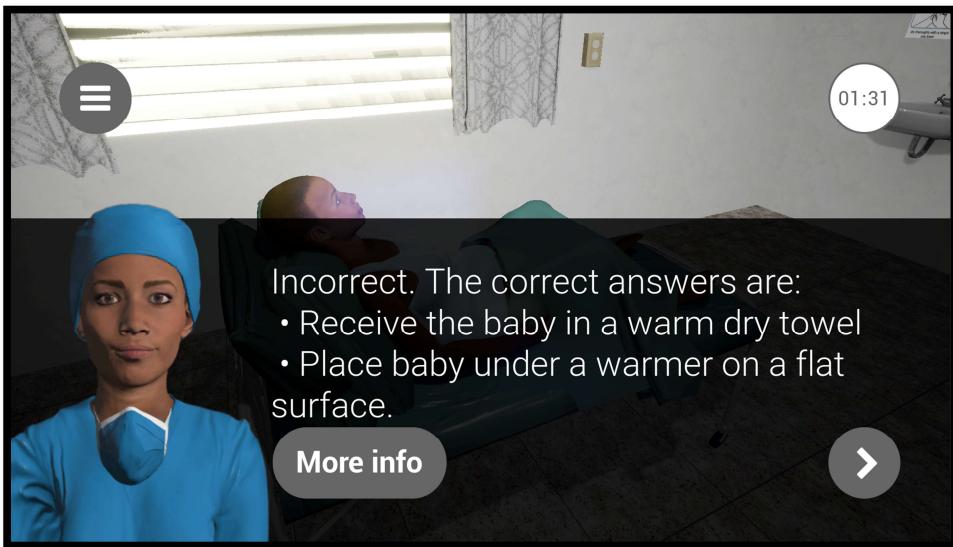
- c. Technique learning tasks, where the learner is assessed on their understanding of how to perform a clinical task, e.g. how to bag-ventilate a baby and perform bag presses at the correct rate consistently (Supplementary figure 6).



Supplementary Figure 6: Learning task assessing student's ability to perform bag-mask ventilation

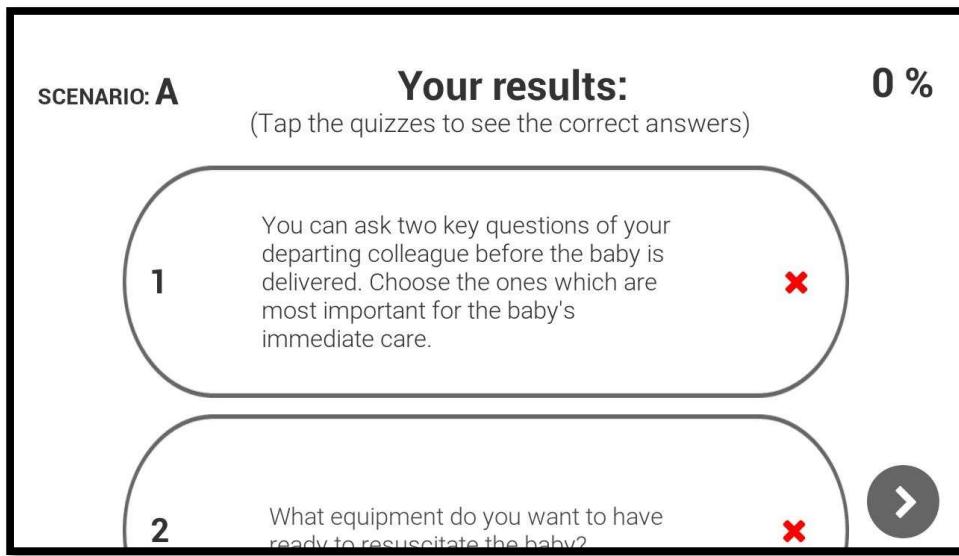
Each learning task elicits input from the learner. Each learning task is timed (Supplementary figure 6 top-right corner) but the learner has control over how long to contemplate over the question before attempting to answer it. The elicited input can be assessed as being correct or incorrect. For each

incorrect learner attempt, standardised feedback is provided, along with the option of seeing more information (Supplementary figure 7).



Supplementary Figure 7: Screenshot of example error feedback window in LIFE application

The standardised feedback on the first incorrect attempt requests the learner to repeat the task. The feedback on the second incorrect attempt provides a detailed explanation of the correct choices to select (Supplementary figure 7). The learner is forced to repeat the learning task until they make a correct attempt before they can then proceed to the next task. The end of the scenario is signalled by a crying baby, indicating that the baby is now breathing, and the neonatal scenario has been completed. A breakdown of scores is then provided to the learner (Supplementary figure 8).



Supplementary Figure 8: Learner's score card

Performance is calculated as the total score from all questions attempted where the learner was correct on the first try, without any feedback or help. The learner must attain a perfect score in Scenario A for the next scenario (in this case Scenario B) be *unlocked* (i.e. be given access to the content of the next scenario).

What the learner does during the learning sessions is captured by the number of learning tasks attempted, the number of tries per learning task, the amount of time they spend on each learning task, the level of feedback provided with each try, and the final performance score. Each quiz is a learning task representing a unique knowledge component that addresses a learning "...concept, principle, fact, skill, schema, production rule, misconception..." [5] within the clinical care-giving algorithm.

The scenario model that is used is one that replicates content from the "Emergency Triage, Assessment and Treatment plus admission care" (ETAT+), a validated face-to-face training programme [6, 7] that is approved by the World Health Organisation [8]. The ETAT+ content adapted for LIFE has been used to train healthcare workers and medical students across Eastern and Southern Africa, and

now East Asia on evidence-based, best-practice care for most common conditions in very sick children in low-income settings [6-8].

LIFE has been developed to be accessible at scale by healthcare providers and able to function off-line on low-end smartphone devices. The learner gets to choose when to use the learning app: that decision is not prescribed by the LIFE team. A key objective of LIFE is to provide self-regulated training opportunities akin to continuous professional development to learners. LIFE's design emulates the low-dose high-frequency (LDHF) training model to encourage repeated refreshing of emergency care knowledge but without any face-to-face facilitation or classroom learning [9]. In low resource settings, this model, although typically face-to-face, has been shown to be effective for clinical care training in SSA [10]. The development of the simulated scenarios is an iterative user-centred design approach with continuous feedback from new and old cohorts of study participants on training content, platform interactivity, user experience and design parameters for future consideration. The LIFE team continually evaluates the platform with different cohorts of healthcare providers in East Africa.

Supplementary 2: Procedures used in Nominal Group Technique

Open with introductions

Go through informed consent process

LIFE game play

Details on how to conduct Nominal Group Technique (NGT) are detailed elsewhere [11]. Due to concerns about exposure to serious gaming and digital learning technologies, limited time going through the LIFE app and language barriers, NGT main question - "How might LIFE be better designed to support and motivate personalized learning in Kenyan context?"- was broken down into modular questions using visual aides to help guide the NGT. In brief, the phases listed below explain how NGT was carried out.

1. *Nominal or silent phase.* During this phase individuals considered their responses to ***the question*** privately and write down their responses without discussion. Interaction was discouraged to prevent individuals dominating the process of idea generation. The role of the facilitator at this phase was to introduce the task and to focus the group upon the question without influencing the responses individuals made.
2. *Item generation phase.* The ideas generated by individuals were then shared within the group. This was done through a process which involved the leader asking each member in turn to present an idea in a ***succinct*** phrase. All ideas were recorded verbatim on a flip chart. This procedure continued without discussion until no new ideas were forthcoming. Participants were allowed to pass when they had no items to present but could contribute again in future rounds if an idea occurred to them subsequently.

In this study, the nominal group silent phase considered on the question “*How might LIFE be better designed to support and motivate personalised learning*”. Participants listed on a sheet of paper responses linked to six key representative aspects of the LIFE game interactions identified a priori (the quiz items, the tactile task items, the error interfaces, the help instructions, the more information interfaces and the score screens), until all were confident that they had generated an exhaustive list of items. The next step of this phase involved the participants listing on a white board what they had generated, one by one, adding new items not listed by previous participant, until all were done.

3. *Discussion and clarification phase.* This step in the process enabled the participants to ask questions, to seek clarification and to indicate agreement or disagreement with any items on the list. Each item was discussed sequentially, and participants were able to combine items with similar meanings or to eliminate those items which were duplicated. The facilitators role

during this phase was to lead the discussion and to ensure that the influence of the more vocal or powerful members of the group was minimised.

4. *Voting phase.* Each participant was asked to select ten items on the list that were most important to them and to rank these in order of priority, assigning a value of 1 to the most important item and a value of 10 to the least important item. This is done independently and privately. The facilitator then collected the ranking forms and tallied the results in order to determine the group's priorities.

Supplementary 3: Semi-structured interview questions for phase two of the study

Open with introductions

Go through informed consent process

LIFE game play

GLOBAL AIM: How might LIFE be better designed to support and motivate personalised learning of new and continuing healthcare courses in Kenya.

1. What about real-life frontline experience in a Kenyan hospital practice does this LIFE scenario not address?
2. In your experience, given varying learning capabilities of clinician students, how would you advise LIFE to better individually support each learner?
3. What would you advise LIFE to include to better encourage self-assessment and reflective evaluation within student clinicians?
4. Within LIFE what do you think should be done to ensure accurate understanding of the material at a personal level?

Supplementary 4: Semi-structured interview questions for phase three of the study

Open with introductions

Go through informed consent process

1. How many times did you end up playing LIFE?
2. **[IN GENERAL]**, how has your experience going through ETAT+ material through LIFE smartphone application been?
 - a. Why do you think it took you #N tries to achieve a score of 100%?
 - b. Do you think your experience had any role in how you performed? Why?
3. Does the content you've learnt through LIFE relate to the training you are currently receiving?
4. What made ETAT+ content on the LIFE smartphone application **[DIS]engaging** for you and why?
5. **[IN DETAIL]**, how did you find the feedback provided through LIFE? Why?
 - a. If you didn't get a task correct, how would you prefer help to be provided?
6. Did you use the LIFE application more than once?
 - a. If yes,
 - i. What made you use LIFE for learning again and why?
 - ii. How did your learning strategy change in the subsequent play and why?
 - iii. What would make using LIFE more rewarding for you?
 - b. If no,
 - i. What made you not repeatedly use of LIFE?
 - ii. Finish this sentence: "*If only LIFE was ... I would use it more*"
7. What would motivate you to re-use LIFE to learn **during your own free time**?
8. Given the chance to earn *Continuous Professional Development* (CPD) points, would you use LIFE differently? Why **[NOT]**?
9. If you knew you were going to be asked to provide neonatal resuscitation care based on your score on LIFE, how would you use LIFE app differently?
10. Did learning through LIFE have any impact on your beliefs about your capabilities to deliver emergency care? Why?
11. Anything more to add?

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