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Evaluating TESLA-G, a gamified, Telegram-delivered, quizzing platform for surgical education in medical students: a protocol for a pilot randomised controlled trial

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Evaluating TESLA-G, a gamified, Telegram-delivered, quizzing platform for surgical education in medical students: a protocol for a pilot randomised controlled trial

Matthew Song Peng Ng, Ahmad Ishqi Jabir, Tony De Rong Ng, Yi-Ian Ang, Jeng Long Chia, Darren Ngiap Hao Tan, James Lee, Dinesh Carl Junis Mahendran, Lorainne Tudor Car & Clement Luck Khng Chia

1 Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore
2 Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore, Singapore
3 Department of General Surgery, National University Health System, Singapore, Singapore
4 Department of General Medicine, Khoo Teck Puat Hospital, Singapore, Singapore
5 Department of General Surgery, Khoo Teck Puat Hospital, Singapore, Singapore

Correspondence to Assistant Professor Lorainne Tudor Car; lorainne.tudor.car@ntu.edu.sg

Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore, Singapore
11 Mandalay Rd, Singapore 308232

Lorainne Tudor Car and Clement Luck Khng Chia are joint senior authors.

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Abstract

Introduction

Online multiple-choice question (MCQ) quizzes are popular in medical education due to their ease of access and ability for test-enhanced learning. However, a general lack of motivation among students often results in decreasing usage over time. We aim to address this limitation by developing Telegram Education for Surgical Learning and Application Gamified (TESLA-G), an online platform for surgical education that incorporates game elements into conventional MCQ quizzes.

Methods and analysis

This online, pilot randomised control trial will be conducted over two weeks. Fifty full-time undergraduate medical students will be recruited and randomised into an intervention group (TESLA-G) and an active control group (non-gamified quizzing platform) with a 1:1 allocation ratio, stratified by year of study.

We will evaluate TESLA-G in the area of endocrine surgery education. Our platform is designed based on Bloom’s taxonomy of learning domains: questions are created in blocks of 5 questions per endocrine surgery topic, with each question corresponding to one level on Bloom’s taxonomy. This structure promotes mastery while boosting student engagement and motivation. All questions are created by two board-certified general surgeons and one endocrinologist, and validated by the research team.
The feasibility and acceptability of the pilot study will be assessed by participant recruitment and retention rates, acceptability of the intervention, adherence and task completion rate, fidelity of the intervention delivery, and perception of the intervention. The effectiveness of the intervention (TESLA-G) compared to the control will be assessed by improvement in knowledge from pre- to post-intervention, learner satisfaction post-intervention, and retention of knowledge 2 weeks post-intervention.

**Ethics and dissemination**

This research is approved by Singapore Nanyang Technological University (NTU) Institutional Review Boards (Reference Number: IRB-2021-732). This study poses minimal risk to participants. Study results will be published in peer-reviewed open-access journals and presented in conference presentations.

**Trial registration number**

NCT05520671
Strengths and limitations of this study

● This study contributes to the growing body of literature evaluating the use of test-based learning, messaging apps and gamification in medical education.
● The gamified, Telegram-delivered, surgical education-focused, quizzing intervention in this study will be structured in line with Bloom’s taxonomy.
● We will use quantitative and qualitative approaches to assess our intervention with the aim of informing a future randomised controlled trial.
● A potential limitation of this study is that 14 days of intervention may be insufficient to observe improvements in surgical knowledge.
● The intervention will focus on endocrine surgery and the findings may not be generalisable to other surgical or medical subspecialties.
Introduction

Background and rationale

Multiple-choice question (MCQ) quizzes are a well-known and widely used medium for summative assessment, especially in medical education [1,2]. Their ability to provide objective grading and immediate feedback also make them popular tools for formative assessment [3,4].

While MCQ quizzes tend to be associated with diagnostic or assessment tools, Roediger (2006) proposes that tests like these can be used to improve learning via test-enhanced learning [5]. This effect has been increasingly explored in medical education [6]. Randomised controlled trials have demonstrated how test-enhanced learning can increase acquisition and retention of new medical knowledge among medical students [7] and healthcare professionals [8]. Recent systematic review by Green (2018) also supported these findings [9].

With the progressive use of technology in medical education, online learning is becoming increasingly common. Online learning has been found to be as effective as offline learning in medical education based on meta-analyses by Pei (2019) and Vaona (2018) [10,11]. Brame (2017) suggests that making MCQ quizzes available online would allow easy access to frequent practice, which could work synergistically with test-enhanced learning to promote student learning and long-term knowledge retention [12]. This is further supported by studies that demonstrated increased exam performance after administering pre-exam online quizzes to undergraduate university students [13,14]. Kibble (2007) also established a positive relationship between unsupervised formative online quizzes and academic performance among medical students [15].
However, online MCQ quizzes are limited by a decline in quiz participation over time and an increase in drop-out rates. [13,14,16]. This was observed in several studies despite the initial enthusiasm and high take-up rate among the student body. Mitra (2015) and Johnson (2006) specifically attributed this high attrition to a general lack of motivation among the students to use the MCQ quizzes [13,16]. We aim to address this limitation of low motivation among students using online MCQ quizzes by developing Telegram Education for Surgical Learning and Application - Gamified (TESLA-G). TESLA-G is an online platform for surgical education that incorporates game elements into conventional online MCQ quizzes.

Gamification can be defined as the use of game elements such as point systems, leaderboards, and incentives in non-gaming contexts [17]. A randomised controlled trial by Barrio (2016) showed that the use of gamification in undergraduate education can boost motivation and interest [18]. A recent review by Sandrone (2021) further suggests that the use of gamification in medical education can promote engagement and motivation among learners [19]. Additionally, systematic reviews [20,21] suggest that the use of gamification for learning among healthcare professionals is as effective as other educational methods in promoting knowledge and expertise.

Nevin (2014) successfully incorporated gamification in medical education through Kaizen-IM, an online learning platform developed by the authors for internal medicine residents. The authors demonstrated that the gamification elements such as team-based score system, a leaderboard showing rankings, and badges as incentives improve medical knowledge acquisition and retention. Participants also mentioned that the game elements, especially the leaderboard, were significant motivators in their usage of the platform [22]. Notably, the use of mobile technology in gamified learning has been shown to be a motivating factor among students. Licorish (2018) found that the use of the gamified mobile platform Kahoot! among undergraduate students
promoted student engagement and motivation [23]. This was attributed to students being highly proficient in mobile technology, which greatly contributed to significant student enjoyment in trying out applications and games that have been built specifically for mobile platforms [23].

Instant messaging applications have been used as a supplementary tool to medical education, [24], and several studies have shown an improvement in knowledge level through the use of these platforms [25–28], most notably with the application WhatsApp. More recently however, the increasingly popular messaging application Telegram has been trialled for use in medical education in the context of the COVID-19 pandemic [29,30]. Telegram was the most downloaded app in the world in January 2021 [31], and still remains as the top five most popular messaging apps globally in 2022 [32]. Not only is this app accessible on almost all computer and mobile platforms, the increasing use of Telegram in the upcoming years would mean that it is very likely that participants will already have this app installed in their devices even before the commencement of the study. By tapping on existing Telegram features and its well-documented Application Programming Interface (API), we will implement TESLA-G to provide flexible and convenient surgical education anytime and anywhere. Hence, our online, gamified quizzing platform TESLA-G will be delivered using Telegram with the aim of easier delivery of the intervention and greater uptake. We intend to evaluate our intervention in a stepwise manner in line with the UK Medical Research Council’s guidance for developing and evaluating complex interventions [33]. In this pilot study, we will evaluate the feasibility and acceptability of delivering our intervention with the aim of informing a future randomised controlled trial.
Objectives

The main objective of the pilot randomised controlled trial is to evaluate the feasibility and acceptability of a gamified, online, Telegram-delivered quizzing platform TESLA-G compared to conventional MCQ quizzes for surgical education among medical students.

More specifically, we will investigate:

1. The feasibility of recruitment, specifically the duration required to complete the recruitment process, the recruitment strategy, randomisation and stratification strategy, and participants’ retention rate throughout the proposed intervention period.

2. The acceptability of the intervention to medical students, in terms of its technical, pedagogical, and educational content (surgical content).

3. The participants’ adherence to the intervention, in terms of the number of completed quiz questions, frequency of use, and average daily quiz completion rate.

4. The fidelity of the intervention protocol, in terms of whether the assessment materials, technical implementation of the intervention, and study procedures are delivered and successful.

5. The participants’ experience of the intervention, by inviting a purposive sample of the medical students to share their views via semi-structured interviews after the intervention.
Our secondary objectives are:

1. To evaluate the effectiveness of TESLA-G compared to conventional MCQ quizzes in improving surgical knowledge by comparing the change in scores between the pre- and post-intervention tests.

2. To compare students' satisfaction with TESLA-G compared to conventional MCQ quizzes using a post-intervention satisfaction survey.

3. To evaluate the effectiveness of TESLA-G compared to conventional MCQ quizzes in retention of surgical knowledge which will be determined by comparing the scores a follow-up knowledge test administered 2 weeks after the post-intervention test.
Methods and analysis

Trial design

We report this protocol in line with the SPIRIT (Standard Protocol Items for Randomised Trials) recommendations [34]. This is an online, pilot randomised controlled trial with two parallel active groups. It will involve an intervention group and an active control group. Participants will be randomised into these two groups with a 1:1 allocation ratio stratified by year of study.

Study setting

The study is an online study conducted on Telegram. The study will recruit first to fifth year medical students from a medical school in Singapore.

Eligibility criteria

Eligible participants must be

1. at least 18 years of age;

2. currently enrolled in a full-time 5-year undergraduate programme in the medical school that leads to the Bachelor of Medicine and Bachelor of Surgery (MBBS);

3. willing and able to provide consent for participating in the entire duration of the study including all pre- and post-study assessments.
The intervention

TESLA-G is a novel gamified quizzing platform aimed at improving surgical knowledge among undergraduate medical students. For the purpose of this study, we will evaluate the use of TESLA-G in the learning of endocrine surgery among medical students. Our platform is designed based on Bloom’s taxonomy of learning domains, which is a widely applied and researched framework to construct learning objectives [35]. Questions will be created in blocks, where each block will test a specific topic in endocrine surgery. Each block has 5 questions, and each question corresponds to the first five levels of the Bloom’s taxonomy (Remember, Understand, Apply, Analyse, Evaluate) and each level in game (Table 1). The questions are structured in this way to promote mastery in endocrine surgery while boosting student engagement and motivation.

For this study, we aim to create 56 blocks of 5 questions, totalling 280 questions. All questions will be created by two board-certified general surgeons and one endocrinologist, and validated by the research team.
<table>
<thead>
<tr>
<th>Level 1</th>
<th>Remember</th>
<th>Questions here encourage students to recognise and recall facts.</th>
<th>FNAC thyroid reveals a benign follicular nodule. What Bethesda category would this be in?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2</td>
<td>Understand</td>
<td>Questions here motivate students to understand the meaning behind the memorised facts.</td>
<td>FNAC thyroid reveals a Bethesda category II follicular nodule. What is the probability of malignancy?</td>
</tr>
<tr>
<td>Level 3</td>
<td>Apply</td>
<td>Questions here allow students to apply their knowledge in a clinical setting.</td>
<td>31 year old lady was referred by a GP who noticed a goitre incidentally. Which of the following clinical features would be most suspicious of malignancy?</td>
</tr>
<tr>
<td>Level 4</td>
<td>Analyse</td>
<td>Questions here would expect students to analyse the clinical presentation and use logical deduction to figure out the differential diagnoses.</td>
<td>31 year old lady was referred by a GP who noticed a goitre incidentally. Further workup shows a solitary nodule in the right thyroid 2.5cm. FNAC reveals Bethesda category II follicular nodule. Patient thyroid function is normal.</td>
</tr>
<tr>
<td>Level 5</td>
<td>Evaluate</td>
<td>Based on a constellation of clinical findings, students are expected to critically examine and select the most appropriate investigations or management options.</td>
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<td>31 year old lady was referred by a GP who noticed a goitre incidentally. Further workup shows a solitary nodule in the right thyroid 2.5cm. FNAC reveals Bethesda category II follicular nodule. Patient thyroid function is normal. What is the most appropriate management?</td>
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Table 1: sample block of 5 questions corresponding to different Bloom’s taxonomy levels
The aim of the game is for players to get as many points as they can before the timer runs out. Each game will feature only one block of 5 questions, allowing students to focus on a specific topic in endocrine surgery per game (Fig 1).

Below is a run-through of the game:

1. The game starts at Level 1 with a 3-minute countdown timer and 3 lives.
2. For every question answered correctly, students will be awarded points based on their speed and the question level. An explanation of the question will also be shown. They will then progress to the next level up till level 5.
3. Consecutive correct answers will be rewarded via a point multiplier system. The longer their “streak” of correct answers, the higher the multiplier. It should be noted that levelling up does not require consecutive correct answers.
4. If they get a question wrong, they lose one life, and the point multiplier system resets. They must then answer that question again until they get it correct.
5. The game ends if the level 5 question is answered correctly, if all 3 lives have been used, or if the timer runs out. The total score is then tabulated.

To ensure proper mastery of surgical concepts, the countdown timer will pause in between questions for students to refer to the explanation pop-up. Students will be given as much time as they need to read the explanation and understand the information presented before they move on to the next question. There is no score deduction for spending too much time reading the explanation after each question.

To promote competition-based learning, all students are ranked against each other based on their points, and a leaderboard that displays the top 10 students is sent to all students daily. We
also allow students to track their own learning by providing a personalised dashboard for students to see their score history and progress. Finally, to promote consistent usage of TESLA-G, a bonus point multiplier is awarded for every consecutive day the game is played.

Timeline

The study flow is summarised in Fig 2 and the logic model is shown in Fig 3. Before any participants are recruited, all tests and surveys will first be piloted by all researchers involved in this study. Qualitative feedback will be independently obtained from at least 3 researchers, and tests and surveys will be amended accordingly.

(i) Pre-intervention

Fifty medical students (N = 50) will be recruited for the study based on the eligibility criteria. After obtaining informed consent, all participants will be expected to complete a demographics survey. Basic information about name, gender, age and year of study in medical school will be collected.

The Telegram username and email address of each participant will also be collected and verified. This is for the main purpose of disseminating information regarding our study. These include important deadlines to take note of, instructions on how to access the quizzing platforms and links to the other surveys required for our study.

All participants will then complete a pre-intervention knowledge test comprising 20 MCQs on endocrine surgery over a 30-minute period. This will determine the baseline surgical knowledge level among all participants.
(ii) Intervention

Participants will be verified to have completed all the above before being randomised into either the intervention group or the control group. Participants will then be provided with detailed instructions on using either TESLA-G for the intervention group or the conventional quizzing platform for the control group.

Participants in the intervention group will be provided access to TESLA-G as previously described. A link to access TESLA-G will be sent to participants from an automated Telegram bot; this access will be provided for 14 days.

Participants in the control group will be given access to a conventional quizzing platform, which will be a non-gamified version of TESLA-G. Whenever a participant enters the platform, a question stem and five options will be displayed. The participant will select an option, and the correct answer appears with the explanation provided. The platform will then send the next question, and the process continues, until the participant decides to exit the platform or all the questions in the platform have been answered. Similar to the intervention group, the questions will be queued in blocks where each block corresponds to a specific topic in endocrine surgery. Within each block, questions will be randomised, that is, they will not be queued based on increasing levels of Bloom’s taxonomy. Participants will also not be notified what level of Bloom’s taxonomy each question is classified under. Just like the intervention group, participants will be sent the link to access this platform from an automated Telegram bot, and they will be able to use the platform for 14 days.
For both the intervention and the control groups, all questions will be made available to all participants from the beginning of the study. If any participant does not use their quizzing platform for more than 48 hours, a Telegram message will be sent as a gentle reminder to continue participation. This would promote continuous usage of the quizzing platforms throughout the entire duration of the study.

Of note, throughout the usage of either quizzing platform, participants will be shown new and previously completed questions, for the purpose of mastering new knowledge and reinforcing past concepts, respectively.

Participants will use their assigned platform at their own pace and time. During this period, user metrics will be collected from both the intervention and the control groups including overall platform, per-participant and per question metrics as presented in Table 2.

Finally, throughout the duration of the intervention, participants will be able to contact a designated study team member via Telegram or via email for any assistance with potential technical difficulties with using their quizzing platform.
Overall platform metrics | Per-participant metrics | Per-question/block metrics
---|---|---
Game performance
- Number of logins per hour, per day and over the full study duration
- Total usage duration per hour, per day and over the full study duration | Participant engagement
- Number of daily logins
- Number of questions and blocks that were completed daily
- Number of questions and blocks that were re-attempted daily
- Time of logins | Question engagement
- Number of users who completed each question and block
- Amount of time spent on the explanation pop-up

Participant performance
- Daily usage duration
- Individual scores per gameplay | Question performance
- Distribution of answers for each question
- Number of users who obtained the correct answer for each question
- Numbers of users who obtained a full completion for each block

Table 2: game metrics to be collected from both groups. A block refers to a question block of 5 questions, as previously described.
(iii) Post-intervention

After 14 days, all participants will complete a post-intervention knowledge test which again comprises 20 MCQs on endocrine surgery over a 30-minute period. This test will be of a similar standard to the pre-intervention test as described earlier. Improvement in surgical knowledge will be measured as the difference in knowledge test scores pre-intervention and post-intervention.

All participants will also complete a post-intervention learner satisfaction survey. This will be in the form of a Likert scale adapted from the System Usability Survey (SUS) [36] and the Student Evaluation of Educational Quality (SEEQ) Questionnaire [37]. The survey will find out if the intervention group of students are more satisfied than the control group. To incentivise participants, the top three participants of the leaderboard will receive small tokens of appreciation in the form of a certificate and a custom badge reel with the TESLA-G logo.

After another 14 days, participants will be asked to do a follow-up knowledge test which once again comprises 20 MCQs on endocrine surgery over a 30-minute period. At this point, participants in both the control and the intervention groups will not have access to their respective online quizzing platforms. This test will be of a similar standard to the post-intervention test as described earlier. Any retention in surgical knowledge will be measured as the difference in knowledge test scores post-intervention and follow-up.

After the follow-up knowledge test, ten participants from the intervention group will be purposefully selected for individual interviews. Two participants - one who has completed at least 80% of the quizzes and one who has not - will be selected from each of the five academic years of the medical school. We aim to obtain qualitative feedback regarding the overall
experience of TESLA-G, along with the benefits, drawbacks, receptiveness and usefulness of the platform as a supplement to surgical education. The interviews will be conducted based on the interview guide (Supplementary File, Interview Guide) which has been adapted from a previous exploratory study on using Telegram for surgical education [38]. The interviews will also be piloted on up to five students and/or research team members prior to the beginning of the study.

The interviews will be conducted individually, either online or in-person, and will last 60 minutes. Written and verbal consent will be taken, before the interviews are recorded to be transcribed into text data for qualitative analysis. The audio recordings from the interviews will be transcribed by an automated software and proof-read to ensure that the transcripts are accurate. The completed transcripts will not contain any identifiers.

Outcome measures

A mixed-method approach will be used to establish the feasibility and acceptability of the intervention as primary outcomes. Our secondary outcomes will be improvement of surgical knowledge between the control and intervention group and potential adverse effects. Finally, qualitative feedback from the participants regarding their experience of the intervention will be thematically analysed.

(i) Feasibility

The feasibility of the intervention will be assessed quantitatively as shown below. These are the goals for our intervention:

- Enrollment of 50 participants in a month
- Retention of at least 75% of participants who are enrolled
- Completion of at least 80% of the quizzes

Success in achieving all three goals will indicate that it is definitely feasible to conduct a full-scale randomised controlled trial (RCT) while achieving two out of three goals will indicate that it is probably feasible. Achieving less than two goals will suggest that a full-scale RCT is not feasible with the current procedure.

In addition to the above outcomes, we will also determine:
- The feasibility of the randomisation procedure to ensure equal number of participants within the different university years in each stratum within the intervention and control groups
- Amount of time on app and on task
- Feasibility of the delivery method for the pre-, post- and follow-up assessments
- Number of app crashes
- Number of app exits during task

(ii) Acceptability

The acceptability of the intervention and the study procedure will be assessed both quantitatively and qualitatively. Quantitative data will be collected via a post-intervention learner satisfaction survey for both the control and intervention groups. This survey will consist of two parts - a system satisfaction questionnaire and a content satisfaction questionnaire.

The system satisfaction questionnaire measures the system acceptability score via a System Usability Survey (SUS) [36]. It is a 10-item questionnaire with a 5-point Likert scale that ranges
from 1 (strongly disagree) to 5 (strongly agree). This widely used usability scale will be used to compare the relative usability between TESLA-G and our conventional quizzing platform based on a normalised score. For the SUS, we aim to get an average score of at least 70 which would indicate Grade B based on the Sauro and Lewis (2016) curved grading scale [39].

The content satisfaction questionnaire measures the content satisfaction score and is loosely adapted from the Student Evaluation of Educational Quality (SEEQ) Questionnaire [37]. The SEEQ evaluates 9 distinct components of teaching effectiveness with a 5-point Likert scale that ranges from 1 (very poor) to 5 (very good). This validated study has been rigorously evaluated in higher education [40,41] and has been used in clinical education [42,43]. This questionnaire will compare the relative benefit of content delivery between TESLA-G and our conventional quizzing platform. For this, we aim for a mean score of at least 6.0 for TESLA-G with a significantly higher score when compared to the conventional quizzing platform.

(iii) Improvement of surgical knowledge

The difference in the improvement of surgical knowledge between the control and intervention group will be determined by comparing the scores of pre- and post-intervention knowledge tests. These tests consist of questions on endocrine surgery which will be created separately by two board-certified general surgeons and one endocrinologist. All questions will also be validated by the research team. It should be noted however, that the study will not be sufficiently powered to identify the comparative effectiveness between the control and intervention groups in terms of improvement of surgical knowledge overtime. Hence the analysis will be primarily conducted to determine any potential adverse effects and increase in the surgical knowledge within each group, and secondarily between groups. This will be done using a confidence interval of 95% using a small effect size of 0.2 [44].
(iv) Qualitative feedback

The interview transcripts obtained from the participants who used TESLA-G will be coded into various categories, based on the overall question about how TESLA-G has been useful in improving surgical knowledge. Recurring themes will then be identified and substantiated with illustrative quotes. These themes as well as verbatim quotes will then be incorporated into the discussion of the findings chapter as with all qualitative studies.

Sample size and recruitment

Fifty participants \((N = 50)\) will be recruited, i.e. 25 participants per arm. This was based on a study by Whitehead et al. (2015) which suggested that 25 participants for each arm is optimum for studies with small effect size (between 0.1 to 0.3) for 90% power [45]. Additionally, a purposive sample of at least ten medical students \((N = 10)\) will be invited to share their views of the intervention via semi-structured interviews. This is based on consideration of the resources available.

Our study advertisement will be disseminated to all medical students from LKC School of Medicine via the respective Telegram group channels for each cohort. We will also advertise through advertisement posters and recruitment calls during regular lectures/seminars as well as through personal contacts. The study advertisement has a link to a secure registration form hosted by the research IT department. Every participant will be expected to fill in this registration form. This registration form will collect the name and email address of each participant. A letter of informed consent will be emailed to each participant, and he/she will be expected to provide consent in order to be considered as recruited for the study.
**Blinding and randomisation**

Participants will be partially blinded. They will not know if they have been given the conventional quizzing platform or TESLA-G. Instead, they will be told that they have been randomly allocated to one of two different quizzing platforms. All researchers involved in statistical analysis will be blinded as far as possible. They will not know which group is the control and which group is the intervention until the analysis is complete.

Only one researcher will be involved in dissemination of information to participants, and s/he will not be blinded. This is necessary because both quizzing platforms will have different instructions on accessing and using the platforms. It is important that the correct instructions are sent to each participant. This researcher will also be involved in answering any platform-related queries from participants throughout the study.

Participants will be stratified by their year of study. Following this, participants will be randomly allocated into either the intervention or the control group. Permuted block randomisation will be conducted for each stratum using a computerised random number generator to ensure a 1:1 allocation ratio and equal group sizes. To ensure allocation concealment, this randomisation process will be conducted and kept confidential by a trusted individual outside of the research team.

**Statistical analysis**

Analysis of quantitative data comparing TESLA-G with conventional quizzing platforms will be performed using commercial statistical software (SPSS for Windows, version 22.0, Chicago,
Illinois, USA). All categorical variables will be described as percentages and compared by Chi-
squared test. The primary outcomes will be analysed descriptively with outcomes being the
means, standard deviations, and interval estimates of variables relating to the feasibility and
acceptability of the study. The secondary outcomes relating to the effectiveness of TESLA-G,
such as the knowledge test scores and learner satisfaction scores for each group, will be
presented using descriptive statistics as well. Comparison of scores will be done with paired t-
test analysis and repeated-measures analysis of variance (ANOVA) statistics using a
confidence interval of 95% [44].

Analysis of the qualitative feedback from the interviews will be performed with a parallel
template analysis of inductive and deductive analysis until saturation is reached. Open coding of
the transcripts will be performed by at least two independent coders. Qualitative data will then
be thematically analysed through a selected qualitative data analysis software. The codes
identified will subsequently be categorised into themes. Number and frequency of responses will
also be tabulated.

**Data monitoring and harms**

Participants will be encouraged to comply with the protocol as far as possible. Researchers will
check that participants meet the submission deadlines of all pre- and post-intervention tests and
surveys. Researchers will also ensure that all tests and surveys are properly filled up.

Participants who do not comply with the study protocol (such as submitting tests late or
submitting surveys with all items answered with the same response) will not be removed from
the study as analysis will be done with an intention-to-treat approach.
This is a very low-risk study. Throughout this study, students will be encouraged to inform the research team and their university’s student support services if they experience any issues, harm or psychological distress. Such incidents will also be recorded and reviewed for future improvement. A data monitoring committee (DMC) will not be needed.

**Patient and public involvement statement**

Patients or members of the public will not be involved in the design, conduct, reporting or dissemination plans of this research.
Discussion

Implications

The primary objective of this pilot trial is to provide important information regarding the feasibility and acceptability of TESLA-G among medical students, with the aim of informing a future full-scale RCT. As a secondary objective, a demonstration of statistically significant improvements - in surgical knowledge, learner satisfaction and knowledge retention - by TESLA-G in this pilot trial may suggest a greater effect in a full-scale RCT with a larger sample size.

We aim to contribute to the growing body of literature evaluating the use of test-based learning, messaging apps and gamification in medical education. One key strength of TESLA-G is that it is structured in line with Bloom’s taxonomy [35], which has been recently applied in clinical learning, such as in clinical simulation [46] and in clinical-oriented surgical education [47]. Medical students in our study will attempt blocks of 5 questions that are specifically designed according to the increasing difficulty levels of Bloom’s taxonomy.

Limitations

Firstly, the effectiveness of participant blinding is limited due to the difficulty in preventing communication among participants. It would be unfeasible to physically or digitally isolate the intervention and control groups from each other for the entire study duration. Participants will however be blinded as to whether their online quizzing platform belongs to the intervention group or the control group, and constant reminders will be given to participants before and
during the study to ensure they do not communicate with other study participants or compare the test and control platforms.

Secondly, the intervention duration of 14 days may be too short a time to allow the beneficial effects of TESLA-G (e.g. improvement in surgical knowledge) to manifest. If this is so, a full-scale RCT with a larger sample size may demonstrate a greater effect.

Lastly, endocrine surgery is the only surgical topic evaluated in the study, hence results showing the effectiveness of TESLA-G may not be generalisable to other surgical subspecialties, or other medical specialties. Future work would involve expanding TESLA-G to encompass other surgical subspecialties, and using TESLA-G as a template to develop more gamified online platforms that would better cater to the other medical specialties.
Ethics and dissemination

Research ethics approval

This research has been approved by NTU Institutional Review Boards (Reference Number: IRB-2021-732).

Consent

All participants will be expected to read and sign a letter of informed consent before they are considered as recruited into the study. For participants below the age of 21, this letter will be co-signed with their parents. This letter would include the study information, participant rights and contact details of the Project Investigators.

Participants will be reminded that they can withdraw from the study at any point in time without giving any reasons by informing the principal investigator and all data collected of the participant will be discarded.

Data management and confidentiality

All data collected during the study will be kept confidential. Any identifiable information will only be stored on the university's secure storage folders. Only the principal investigators will have access to these data for the sole purposes of verification and participant follow-up, if needed.

Data stored in Telegram servers and TESLA-G servers will be indexed according to the participants’ computer-generated unique ID to maintain anonymity, and at no point in time will
these servers store identifiable information from any participant. At the end of the study, only anonymised data indexed by unique IDs will be made available by the principal investigators to the research team for data analysis.

Data will be backed-up regularly. Personal data will never be used in a publication or presentation. All data collected will be kept in accordance with the University’s Research Data Management Policy. Research data used in any publication will be kept for a minimum of 10 years before being discarded.

**Dissemination plan**

Study results will be published in peer-reviewed open-access journals and presented in conference presentations.
References


45 Whitehead AL, Julious SA, Cooper CL, et al. Estimating the sample size for a pilot
classified trial to minimise the overall trial sample size for the external pilot and main trial


*Ann Med Surg (Lond)* 2021;**69**:102656.
Acknowledgements

Authors’ contributions

CLKC and LTC conceived the study concept. MSPN, AIJ, YIA and TDRN drafted the manuscript and obtained funding. MSPN developed the study design and statistical analysis plan. JLC and DNHT developed the software aspects of TESLA-G. CLKC, LTC and AIJ provided critical revision. All contributors have approved the final version of the manuscript.

Funding

As of August 2021, this study has been funded by the Games for Health Innovations Centre (ALIVE) Serious Games Grant (Grant Number: SGG20/SN02). Recruitment of the study will occur between August 2022 and September 2022. The pilot trial will commence in October 2022, and results will be expected to be available by 2023.

Competing interests

No declaration of interests.
Figure legend

Fig 1: flowchart showing the run-through of the game

Fig 2: study flow diagram

Fig 3: logic model of the study
Flowchart showing the run-through of the game

Game starts

3-minute countdown timer and 3 lives

Level 1

Correct answer

Points awarded based on speed and question level
Point multiplier system: Longer streak = Higher multiplier
Proceeds to level 2

Wrong answer

Lose a life
Point multiplier resets

1. Answered level 5 question correctly
2. Ran out of lives
3. Ran out of time

Wrong answer

Game over

Level 5

...
Study flow diagram

280x553mm (96 x 96 DPI)
Logic model of the study

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Mechanism of change</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical students in the intervention group will use TELSA-G for the learning of endocrine surgery</td>
<td>Students will progress up Bloom’s taxonomy by attempting questions of increasingly higher-order thinking</td>
<td>Superior improvement in surgical knowledge for the intervention group</td>
</tr>
<tr>
<td></td>
<td>Score system that rewards students based on answering accuracy (how many questions answered correctly) and consistency (how many consecutive questions answered correctly)</td>
<td>Increased learner satisfaction for the intervention group</td>
</tr>
<tr>
<td></td>
<td>Competition-based learning where students are ranked against each other on a leaderboard which is visible to all students</td>
<td>Superior retention of surgical knowledge for the intervention group</td>
</tr>
<tr>
<td></td>
<td>Incentive in the form of a custom badge reel for the top 3 students</td>
<td></td>
</tr>
</tbody>
</table>

183x181mm (96 x 96 DPI)
# Interview Guide

## Questions on demographics

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Which year of medical school are you currently in?</td>
</tr>
<tr>
<td>2</td>
<td>Have you completed your general surgery rotation?</td>
</tr>
<tr>
<td>3</td>
<td>Are you currently taking part in your general surgery rotation?</td>
</tr>
<tr>
<td>4</td>
<td>How long have you been using Telegram?</td>
</tr>
<tr>
<td>5</td>
<td>What do you primarily use Telegram for?</td>
</tr>
<tr>
<td>6</td>
<td>What other messaging apps do you use?</td>
</tr>
</tbody>
</table>

## Questions for TESLA-G

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>Prompts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What role has mobile learning (i.e., learning delivered via mobile devices) had on your education?</td>
<td>During this pandemic; In general; In surgical education; In other areas; Types of mobile learning used; Pros/Cons to its use</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Areas/Topics</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>What is your view on the use of messaging apps (e.g. Telegram or WhatsApp) in your medical education?</td>
<td>Areas in which they can be used; Pros/cons of using them; Preferences</td>
</tr>
<tr>
<td>3</td>
<td>What is your view of TESLA-G?</td>
<td>Benefits/limitations</td>
</tr>
<tr>
<td>4</td>
<td>What impact did the TESLA-G have on your surgical competency?</td>
<td>Knowledge; Skills</td>
</tr>
<tr>
<td>5</td>
<td>What impact did TESLA-G have on your attitudes towards surgery?</td>
<td>Surgical training; Surgery as a speciality/choice of residency</td>
</tr>
<tr>
<td>6</td>
<td>What is your view of the potential inclusion of TESLA-G in formal undergraduate surgical education in future?</td>
<td>Benefits/limitations</td>
</tr>
<tr>
<td>7</td>
<td>How can TESLA-G be improved?</td>
<td>Additional content; Features</td>
</tr>
<tr>
<td>8</td>
<td>What is your view on other similar learning platforms that you have used?</td>
<td>Similarities/differences; Advantages/disadvantages</td>
</tr>
<tr>
<td>9</td>
<td>What is your view on the use of such learning platforms in other areas of your medical education?</td>
<td>Areas; Format of the channel; Advantages; Disadvantages</td>
</tr>
<tr>
<td>10</td>
<td>Are there any other observations or comments that you would like to share with me today?</td>
<td></td>
</tr>
</tbody>
</table>
Reporting checklist for protocol of a clinical trial.

Based on the SPIRIT guidelines.

**Instructions to authors**

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the SPIRIT reporting guidelines, and cite them as:


<table>
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<th>Page Number</th>
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</thead>
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<tr>
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<td>Descriptive title identifying the study design, population, interventions, and, if applicable, trial acronym</td>
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<tr>
<td>Trial registration</td>
<td>#2a</td>
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<tr>
<td>Trial identifier and registry name. If not yet registered,</td>
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</tbody>
</table>

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml
name of intended registry

Trial registration: data set

#2b All items from the World Health Organization Trial Registration Data Set

Protocol version

#3 Date and version identifier

Funding

#4 Sources and types of financial, material, and other support

Roles and responsibilities:

#5a Names, affiliations, and roles of protocol contributors

Roles and responsibilities:

#5b Name and contact information for the trial sponsor

Roles and responsibilities:

#5c Role of study sponsor and funders, if any, in study design; collection, management, analysis, and interpretation of data; writing of the report; and the decision to submit the report for publication, including whether they will have ultimate authority over any of these activities

Roles and responsibilities:

#5d Composition, roles, and responsibilities of the coordinating centre, steering committee, endpoint adjudication committee, data management team, and other individuals or groups overseeing the trial, if applicable (see Item 21a for data monitoring committee)

Introduction
Background and rationale: Description of research question and justification for undertaking the trial, including summary of relevant studies (published and unpublished) examining benefits and harms for each intervention.

Background and rationale: choice of comparators: Explanation for choice of comparators.

Objectives: Specific objectives or hypotheses.

Trial design: Description of trial design including type of trial (eg, parallel group, crossover, factorial, single group), allocation ratio, and framework (eg, superiority, equivalence, non-inferiority, exploratory).

Methods:

Participants, interventions, and outcomes:

Study setting: Description of study settings (eg, community clinic, academic hospital) and list of countries where data will be collected. Reference to where list of study sites can be obtained.

Eligibility criteria: Inclusion and exclusion criteria for participants. If applicable, eligibility criteria for study centres and individuals who will perform the interventions (eg,
surgeons, psychotherapists)

Interventions: #11a Interventions for each group with sufficient detail to allow replication, including how and when they will be administered

Interventions: #11b Criteria for discontinuing or modifying allocated interventions for a given trial participant (eg, drug dose change in response to harms, participant request, or improving / worsening disease)

Interventions: #11c Strategies to improve adherence to intervention protocols, and any procedures for monitoring adherence (eg, drug tablet return; laboratory tests)

Interventions: #11d Relevant concomitant care and interventions that are permitted or prohibited during the trial

Outcomes #12 Primary, secondary, and other outcomes, including the specific measurement variable (eg, systolic blood pressure), analysis metric (eg, change from baseline, final value, time to event), method of aggregation (eg, median, proportion), and time point for each outcome. Explanation of the clinical relevance of chosen efficacy and harm outcomes is strongly recommended

Participant timeline #13 Time schedule of enrolment, interventions (including any run-ins and washouts), assessments, and visits for participants. A schematic diagram is highly recommended (see Figure)
Sample size  
#14 Estimated number of participants needed to achieve study objectives and how it was determined, including clinical and statistical assumptions supporting any sample size calculations.

Recruitment  
#15 Strategies for achieving adequate participant enrolment to reach target sample size.

Methods: Assignment of interventions (for controlled trials)

Allocation: sequence  
#16a Method of generating the allocation sequence (eg, computer-generated random numbers), and list of any factors for stratification. To reduce predictability of a random sequence, details of any planned restriction (eg, blocking) should be provided in a separate document that is unavailable to those who enrol participants or assign interventions.

Allocation concealment mechanism  
#16b Mechanism of implementing the allocation sequence (eg, central telephone; sequentially numbered, opaque, sealed envelopes), describing any steps to conceal the sequence until interventions are assigned.

Allocation implementation  
#16c Who will generate the allocation sequence, who will enrol participants, and who will assign participants to interventions.
Blinding (masking)  

Who will be blinded after assignment to interventions (eg, trial participants, care providers, outcome assessors, data analysts), and how

Blinding (masking):  
If blinded, circumstances under which unblinding is permissible, and procedure for revealing a participant’s allocated intervention during the trial

Methods: Data collection, management, and analysis

Data collection plan  
Plans for assessment and collection of outcome, baseline, and other trial data, including any related processes to promote data quality (eg, duplicate measurements, training of assessors) and a description of study instruments (eg, questionnaires, laboratory tests) along with their reliability and validity, if known. Reference to where data collection forms can be found, if not in the protocol.

Data collection plan: retention  
Plans to promote participant retention and complete follow-up, including list of any outcome data to be collected for participants who discontinue or deviate from intervention protocols.

Data management  
Plans for data entry, coding, security, and storage, including any related processes to promote data quality (eg, double data entry; range checks for data values).
Reference to where details of data management procedures can be found, if not in the protocol

**Statistics: outcomes**  
#20a Statistical methods for analysing primary and secondary outcomes. Reference to where other details of the statistical analysis plan can be found, if not in the protocol  
24-25

**Statistics: additional analyses**  
#20b Methods for any additional analyses (eg, subgroup and adjusted analyses)  
25

**Statistics: analysis population and missing data**  
#20c Definition of analysis population relating to protocol non-adherence (eg, as randomised analysis), and any statistical methods to handle missing data (eg, multiple imputation)  
25

**Methods: Monitoring**

**Data monitoring:**  
#21a Composition of data monitoring committee (DMC); summary of its role and reporting structure; statement of whether it is independent from the sponsor and competing interests; and reference to where further details about its charter can be found, if not in the protocol. Alternatively, an explanation of why a DMC is not needed  
26

**Data monitoring:**  
#21b Description of any interim analyses and stopping guidelines, including who will have access to these interim results and make the final decision to terminate the trial  
n/a

**Harms**  
#22 Plans for collecting, assessing, reporting, and managing solicited and spontaneously reported adverse events and other unintended effects of trial interventions or trial  
26
<table>
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<th>Auditing</th>
<th>#23</th>
<th>Frequency and procedures for auditing trial conduct, if any, and whether the process will be independent from investigators and the sponsor</th>
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<td>Plans for seeking research ethics committee / institutional review board (REC / IRB) approval</td>
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<tr>
<td>Research ethics</td>
<td>#24</td>
<td>Plans for communicating important protocol modifications (eg, changes to eligibility criteria, outcomes, analyses) to relevant parties (eg, investigators, REC / IRBs, trial participants, trial registries, journals, regulators)</td>
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</tr>
<tr>
<td>Protocol</td>
<td>#25</td>
<td>Who will obtain informed consent or assent from potential trial participants or authorised surrogates, and how (see Item 32)</td>
<td>29</td>
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<tr>
<td>Consent or assent</td>
<td>#26a</td>
<td>Additional consent provisions for collection and use of participant data and biological specimens in ancillary studies, if applicable</td>
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<td>Consent or assent: ancillary studies</td>
<td>#26b</td>
<td>How personal information about potential and enrolled participants will be collected, shared, and maintained in order to protect confidentiality before, during, and after the trial</td>
<td>29-30</td>
</tr>
<tr>
<td>Confidentiality</td>
<td>#27</td>
<td>Financial and other competing interests for principal</td>
<td>35</td>
</tr>
<tr>
<td>Declaration of</td>
<td>#28</td>
<td></td>
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</tbody>
</table>

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interests

Data access #29 Statement of who will have access to the final trial dataset, and disclosure of contractual agreements that limit such access for investigators

Ancillary and post trial care #30 Provisions, if any, for ancillary and post-trial care, and for compensation to those who suffer harm from trial participation

Dissemination policy: #31a Plans for investigators and sponsor to communicate trial results to participants, healthcare professionals, the public, and other relevant groups (eg, via publication, reporting in results databases, or other data sharing arrangements), including any publication restrictions

Dissemination policy: #31b Authorship eligibility guidelines and any intended use of professional writers

Dissemination policy: #31c Plans, if any, for granting public access to the full protocol, participant-level dataset, and statistical code

Appendices

Informed consent #32 Model consent form and other related documentation given to participants and authorised surrogates

Biological specimens #33 Plans for collection, laboratory evaluation, and storage of biological specimens for genetic or molecular analysis in the current trial and for future use in ancillary studies, if applicable
The SPIRIT Explanation and Elaboration paper is distributed under the terms of the Creative Commons Attribution License CC-BY-NC. This checklist was completed on 07. September 2022 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai
Evaluating TESLA-G, a gamified, Telegram-delivered, quizzing platform for surgical education in medical students: protocol for a pilot randomised controlled trial

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<td>Date Submitted by the Author:</td>
<td>22-Mar-2023</td>
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<tr>
<td>Complete List of Authors:</td>
<td>Ng, Matthew Song Peng; NUS Yong Loo Lin School of Medicine, Jabir, Ahmad Ishqi; Nanyang Technological University Ng, Tony De Rong; National University of Singapore Ang, Yi-Ian; National University of Singapore Chia, Jeng Long; National University of Singapore Tan, Darren Ngiap Hao; National University of Singapore Lee, James; National University Health System, Department of General Surgery Mahendran, Dinesh Carl Junis; Khoo Teck Puat Hospital, Department of General Medicine Tudor Car, Lorainne; Nanyang Technological University Chia, Clement Luck Khng; Khoo Teck Puat Hospital, Department of General Surgery</td>
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<td>Secondary Subject Heading:</td>
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Evaluating TESLA-G, a gamified, Telegram-delivered, quizzing platform for surgical education in medical students: protocol for a pilot randomised controlled trial

Matthew Song Peng Ng, Ahmad Ishqi Jabir, Tony De Rong Ng, Yi-Ian Ang, Jeng Long Chia, Darren Ngiap Hao Tan, James Lee, Dinesh Carl Junis Mahendran, Lorainne Tudor Car, Clement Luck Khng Chia

1 Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore
2 Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore, Singapore
3 Department of General Surgery, National University Health System, Singapore, Singapore
4 Department of General Medicine, Khoo Teck Puat Hospital, Singapore, Singapore
5 Department of General Surgery, Khoo Teck Puat Hospital, Singapore, Singapore

Correspondence to:
Lorainne Tudor Car
Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore, Singapore
11 Mandalay Rd, Singapore 308232
lorainne.tudor.car@ntu.edu.sg

*Lorainne Tudor Car and Clement Luck Khng Chia are joint senior authors

Word count: 4854
Last modified 26 Sept 2022
Version number: v1.5
Abstract

Introduction

Online multiple-choice question (MCQ) quizzes are popular in medical education due to their ease of access and ability for test-enhanced learning. However, a general lack of motivation among students often results in decreasing usage over time. We aim to address this limitation by developing Telegram Education for Surgical Learning and Application Gamified (TESLA-G), an online platform for surgical education that incorporates game elements into conventional MCQ quizzes.

Methods and analysis

This online, pilot randomised control trial will be conducted over two weeks. Fifty full-time undergraduate medical students from a medical school in Singapore will be recruited and randomised into an intervention group (TESLA-G) and an active control group (non-gamified quizzing platform) with a 1:1 allocation ratio, stratified by year of study.

We will evaluate TESLA-G in the area of endocrine surgery education. Our platform is designed based on Bloom’s taxonomy of learning domains: questions are created in blocks of 5 questions per endocrine surgery topic, with each question corresponding to one level on Bloom’s taxonomy. This structure promotes mastery while boosting student engagement and motivation. All questions are created by two board-certified general surgeons and one endocrinologist, and validated by the research team. The feasibility of this pilot study will be determined quantitatively by participant enrollment, participant retention and degree of completion of the quizzes. The
acceptability of the intervention will be assessed quantitatively by a post-intervention learner satisfaction survey consisting of a system satisfaction questionnaire and a content satisfaction questionnaire. The improvement of surgical knowledge will be assessed by comparing the scores of pre- and post-intervention knowledge tests, which consist of separately-created questions on endocrine surgery. Retention of surgical knowledge will be measured using a follow-up knowledge test administered two weeks post-intervention. Lastly, qualitative feedback from participants regarding their experience will be obtained and thematically analysed.

Ethics and dissemination

This research is approved by Singapore Nanyang Technological University (NTU) Institutional Review Boards (Reference Number: IRB-2021-732). All participants will be expected to read and sign a letter of informed consent before they are considered as recruited into the study. This study poses minimal risk to participants. Study results will be published in peer-reviewed open-access journals and presented in conference presentations.

Trial registration number

NCT05520671.
1 **Strengths and limitations of this study**

2

3 - This study contributes to the growing body of literature evaluating the use of test-based learning, messaging apps and gamification in medical education.

4 - The gamified, Telegram-delivered, surgical education-focused, quizzing intervention in this study will be structured in line with Bloom’s taxonomy.

5 - We will use quantitative and qualitative approaches to assess our intervention with the aim of informing a future randomised controlled trial.

6 - A potential limitation of this study is that 14 days of intervention may be insufficient to observe improvements in surgical knowledge.

7 - The intervention will focus on endocrine surgery and the findings may not be generalisable to other surgical or medical subspecialties.
Introduction

Background and rationale

Multiple-choice question (MCQ) quizzes are a well-known and widely used medium for summative assessment, especially in medical education [1,2]. Their ability to provide objective grading and immediate feedback also make them popular tools for formative assessment [3,4]. While MCQ quizzes tend to be associated with diagnostic or assessment tools, Roediger (2006) proposes that tests like these can be used to improve learning via test-enhanced learning [5]. This effect has been increasingly explored in medical education [6]. Randomised controlled trials have demonstrated how test-enhanced learning can increase acquisition and retention of new medical knowledge among medical students [7] and healthcare professionals [8]. Recent systematic review by Green (2018) also supported these findings [9].

With the progressive use of technology in medical education, online learning is becoming increasingly common. Online learning has been found to be as effective as offline learning in medical education based on meta-analyses by Pei (2019) and Vaona (2018) [10,11]. Brame (2017) suggests that making MCQ quizzes available online would allow easy access to frequent practice, which could work synergistically with test-enhanced learning to promote student learning and long-term knowledge retention [12]. This is further supported by studies that demonstrated increased exam performance after administering pre-exam online quizzes to undergraduate university students [13,14]. Kibble (2007) also established a positive relationship between unsupervised formative online quizzes and academic performance among medical students [15].
However, online MCQ quizzes are limited by a decline in quiz participation over time and an increase in drop-out rates. [13,14,16]. This was observed in several studies despite the initial enthusiasm and high take-up rate among the student body. Mitra (2015) and Johnson (2006) specifically attributed this high attrition to a general lack of motivation among the students to use the MCQ quizzes [13,16]. We aim to address this limitation of low motivation among students using online MCQ quizzes by developing Telegram Education for Surgical Learning and Application - Gamified (TESLA-G). TESLA-G is an online platform for surgical education that incorporates game elements into conventional online MCQ quizzes.

Gamification can be defined as the use of game elements such as point systems, leaderboards, and incentives in non-gaming contexts [17]. A randomised controlled trial by Barrio (2016) showed that the use of gamification in undergraduate education can boost motivation and interest [18]. A recent review by Sandrone (2021) further suggests that the use of gamification in medical education can promote engagement and motivation among learners [19]. Additionally, systematic reviews [20,21] suggest that the use of gamification for learning among healthcare professionals is as effective as other educational methods in promoting knowledge and expertise.

Nevin (2014) successfully incorporated gamification in medical education through Kaizen-IM, an online learning platform developed by the authors for internal medicine residents. The authors demonstrated that the gamification elements such as team-based score system, a leaderboard showing rankings, and badges as incentives improve medical knowledge acquisition and retention. Participants also mentioned that the game elements, especially the leaderboard, were significant motivators in their usage of the platform [22]. Notably, the use of mobile technology in gamified learning has been shown to be a motivating factor among students. Licorish (2018) found that the use of the gamified mobile platform Kahoot! among undergraduate students
promoted student engagement and motivation [23]. This was attributed to students being highly proficient in mobile technology, which greatly contributed to significant student enjoyment in trying out applications and games that have been built specifically for mobile platforms [23].

Instant messaging applications have been used as a supplementary tool to medical education, [24], and several studies have shown an improvement in knowledge level through the use of these platforms [25–28], most notably with the application WhatsApp. More recently however, the increasingly popular messaging application Telegram has been trialled for use in medical education in the context of the COVID-19 pandemic [29,30]. Telegram was the most downloaded app in the world in January 2021 [31], and still remains as the top five most popular messaging apps globally in 2022 [32]. Not only is this app accessible on almost all computer and mobile platforms, the increasing use of Telegram in the upcoming years would mean that it is very likely that participants will already have this app installed in their devices even before the commencement of the study. By tapping on existing Telegram features and its well-documented Application Programming Interface (API), we will implement TESLA-G to provide flexible and convenient surgical education anytime and anywhere. Hence, our online, gamified quizzing platform TESLA-G will be delivered using Telegram with the aim of easier delivery of the intervention and greater uptake. We intend to evaluate our intervention in a stepwise manner in line with the UK Medical Research Council’s guidance for developing and evaluating complex interventions [33]. In this pilot study, we will evaluate the feasibility and acceptability of delivering our intervention with the aim of informing a future randomised controlled trial.
Objectives

The main objective of the pilot randomised controlled trial is to evaluate the feasibility and acceptability of a gamified, online, Telegram-delivered quizzing platform TESLA-G compared to conventional MCQ quizzes for surgical education among medical students.

More specifically, we will investigate:

1. The feasibility of recruitment, specifically the duration required to complete the recruitment process, the recruitment strategy, randomisation and stratification strategy, and participants’ retention rate throughout the proposed intervention period.

2. The acceptability of the intervention to medical students, in terms of its technical, pedagogical, and educational content (surgical content).

3. The participants’ adherence to the intervention, in terms of the number of completed quiz questions, frequency of use, and average daily quiz completion rate.

4. The fidelity of the intervention protocol, in terms of whether the assessment materials, technical implementation of the intervention, and study procedures are delivered and successful.

5. The participants’ experience of the intervention, by inviting a purposive sample of the medical students to share their views via semi-structured interviews after the intervention.
Our secondary objectives are:

1. To evaluate the effectiveness of TESLA-G compared to conventional MCQ quizzes in improving surgical knowledge by comparing the change in scores between the pre- and post-intervention tests.

2. To compare students’ satisfaction with TESLA-G compared to conventional MCQ quizzes using a post-intervention satisfaction survey.

3. To evaluate the effectiveness of TESLA-G compared to conventional MCQ quizzes in retention of surgical knowledge which will be determined by comparing the scores a follow-up knowledge test administered 2 weeks after the post-intervention test.
Methods and analysis

Trial design

We report this protocol in line with the SPIRIT (Standard Protocol Items for Randomised Trials) recommendations [34]. This is an online, pilot randomised controlled trial with two parallel active groups. It will involve an intervention group and an active control group. Participants will be randomised into these two groups with a 1:1 allocation ratio stratified by year of study.

Study setting

The study is an online study conducted on Telegram. The study will recruit first to fifth year medical students from a medical school in Singapore.

Eligibility criteria

Eligible participants must be:

1. at least 18 years of age;
2. currently enrolled in a full-time 5-year undergraduate programme in the medical school that leads to the Bachelor of Medicine and Bachelor of Surgery (MBBS);
3. willing and able to provide consent (Supplementary File 1) for participating in the entire duration of the study including all pre- and post-study assessments.
Intervention

TESLA-G is a novel gamified quizzing platform aimed at improving surgical knowledge among undergraduate medical students. For the purpose of this study, we will evaluate the use of TESLA-G in the learning of endocrine surgery among medical students. Our platform is designed based on Bloom’s taxonomy of learning domains, which is a widely applied and researched framework to construct learning objectives [35]. Questions will be created in blocks, where each block will test a specific topic in endocrine surgery. Each block has 5 questions, and each question corresponds to the first five levels of the Bloom’s taxonomy (Remember, Understand, Apply, Analyse, Evaluate) and each level in game (Table 1). The questions are structured in this way to promote mastery in endocrine surgery while boosting student engagement and motivation.

For this study, we aim to create 56 blocks of 5 questions, totalling 280 questions. Each question in the 5-question block will correspond to each level of the Bloom’s taxonomy, hence there will be an equal number of questions per level, All questions will be created by two board-certified general surgeons and one endocrinologist, and validated by the research team.
<table>
<thead>
<tr>
<th>Level 1</th>
<th>Remember</th>
<th>Questions here encourage students to recognise and recall facts.</th>
<th>FNAC thyroid reveals a benign follicular nodule. What Bethesda category would this be in?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2</td>
<td>Understand</td>
<td>Questions here motivate students to understand the meaning behind the memorised facts.</td>
<td>FNAC thyroid reveals a Bethesda category II follicular nodule. What is the probability of malignancy?</td>
</tr>
<tr>
<td>Level 3</td>
<td>Apply</td>
<td>Questions here allow students to apply their knowledge in a clinical setting.</td>
<td>31 year old lady was referred by a GP who noticed a goitre incidentally. Which of the following clinical features would be most suspicious of malignancy?</td>
</tr>
<tr>
<td>Level 4</td>
<td>Analyse</td>
<td>Questions here would expect students to analyse the clinical presentation and use logical deduction to figure out the differential diagnoses.</td>
<td>31 year old lady was referred by a GP who noticed a goitre incidentally. Further workup shows a solitary nodule in the right thyroid 2.5cm. FNAC reveals Bethesda category II follicular nodule. Patient thyroid function is normal.</td>
</tr>
<tr>
<td>Level 5</td>
<td>Evaluate</td>
<td>What is the most likely differential?</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
<td>--------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Based on a constellation of clinical findings, students are expected to critically examine and select the most appropriate investigations or management options.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>31 year old lady was referred by a GP who noticed a goitre incidentally. Further workup shows a solitary nodule in the right thyroid 2.5cm. FNAC reveals Bethesda category II follicular nodule. Patient thyroid function is normal. What is the most appropriate management?</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1.** Sample block of 5 questions corresponding to different Bloom’s taxonomy levels
The aim of the game is for players to get as many points as they can before the timer runs out. Each game will feature only one block of 5 questions, allowing students to focus on a specific topic in endocrine surgery per game (Fig 1).

Below is a run-through of the game:

1. The game starts at Level 1 with a 3-minute countdown timer and 3 lives.
2. For every question answered correctly, students will be awarded points based on their speed and the question level. An explanation of the question will also be shown. They will then progress to the next level up till level 5.
3. Consecutive correct answers will be rewarded via a point multiplier system. The longer their “streak” of correct answers, the higher the multiplier. It should be noted that levelling up does not require consecutive correct answers.
4. If they get a question wrong, they lose one life, and the point multiplier system resets. They must then answer that question again until they get it correct.
5. The game ends if the level 5 question is answered correctly, if all 3 lives have been used, or if the timer runs out. The total score is then tabulated.

To ensure proper mastery of surgical concepts, the countdown timer will pause in between questions for students to refer to the explanation pop-up. Students will be given as much time as they need to read the explanation and understand the information presented before they move on to the next question. There is no score deduction for spending too much time reading the explanation after each question.

To promote competition-based learning, all students are ranked against each other based on their points, and a leaderboard that displays the top 10 students is sent to all students daily. We
also allow students to track their own learning by providing a personalised dashboard for students to see their score history and progress. Finally, to promote consistent usage of TESLA-G, a bonus point multiplier is awarded for every consecutive day the game is played.

**Timeline**

The study flow is summarised in Fig 2 and the logic model is shown in Fig 3. Before any participants are recruited, all tests and surveys will first be piloted by all researchers involved in this study. Qualitative feedback will be independently obtained from at least 3 researchers, and tests and surveys will be amended accordingly.

(i) **Pre-intervention**

Fifty medical students ($N = 50$) will be recruited for the study based on the eligibility criteria. After obtaining informed consent, all participants will be expected to complete a demographics survey. Basic information about name, gender, age and year of study in medical school will be collected.

The Telegram username and email address of each participant will also be collected and verified. This is for the main purpose of disseminating information regarding our study. These include important deadlines to take note of, instructions on how to access the quizzing platforms and links to the other surveys required for our study.

All participants will then complete a pre-intervention knowledge test comprising 20 MCQs on endocrine surgery over a 30-minute period. This will determine the baseline surgical knowledge level among all participants.
(ii) **Intervention**

Participants will be verified to have completed all the above before being randomised into either the intervention group or the control group. Participants will then be provided with detailed instructions on using either TESLA-G for the intervention group or the conventional quizzing platform for the control group.

Participants in the intervention group will be provided access to TESLA-G as previously described. A link to access TESLA-G will be sent to participants from an automated Telegram bot; this access will be provided for 14 days.

Participants in the control group will be given access to a conventional quizzing platform, which will be a non-gamified version of TESLA-G. Whenever a participant enters the platform, a question stem and five options will be displayed. The participant will select an option, and the correct answer appears with the explanation provided. The platform will then send the next question, and the process continues, until the participant decides to exit the platform or all the questions in the platform have been answered. Similar to the intervention group, the questions will be queued in blocks where each block corresponds to a specific topic in endocrine surgery. Within each block, questions will be randomised, that is, they will not be queued based on increasing levels of Bloom’s taxonomy. Participants will also not be notified what level of Bloom’s taxonomy each question is classified under. Just like the intervention group, participants will be sent the link to access this platform from an automated Telegram bot, and they will be able to use the platform for 14 days.
For both the intervention and the control groups, all questions will be made available to all participants from the beginning of the study. If any participant does not use their quizzing platform for more than 48 hours, a Telegram message will be sent as a gentle reminder to continue participation. This would promote continuous usage of the quizzing platforms throughout the entire duration of the study.

Of note, throughout the usage of either quizzing platform, participants will be shown new and previously completed questions, for the purpose of mastering new knowledge and reinforcing past concepts, respectively.

Participants will use their assigned platform at their own pace and time. During this period, user metrics will be collected from both the intervention and the control groups including overall platform, per-participant and per question metrics as presented in Table 2.

Finally, throughout the duration of the intervention, participants will be able to contact a designated study team member via Telegram or via email for any assistance with potential technical difficulties with using their quizzing platform.
<table>
<thead>
<tr>
<th>Overall platform metrics</th>
<th>Per-participant metrics</th>
<th>Per-question/block metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Game performance</strong></td>
<td><strong>Participant engagement</strong></td>
<td><strong>Question engagement</strong></td>
</tr>
<tr>
<td>- Number of logins per hour, per day and over the full study duration</td>
<td>- Number of daily logins</td>
<td>- Number of users who completed each question and block</td>
</tr>
<tr>
<td>- Total usage duration per hour, per day and over the full study duration</td>
<td>- Number of questions and blocks that were completed daily</td>
<td>- Amount of time spent on the explanation pop-up</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participant performance</th>
<th>Question performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Daily usage duration</td>
<td>- Distribution of answers for each question</td>
</tr>
<tr>
<td>- Individual scores per gameplay</td>
<td>- Number of users who obtained the correct answer for each question</td>
</tr>
<tr>
<td></td>
<td>- Numbers of users who obtained a full completion for each block</td>
</tr>
</tbody>
</table>

Table 2. Game metrics to be collected from both groups

A block refers to a question block of 5 questions, as previously described.
(iii) **Post-intervention**

After 14 days, all participants will complete a post-intervention knowledge test which again comprises 20 MCQs on endocrine surgery over a 30-minute period. This test will be of a similar standard to the pre-intervention test as described earlier. Improvement in surgical knowledge will be measured as the difference in knowledge test scores pre-intervention and post-intervention.

All participants will also complete a post-intervention learner satisfaction survey. This will be in the form of a Likert scale adapted from the System Usability Survey (SUS) [36] and the Student Evaluation of Educational Quality (SEEQ) Questionnaire [37]. The survey will find out if the intervention group of students are more satisfied than the control group. To incentivise participants, the top three participants of the leaderboard will receive small tokens of appreciation in the form of a certificate and a custom badge reel with the TESLA-G logo.

After another 14 days, participants will be asked to do a follow-up knowledge test which once again comprises 20 MCQs on endocrine surgery over a 30-minute period. At this point, participants in both the control and the intervention groups will not have access to their respective online quizzing platforms. This test will be of a similar standard to the post-intervention test as described earlier. Any retention in surgical knowledge will be measured as the difference in knowledge test scores post-intervention and follow-up.

After the follow-up knowledge test, ten participants from the intervention group will be purposefully selected for individual interviews. Two participants - one who has completed at least 80% of the quizzes and one who has not - will be selected from each of the five academic years of the medical school. We aim to obtain qualitative feedback regarding the overall
experience of TESLA-G, along with the benefits, drawbacks, receptiveness and usefulness of
the platform as a supplement to surgical education. The interviews will be conducted based on
the interview guide (Supplementary File 2) which has been adapted from a previous exploratory
study on using Telegram for surgical education [38]. The interviews will also be piloted on up to
dfive students and/or research team members prior to the beginning of the study.

The interviews will be conducted individually, either online or in-person, and will last 60 minutes.
Written and verbal consent will be taken, before the interviews are recorded to be transcribed
into text data for qualitative analysis. The audio recordings from the interviews will be
transcribed by an automated software and proof-read to ensure that the transcripts are
accurate. The completed transcripts will not contain any identifiers.

Outcome measures

A mixed-method approach will be used to establish the feasibility and acceptability of the
intervention as primary outcomes. Our secondary outcomes will be improvement of surgical
knowledge between the control and intervention group and potential adverse effects. Finally,
qualitative feedback from the participants regarding their experience of the intervention will be
thematically analysed.

(i) Feasibility

The feasibility of the intervention will be assessed quantitatively as shown below. These are the
goals for our intervention:

- Enrollment of 50 participants in a month
- Retention of at least 75% of participants who are enrolled
● Completion of at least 80% of the quizzes

Retention of participants will be quantified by the number of participants who complete both the pre-intervention knowledge test and the post-intervention knowledge test. Success in achieving all three goals will indicate that it is definitely feasible to conduct a full-scale randomised controlled trial (RCT) while achieving two out of three goals will indicate that it is probably feasible. Achieving less than two goals will suggest that a full-scale RCT is not feasible with the current procedure.

In addition to the above outcomes, we will also determine:

● The feasibility of the randomisation procedure to ensure equal number of participants within the different university years in each stratum within the intervention and control groups

● Amount of time on app and on task

● Feasibility of the delivery method for the pre-, post- and follow-up assessments

● Number of app crashes

● Number of app exits during task

(ii) Acceptability

The acceptability of the intervention and the study procedure will be assessed both quantitatively and qualitatively. Quantitative data will be collected via a post-intervention learner satisfaction survey for both the control and intervention groups. This survey will consist of two parts - a system satisfaction questionnaire and a content satisfaction questionnaire.
The system satisfaction questionnaire measures the system acceptability score via a System Usability Survey (SUS) [36]. It is a 10-item questionnaire with a 5-point Likert scale that ranges from 1 (strongly disagree) to 5 (strongly agree). This widely used usability scale will be used to compare the relative usability between TESLA-G and our conventional quizzing platform based on a normalised score. For the SUS, we aim to get an average score of at least 70 which would indicate Grade B based on the Sauro and Lewis (2016) curved grading scale [39].

The content satisfaction questionnaire measures the content satisfaction score and is loosely adapted from the Student Evaluation of Educational Quality (SEEQ) Questionnaire [37]. The SEEQ evaluates 9 distinct components of teaching effectiveness with a 5-point Likert scale that ranges from 1 (very poor) to 5 (very good). This validated study has been rigorously evaluated in higher education [40,41] and has been used in clinical education [42,43]. Reliability analysis will be conducted and user's scores triangulated with their input from the qualitative interview to determine the reliability and validity of the questionnaire respectively. This questionnaire will compare the relative benefit of content delivery between TESLA-G and our conventional quizzing platform. For this, we aim for a mean score of at least 6.0 for TESLA-G with a significantly higher score when compared to the conventional quizzing platform.

(iii) Improvement of surgical knowledge

The difference in the improvement of surgical knowledge between the control and intervention group will be determined by comparing the scores of pre- and post-intervention knowledge tests. These tests consist of questions on endocrine surgery which will be created separately by two board-certified general surgeons and one endocrinologist. All questions will also be validated by the research team. It should be noted however, that the study will not be sufficiently powered to identify the comparative effectiveness between the control and intervention groups.
in terms of improvement of surgical knowledge overtime. Hence the analysis will be primarily conducted to determine any potential adverse effects and increase in the surgical knowledge within each group, and secondarily between groups. This will be done using a confidence interval of 95% using a small effect size of 0.2 [44].

(iv) Qualitative feedback

Data will be analysed thematically using the six steps approach outlined by Braun and Clarke [45]. The interview transcripts obtained from the participants who used TESLA-G will be coded into various categories, based on the overall question about how TESLA-G has been useful in improving surgical knowledge. Recurring themes will then be identified and substantiated with illustrative quotes. These themes as well as verbatim quotes will then be iteratively reviewed and incorporated into the discussion of the findings chapter as with all qualitative studies.

Sample size and recruitment

Fifty participants (N = 50) will be recruited, i.e. 25 participants per arm. This was based on a study by Whitehead et al. (2015) which suggested that 25 participants for each arm is optimum for studies with small effect size (between 0.1 to 0.3) for 90% power [46]. Additionally, a purposive sample of at least ten medical students (N = 10) will be invited to share their views of the intervention via semi-structured interviews. This is based on consideration of the resources available.

Our study advertisement will be disseminated to all medical students from LKC School of Medicine via the respective Telegram group channels for each cohort. We will also advertise through advertisement posters and recruitment calls during regular lectures/seminars as well as
through personal contacts. The study advertisement has a link to a secure registration form hosted by the research IT department. Every participant will be expected to fill in this registration form. This registration form will collect the name and email address of each participant. A letter of informed consent will be emailed to each participant, and he/she will be expected to provide consent in order to be considered as recruited for the study.

Blinding and randomisation

Participants will be partially blinded. They will not know if they have been given the conventional quizzing platform or TESLA-G. Instead, they will be told that they have been randomly allocated to one of two different quizzing platforms. All researchers involved in statistical analysis will be blinded as far as possible. They will not know which group is the control and which group is the intervention until the analysis is complete.

Only one researcher will be involved in dissemination of information to participants, and s/he will not be blinded. This is necessary because both quizzing platforms will have different instructions on accessing and using the platforms. It is important that the correct instructions are sent to each participant. This researcher will also be involved in answering any platform-related queries from participants throughout the study.

Participants will be stratified by their year of study. Following this, participants will be randomly allocated into either the intervention or the control group. Permuted block randomisation will be conducted for each stratum using a computerised random number generator to ensure a 1:1 allocation ratio and equal group sizes. To ensure allocation concealment, this randomisation process will be conducted and kept confidential by a trusted individual outside of the research team.
**Statistical analysis**

Analysis of quantitative data comparing TESLA-G with conventional quizzing platforms will be performed using commercial statistical software (SPSS for Windows, version 22.0, Chicago, Illinois, USA). All categorical variables will be described as percentages and compared by Chi-squared test. The primary outcomes will be analysed descriptively with outcomes being the means, standard deviations, and interval estimates of variables relating to the feasibility and acceptability of the study. The secondary outcomes relating to the effectiveness of TESLA-G, such as the knowledge test scores and learner satisfaction scores for each group, will be presented using descriptive statistics as well. Comparison of scores will be done with paired t-test analysis and repeated-measures analysis of variance (ANOVA) statistics using a confidence interval of 95% [44].

Analysis of the qualitative feedback from the interviews will be performed with a parallel template analysis of inductive and deductive analysis until saturation is reached. Open coding of the transcripts will be performed by at least two independent coders. Qualitative data will then be thematically analysed through a selected qualitative data analysis software. The codes identified will subsequently be categorised into themes. Number and frequency of responses will also be tabulated.

**Data monitoring and harms**

Participants will be encouraged to comply with the protocol as far as possible. Researchers will check that participants meet the submission deadlines of all pre- and post-intervention tests and surveys. Researchers will also ensure that all tests and surveys are properly filled up.
Participants who do not comply with the study protocol (such as submitting tests late or submitting surveys with all items answered with the same response) will not be removed from the study as analysis will be done with an intention-to-treat approach.

This is a very low-risk study. Throughout this study, students will be encouraged to inform the research team and their university’s student support services if they experience any issues, harm or psychological distress. Such incidents will also be recorded and reviewed for future improvement. A data monitoring committee (DMC) will not be needed.

**Patient and public involvement**

None.
Ethics and dissemination

Research ethics approval

This research has been approved by NTU Institutional Review Boards (Reference Number: IRB-2021-732).

Consent

All participants will be expected to read and sign a letter of informed consent (Supplementary File 1) before they are considered as recruited into the study. For participants below the age of 21, this letter will be co-signed with their parents. This letter would include the study information, participant rights and contact details of the Project Investigators.

Participants will be reminded that they can withdraw from the study at any point in time without giving any reasons by informing the principal investigator and all data collected of the participant will be discarded.

Data management and confidentiality

All data collected during the study will be kept confidential. Any identifiable information will only be stored on the university’s secure storage folders. Only the principal investigators will have access to these data for the sole purposes of verification and participant follow-up, if needed. Data stored in Telegram servers and TESLA-G servers will be indexed according to the participants’ computer-generated unique ID to maintain anonymity, and at no point in time will
these servers store identifiable information from any participant. At the end of the study, only anonymised data indexed by unique IDs will be made available by the principal investigators to the research team for data analysis.

Data will be backed-up regularly. Personal data will never be used in a publication or presentation. All data collected will be kept in accordance with the University’s Research Data Management Policy. Research data used in any publication will be kept for a minimum of 10 years before being discarded.

Dissemination plan

Study results will be published in peer-reviewed open-access journals and presented in conference presentations.

Study status

Recruitment to the study occurred between August 2022 and September 2022. The pilot trial commenced in October 2022, and results will be expected to be available within 2023.
Discussion

Implications

The primary objective of this pilot trial is to provide important information regarding the feasibility and acceptability of TESLA-G among medical students, with the aim of informing a future full-scale RCT. As a secondary objective, a demonstration of statistically significant improvements in surgical knowledge, learner satisfaction and knowledge retention - by TESLA-G in this pilot trial may suggest a greater effect in a full-scale RCT with a larger sample size.

We aim to contribute to the growing body of literature evaluating the use of test-based learning, messaging apps and gamification in medical education. One key strength of TESLA-G is that it is structured in line with Bloom’s taxonomy [35], which has been recently applied in clinical learning, such as in clinical simulation [47] and in clinical-oriented surgical education [48].

Medical students in our study will attempt blocks of 5 questions that are specifically designed according to the increasing difficulty levels of Bloom’s taxonomy.

Limitations

Firstly, the effectiveness of participant blinding is limited due to the difficulty in preventing communication among participants. It would be unfeasible to physically or digitally isolate the intervention and control groups from each other for the entire study duration. Participants will however be blinded as to whether their online quizzing platform belongs to the intervention group or the control group, and constant reminders will be given to participants before and
during the study to ensure they do not communicate with other study participants or compare
the test and control platforms.

Secondly, the intervention duration of 14 days may be too short a time to allow the beneficial
effects of TESLA-G (e.g. improvement in surgical knowledge) to manifest. If this is so, a full-
scale RCT with a larger sample size may demonstrate a greater effect.

Thirdly, endocrine surgery is the only surgical topic evaluated in the study, hence results
showing the effectiveness of TESLA-G may not be generalisable to other surgical
subspecialties, or other medical specialties. Future work would involve expanding TESLA-G to
encompass other surgical subspecialties and using TESLA-G as a template to develop more
gamified online platforms that would better cater to the other medical specialties.

Lastly, while all undergraduate medical students in the medical school we are recruiting from
already have smartphones compatible with the Telegram application, the students will have to
incur the cost of cellular data for the study. This could be a deterrent to students enrolling in the
study and be a potential source of selection bias.

Contributors

CLKC and LTC conceived the study concept. MSPN, AIJ, YIA and TDRN drafted the manuscript
and obtained funding. MSPN developed the study design and statistical analysis plan. JLC and
DNHT developed the software aspects of TESLA-G. CLKC, LTC and AIJ provided critical
revision. All contributors have approved the final version of the manuscript.
Funding

As of August 2021, this study has been funded by the Games for Health Innovations Centre (ALIVE) Serious Games Grant (Grant Number: SGG20/SN02).

Competing interests

We declare no competing interests.
References


16. Johnson G. Optional online quizzes: College student use and relationship to achievement.


30. Gönüllü E, Soysal A, Can İ, et al. The Use of Social Network in Daily Pediatric Practice and


1 Figure titles

2

3 Figure 1. Flowchart showing the run-through of the game

4 Figure 2. Study flow diagram

5 Figure 3. Logic model of the study

6

7

8
Flowchart showing the run-through of the game

Game starts

3-minute countdown timer and 3 lives

Level 1

Correct answer

Wrong answer

Points awarded based on speed and question level
Point multiplier system: Longer streak = Higher multiplier
Proceeds to level 2

Lose a life
Point multiplier resets

1. Answered level 5 question correctly
2. Ran out of lives
3. Ran out of time

Wrong answer

Game over

Level 5

...
MCQ tests and survey to be piloted among researchers

Medical students recruited  
N = 50

Informed consent to
1. Participate in the study
2. Acknowledge the use of results in future research and publications

Demographics survey
1. Name, gender, age and year of study in medical school
2. Previous surgical education
3. Email address and Telegram username

Pre-intervention
MCQ test on surgical knowledge

Randomised to intervention group or control group

Day 1

Intervention Group  
(N = 25)
TESLA-G (quizzing platform with gamification)

Control Group  
(N = 25)
Conventional quizzing platform

Day 14

Post-intervention
1. MCQ test on surgical knowledge
2. Survey for learner satisfaction

Participant access to their quizzing platforms will be removed

Day 28

2-week follow-up assessment
1. MCQ test on surgical knowledge

Outcome measures
• MCQ test - evaluate improvement in surgical knowledge
• Survey (Likert scale) - evaluate post-intervention learner satisfaction
• Follow-up MCQ test - evaluate retention of surgical knowledge two weeks post-intervention

Random selection of students (N = 10) from intervention group for qualitative feedback regarding the gamified quizzing platform

Study flow diagram

280x553mm (96 x 96 DPI)
Logic model of the study

Medical students in the intervention group will use TELSA-G for the learning of endocrine surgery.

**Intervention**

**Mechanism of change**
- Students will progress up Bloom's taxonomy by attempting questions of increasingly higher-order thinking.
- Score system that rewards students based on answering accuracy (how many questions answered correctly) and consistency (how many consecutive questions answered correctly).
- Competition-based learning where students are ranked against each other on a leaderboard which is visible to all students.
- Incentive in the form of a custom badge reel for the top 3 students.

**Outcomes**
- Superior improvement in surgical knowledge for the intervention group.
- Increased learner satisfaction for the intervention group.
- Superior retention of surgical knowledge for the intervention group.

183x181mm (96 x 96 DPI)
Study Information sheet

Name of PI: Assistant Prof Lorainne Tudor Car

Institution and contact details: Centre for Primary Healthcare Research and Innovation, Lee Kong Chian School of Medicine, 11 Mandaly Rd, Clinical Sciences Building, Level 18, S308232; Email: lorainne.tudor.car@ntu.edu.sg

IRB reference number:

Title of Study: The use of Telegram in surgical education: A Pilot Study

Objective: The principal aim of this study is to investigate the use of gamification in online multiple-choice question (MCQ) quizzes for surgical education.

Procedures: TESLA-G is an online platform for surgical education that incorporates game elements into online MCQ quizzes built on Telegram.

As part of the intervention, you will be expected to complete a demographic questionnaire and a pre-intervention knowledge test online comprising of 20 MCQs on endocrine surgery over a 30-minute period. You will then be assigned to one of two versions of the TESLA-G platform for 2 weeks to answer MCQ questions related to endocrine surgery. These two versions differ in the way the questions are delivered but contain the same set of MCQ questions. After 2 weeks, you will complete a post-intervention knowledge test online which once again comprises of 20 MCQs on endocrine surgery over a 30-minute period. You will also complete a survey online to measure your satisfaction with the application. Two weeks after completing the post-intervention test, you will complete a follow-up knowledge test online which once again comprises of 20 MCQs on endocrine surgery over a 30-minute period. Additionally, 10 of you will be randomly selected to gather qualitative feedback regarding TESLA-G.

The results and performance on the MCQ tests taken during the whole study will not affect nor will they have any bearings on your formative and/or summative grade(s).

Right to Refuse or Withdraw: You are entitled to refuse to participate or discontinue participation at any time in this research. You can withdraw from the research at any time without giving any reasons, by informing the principal investigator and all your data collected will be discarded.

Risks and Discomforts: This is a very low-risk study. Throughout this study, you will be encouraged to inform the research team via Telegram and the university’s student support services if you...
experienced any issues, harms or psychological distress. Such incidents will also be recorded and reviewed for future improvement.

Benefits: There is no direct benefit to you by participating in this research study. The knowledge gained may benefit the public in the future by improving medical education.

Compensation: Upon completion of your participation in the study, you will receive a voucher to the value of $25 from a reputable retailer as a thank you for your time and contribution.

Anonymous and Confidential Data Collection: Demographic data such as your name, gender, age, year of study, Telegram username, and email will be collected as part of the study. No other identifiable information will be collected. Your data will be kept confidential.

Confidentiality of records: Only the principal investigator has your data, and this will not be released to any other person, including members of the research team. Personal data will never be used in a publication or presentation. All data collected will be kept in accordance with the University’s Research Data Management Policy. Research data used in any publication will be kept for a minimum of 10 years before being discarded.

Personal Data:

By signing the Consent Form attached, you (or your legally acceptable representative, if relevant) are authorizing (i) collection, access to, use and storage of your “Personal Data” by NTU, for the purposes of the study and subsequent steps related to this research project; and (ii) disclosure of such Personal Data to, and use and storage by, authorised service providers and relevant third parties, whether located in Singapore or overseas, for the Purpose; and (iii) disclosure of such Personal Data to the relevant government ministries, statutory boards and/or any other government agencies when requested and/or required under relevant legislations.

“Personal Data” means data about you which makes you identifiable: (i) from such data; or (ii) from that data and other information which an organisation has or likely to have access.

Research arising in the future, based on this “Personal Data”, will be subject to review by the relevant institutional review board.

Data collected are the property of the Centre for Primary Healthcare Research and Innovation. In the event of any publication regarding this study, your identity will remain confidential.

Any research data containing your “Personal Data” that is collected for the purposes described in this Consent Form will be stored in Singapore.

Who to contact with questions: Should you have any questions regarding the nature of the study or your participation in this study please contact:
Assist Prof Lorainne Tudor Car  
Centre for Primary Healthcare Research and Innovation  
11 Mandalay Rd, Clinical Sciences Building, Level 18, S308232  
Email: lorainne.tudor.car@ntu.edu.sg  
Contact: 6904 1258

Should you have questions on participants' rights in the study, please contact:  
NTU-Institutional Review Board  
Research Integrity and Ethics Office  
62 Nanyang Drive  
N1.2-B1-02A  
Singapore 637459  
Email: irb@ntu.edu.sg
Consent Form

I have read, discussed and understand the information and procedures in the study information sheet attached to this consent form. My questions concerning the study have been answered to my satisfaction, and I acknowledge that I am participating in this study of my own free will. I understand that I may refuse to participate or stop participating at any time.

Consent to participate in the research

☐ Yes I agree to participate in this research.

☐ No, I do not agree to participate in this research.

Name of Participant __________________________ Signature __________________________ Date ________________

For study involving minors (unmarried subjects who are less than 21 years of age), consent from a parent or guardian is necessary

I give consent for my child as named above to participate in the study and agree to the consent as noted above.

Name of Parent __________________________ Signature __________________________ Date ________________
## Interview Guide

**Questions on demographics**

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Which year of medical school are you currently in?</td>
</tr>
<tr>
<td>2</td>
<td>Have you completed your general surgery rotation?</td>
</tr>
<tr>
<td>3</td>
<td>Are you currently taking part in your general surgery rotation?</td>
</tr>
<tr>
<td>4</td>
<td>How long have you been using Telegram?</td>
</tr>
<tr>
<td>5</td>
<td>What do you primarily use Telegram for?</td>
</tr>
<tr>
<td>6</td>
<td>What other messaging apps do you use?</td>
</tr>
</tbody>
</table>

**Questions for TESLA-G**

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>Prompts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What role has mobile learning (i.e., learning delivered via mobile devices) had on your education?</td>
<td>During this pandemic; In general; In surgical education; In other areas; Types of mobile learning used; Pros/Cons to its use</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Areas/Features</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>What is your view on the use of messaging apps (e.g. Telegram or WhatsApp) in your medical education?</td>
<td>Areas in which they can be used; Pros/cons of using them; Preferences</td>
</tr>
<tr>
<td>3</td>
<td>What is your view of TESLA-G?</td>
<td>Benefits/limitations</td>
</tr>
<tr>
<td>4</td>
<td>What impact did the TESLA-G have on your surgical competency?</td>
<td>Knowledge; Skills</td>
</tr>
<tr>
<td>5</td>
<td>What impact did TESLA-G have on your attitudes towards surgery?</td>
<td>Surgical training; Surgery as a speciality/choice of residency</td>
</tr>
<tr>
<td>6</td>
<td>What is your view of the potential inclusion of TESLA-G in formal undergraduate surgical education in future?</td>
<td>Benefits/limitations</td>
</tr>
<tr>
<td>7</td>
<td>How can TESLA-G be improved?</td>
<td>Additional content; Features</td>
</tr>
<tr>
<td>8</td>
<td>What is your view on other similar learning platforms that you have used?</td>
<td>Similarities/differences; Advantages/disadvantages</td>
</tr>
<tr>
<td>9</td>
<td>What is your view on the use of such learning platforms in other areas of your medical education?</td>
<td>Areas; Format of the channel; Advantages; Disadvantages</td>
</tr>
<tr>
<td>10</td>
<td>Are there any other observations or comments that you would like to share with me today?</td>
<td></td>
</tr>
</tbody>
</table>
# Reporting checklist for protocol of a clinical trial.

Based on the SPIRIT guidelines.

## Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the SPIRIT reporting guidelines, and cite them as:


### Administrative information

<table>
<thead>
<tr>
<th>Reporting Item</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>#1</td>
</tr>
<tr>
<td>Trial registration</td>
<td>#2a</td>
</tr>
</tbody>
</table>

For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml
name of intended registry

Trial registration: data set #2b All items from the World Health Organization Trial Registration Data Set

Protocol version #3 Date and version identifier

Funding #4 Sources and types of financial, material, and other support

Roles and responsibilities:
contributorship #5a Names, affiliations, and roles of protocol contributors

Roles and responsibilities:
sponsor contact information #5b Name and contact information for the trial sponsor

Roles and responsibilities:
sponsor and funder #5c Role of study sponsor and funders, if any, in study design; collection, management, analysis, and interpretation of data; writing of the report; and the decision to submit the report for publication, including whether they will have ultimate authority over any of these activities

Roles and responsibilities:
committees #5d Composition, roles, and responsibilities of the coordinating centre, steering committee, endpoint adjudication committee, data management team, and other individuals or groups overseeing the trial, if applicable (see Item 21a for data monitoring committee)

Introduction
Background and rationale #6a Description of research question and justification for undertaking the trial, including summary of relevant studies (published and unpublished) examining benefits and harms for each intervention

Background and rationale: choice of comparators #6b Explanation for choice of comparators

Objectives #7 Specific objectives or hypotheses

Trial design #8 Description of trial design including type of trial (eg, parallel group, crossover, factorial, single group), allocation ratio, and framework (eg, superiority, equivalence, non-inferiority, exploratory)

Methods:

Participants, interventions, and outcomes

Study setting #9 Description of study settings (eg, community clinic, academic hospital) and list of countries where data will be collected. Reference to where list of study sites can be obtained

Eligibility criteria #10 Inclusion and exclusion criteria for participants. If applicable, eligibility criteria for study centres and individuals who will perform the interventions (eg,
surgeons, psychotherapists)

Interventions: #11a Interventions for each group with sufficient detail to allow replication, including how and when they will be administered

Interventions: #11b Criteria for discontinuing or modifying allocated interventions for a given trial participant (eg, drug dose change in response to harms, participant request, or improving / worsening disease)

Interventions: #11c Strategies to improve adherence to intervention protocols, and any procedures for monitoring adherence (eg, drug tablet return; laboratory tests)

Interventions: #11d Relevant concomitant care and interventions that are permitted or prohibited during the trial

Outcomes #12 Primary, secondary, and other outcomes, including the specific measurement variable (eg, systolic blood pressure), analysis metric (eg, change from baseline, final value, time to event), method of aggregation (eg, median, proportion), and time point for each outcome. Explanation of the clinical relevance of chosen efficacy and harm outcomes is strongly recommended

Participant timeline #13 Time schedule of enrolment, interventions (including any run-ins and washouts), assessments, and visits for participants. A schematic diagram is highly recommended (see Figure)
Sample size  #14 Estimated number of participants needed to achieve study objectives and how it was determined, including clinical and statistical assumptions supporting any sample size calculations

Recruitment  #15 Strategies for achieving adequate participant enrolment to reach target sample size

Methods: Assignment of interventions (for controlled trials)

Allocation: sequence  #16a Method of generating the allocation sequence (eg, computer-generated random numbers), and list of any factors for stratification. To reduce predictability of a random sequence, details of any planned restriction (eg, blocking) should be provided in a separate document that is unavailable to those who enrol participants or assign interventions

Allocation concealment mechanism  #16b Mechanism of implementing the allocation sequence (eg, central telephone; sequentially numbered, opaque, sealed envelopes), describing any steps to conceal the sequence until interventions are assigned

Allocation implementation  #16c Who will generate the allocation sequence, who will enrol participants, and who will assign participants to interventions
Blinding (masking) #17a Who will be blinded after assignment to interventions (eg, trial participants, care providers, outcome assessors, data analysts), and how

Blinding (masking): #17b If blinded, circumstances under which unblinding is emergency permissible, and procedure for revealing a participant’s unblinding allocated intervention during the trial

Methods: Data collection, management, and analysis

Data collection plan #18a Plans for assessment and collection of outcome, baseline, and other trial data, including any related processes to promote data quality (eg, duplicate measurements, training of assessors) and a description of study instruments (eg, questionnaires, laboratory tests) along with their reliability and validity, if known. Reference to where data collection forms can be found, if not in the protocol.

Data collection plan: #18b Plans to promote participant retention and complete follow-up, including list of any outcome data to be collected for participants who discontinue or deviate from intervention protocols

Data management #19 Plans for data entry, coding, security, and storage, including any related processes to promote data quality (eg, double data entry; range checks for data values).
Reference to where details of data management procedures can be found, if not in the protocol

Statistics: outcomes

#20a Statistical methods for analysing primary and secondary outcomes. Reference to where other details of the statistical analysis plan can be found, if not in the protocol

Statistics: additional analyses

#20b Methods for any additional analyses (eg, subgroup and adjusted analyses)

Statistics: analysis population and missing data

#20c Definition of analysis population relating to protocol non-adherence (eg, as randomised analysis), and any statistical methods to handle missing data (eg, multiple imputation)

Methods: Monitoring

Data monitoring:

#21a Composition of data monitoring committee (DMC); summary of its role and reporting structure; statement of whether it is independent from the sponsor and competing interests; and reference to where further details about its charter can be found, if not in the protocol. Alternatively, an explanation of why a DMC is not needed

Data monitoring:

#21b Description of any interim analyses and stopping guidelines, including who will have access to these interim results and make the final decision to terminate the trial

Harms

#22 Plans for collecting, assessing, reporting, and managing solicited and spontaneously reported adverse events and other unintended effects of trial interventions or trial
Auditing

#23 Frequency and procedures for auditing trial conduct, if any, and whether the process will be independent from investigators and the sponsor

n/a

Ethics and dissemination

Research ethics

#24 Plans for seeking research ethics committee / institutional review board (REC / IRB) approval

29

Protocol

#25 Plans for communicating important protocol modifications (eg, changes to eligibility criteria, outcomes, analyses) to relevant parties (eg, investigators, REC / IRBs, trial participants, trial registries, journals, regulators)

n/a

Consent or assent

#26a Who will obtain informed consent or assent from potential trial participants or authorised surrogates, and how (see Item 32)

29

Consent or assent: ancillary studies

#26b Additional consent provisions for collection and use of participant data and biological specimens in ancillary studies, if applicable

n/a

Confidentiality

#27 How personal information about potential and enrolled participants will be collected, shared, and maintained in order to protect confidentiality before, during, and after the trial

29-30

Declaration of

#28 Financial and other competing interests for principal

35
interests

Data access  #29  Statement of who will have access to the final trial dataset, and disclosure of contractual agreements that limit such access for investigators

Ancillary and post trial care  #30  Provisions, if any, for ancillary and post-trial care, and for compensation to those who suffer harm from trial participation

Dissemination policy:  #31a  Plans for investigators and sponsor to communicate trial results to participants, healthcare professionals, the public, and other relevant groups (eg, via publication, reporting in results databases, or other data sharing arrangements), including any publication restrictions

Dissemination policy:  #31b  Authorship eligibility guidelines and any intended use of professional writers

Dissemination policy:  #31c  Plans, if any, for granting public access to the full protocol, participant-level dataset, and statistical code

Appendices

Informed consent  #32  Model consent form and other related documentation given to participants and authorised surrogates

Biological specimens  #33  Plans for collection, laboratory evaluation, and storage of biological specimens for genetic or molecular analysis in the current trial and for future use in ancillary studies, if applicable
The SPIRIT Explanation and Elaboration paper is distributed under the terms of the Creative Commons Attribution License CC-BY-NC. This checklist was completed on 07. September 2022 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai