Graduate thesis

NTNU
Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences

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Evaluation of a New Serious Game Simulating a Day at the General Practitioner's Office: Medical students' perspectives on effects on engagement and motivation for learning and valuable elements in the game.

Graduate thesis in Medical studies

Supervisor: Brita Pukstad and Aslak Steinsbekk

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Abstract

Background

Serious games can boost student motivation and engagement. There is little knowledge about whether students' competency level influences their motivation for learning after playing a serious game.

Aim

To investigate how medical students' motivation and engagement for learning after playing the Serious Game PlayMedico differed with regard to their competency levels and their self-reported experience with the game.

Methods

This was a nonrandomized observational study of two groups who differed in how far in the curriculum they had come who played the self-developed Serious Game PlayMedico. Eighty-one fourth-year medical students at the Norwegian University of Science and Technology (NTNU) participated, one group had completed the relevant curriculum covered in PlayMedico (experienced, EXP group, n= 45) and one group had just started (inexperienced, IEXP group, n=35). PlayMedico simulates a general practitioners office with 9 medical cases covering dermatovenerology, infectious medicine, orthopedics and psychiatry. After a short introduction the students played the game for 30 minutes, and then completed a questionnaire with 10 statements scored from 1 (not true) to 5 (very true) and three free text questions on experience and suggestions for improvement. Seven of the statements were divided into four categories; Attention, Relevance, Confidence and Satisfaction based on the ARCS model.

Results

The IEXP group scored highest on 8 of the 10 statements about motivation and engagement for learning after playing the serious game. For the seven statements linked to the ARCS model, both groups scored highest on the motivational category Relevance (4.5 out of 5) and lowest on Confidence (3.5 out of 5). The IEXP group had a higher mean than the EXP group on Attention (mean diff 0.45 95%CI 0.12 to 0.79) and Satisfaction (mean diff 0.43 95% CI 0.05 to 0.81). In the written feedback the students stated that the game was relevant and engaging, with valuable elements like active participation, feedback, prioritizing, case-based tasks, multimedia, realism and variation. The most important suggestions for improvement were more extensive feedback and removal of technical errors.

Conclusion

Students who had just started on the relevant curriculum rated their motivation and engagement for learning after playing the Serious Game higher than the group having completed the curriculum. From the self-reported feedback, the current version of PlayMedico have valuable elements but can still be improved. Due to limitations of the study the results must be interpreted carefully, and further research is needed.

Funding

A scholarship by the Olav Thon Foundation in 2017 was used to pay a company to program PlayMedico.

Sammendrag

Bakgrunn

Seriøse læringsspill kan øke motivasjon og engasjement for læring blant studenter. Det er begrenset kunnskap om hvorvidt spillernes motivasjon for læring påvirkes av studentenes kompetansenivå.

Mål

Å undersøke om medisinstudenters motivasjon og engasjement for læring etter å ha spilt læringsspillet PlayMedico varierte med hensyn til kompetansenivå og beskrive hvilke elementer i spillet medisinstudenter anså som nyttige.

Metode

Dette var en ikke-randomisert observasjonsstudie av to grupper medisinstudenter som hadde gjennomført ulike deler av læreplanen og som spilte det selvutviklede spillet PlayMedico. 81 fjerdeklasse medisinstudenter på Norges Teknisk-Naturvitenskapelige Universitet (NTNU) deltok. En gruppe var i ferd med å ha en avsluttende eksamen i emnene som dekkes i spillet (experienced, EXP-group, n=45), mens den andre gruppen hadde nettopp startet å lære seg emnene (inexperienced, IEXP-group, n=35). PlayMedico simulerer et fastlegekontor med totalt ni medisinske kasuistikker innenfor fagfeltene dermatovenerologi, infeksjonsmedisin, ortopedi og psykiatri. Etter en kort introduksjon spilte studentene PlayMedico i 30 minutter. Deretter fylte de ut et spørreskjema bestående av 10 utsagn med poengsum fra 1 (Ikke sant) til 5 (Veldig sant) og 3 fritekstspørsmål om opplevelse og forslag til forbedring. 7 av utsagnene var videre delt inn i fire kategorier: «Attention», «Relevance», «Confidence» og «Satisfaction» basert på ARCS-modellen for motivasjon.

Resultater

Den uerfarne gruppen skåret høyest poengsum på 8 av de 10 utsagnene om motivasjon og engasjement for læring etter å ha spilt PlayMedico. For de 7 utsagnene som falt innunder kategoriene i ARCS-modellen, ga gruppene sammenlagt høyest poengsum på motivasjonskategorien «Relevance (4.5 av 5)» og lavest poengsum på motivasjonskategorien «Confidence (3.5 av 5)». Den uerfarne gruppen hadde en høyere gjennomsnittspoengsum enn den erfarne gruppen på kategoriene: «Attention» (gjennomsnittlig forskjell 0.45, 95% konfidensintervall 0.12,- til 0.79) og «Satisfaction» (gjennomsnittlig forskjell 0.43, 95% konfidensintervall 0.05- til 0.81). I fri-tekst svarene uttalte studentene at spillet var relevant og engasjerende, med nyttige elementer slik som aktiv deltakelse, tilbakemeldinger, prioritering, kasus-baserte oppgaver, multimedia, realisme og variasjon. De viktigste forslagene til forbedring var mer omfattende tilbakemeldinger og å fjerne tekniske problemer.

Konklusjon

Studentene som nettopp hadde startet å lære seg de relevante medisinske emnene som dekkes i spillet ga en høyere poengsum på motivasjon og engasjement for læring etter å ha spilt PlayMedico enn de som var i ferd med å ha avsluttende eksamen i emnene i spillet. De selv-rapporterte tilbakemeldinger viser at den nåværende versjonen av PlayMedico har nyttige elementer, men fremdeles kan forberedes. På grunn av begrensninger i studien må resultatene tolkes med forsiktighet og det er behov for videre forskning.

Finansiering

Et stipend fra Olav Thon Stiftelsen I 2017 ble brukt for å programmere PlayMedico.

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1. Introduction

Technology is a constant drive for change, and within education digitalization is becoming an important part of the way we teach and learn (1). The ongoing COVID-19 situation is one example that illustrates how important digital solutions are. Schools and universities have stopped all conventional teaching due to the Corona lock down and are dependent on new ways to reach and teach their students (2-4) .

Serious Games are examples of digital teaching solutions and have in the last few years gained popularity at all educational levels (1, 5). A game can be defined in different ways, and according to Raph Koster *(6) "A game is a system in which the player engages in an abstract challenge, defined by rules, interactivity, and feedback, that results in a quantifiable outcome often eliciting an emotional reaction."* A Serious Game is broadly defined as a game for aims beyond pure entertainment, as the goal is to educate individuals in a specific content domain (7, 8).

The term "serious game" includes a variety of approaches such as quizzes, interactive stories, virtual worlds and simulations (9).

Serious games potential for learning depends on how responsive, dynamic and visualized games are compared to text-book learning (9). In education of health professions, serious gaming appears to give results in line with traditional teaching, and are in many studies more effective in terms of improving knowledge, skills and satisfaction (8, 10-14). Furthermore, previous studies suggest that serious games can be better at motivating and engaging subjects than traditional teaching (11, 15), also demonstrated in the medical field (16-19). Another benefit is that serious games provide a safe environment for students to learn from their mistakes without having to experience real life negative consequences from their actions (20). One can argue that this is of special importance in the medical education where wrong decisions can result in patient injuries or in worst case scenario, death (21-23).

With all this in mind, it is no wonder that the interest of integrating serious games in medical education is increasing (24) . However, the essence of medical education is clinical learning (25), and the availability of Serious Games for clinical learning is limited (24). For instance, there are few Serious Games that provide learning about patients typically seen during a day in general practice (from here one referred to as a GP's office) (26). Further, many of the games for clinical education cover only small aspects of clinical education, lack medical content and are limited from a curricular perspective (27).

1.1 Valuable elements in a Serious Game for medical education

Some studies have investigated what elements medical students value in a clinical Serious Game. Four of these studies (28-31) have suggested that medical students appreciate the following elements:

- Immediate in-game feedback
- Detailed summative feedback after each game
- To work through a complete patient problem on their own
- Realism
- To solve clinical problems
- A scoring system
- To treat various patients simultaneously
- To minimize the occurrence of technical problems
- To be allowed to make errors and learn from it (unlike a clinical setting where there are consequences that can be harmful)
- To feel «responsible» for their actions through experiencing a «face-to-face» encounter with the on-screen patient, and seeing the consequences of their actions unfold on screen
- Repetition, as it serves as a useful aid for knowledge consolidation
- Active learning
- To be able to keep the attention

Active learning, feedback, consolidation and attention have been identified in Cognitive Science as the four main pillars of learning and need to be carefully included in Serious Games to ensure learning effectiveness (28, 32). In order to develop a motivating Serious Game for medical students, it has also been shown promising to let the players make decisions to help or save a patient (stimulating their intrinsic motivation), and to let them simulate being a real doctor which is their future desirable outcome (stimulating their extrinsic motivation)(28).

1.2 Motivation for learning

Motivation plays a crucial role in both the learning process and learning outcome, also among medical students (33, 34). Many have some intuitive feeling for what motivation is, yet the term has proven to be rather difficult to define. Even theorists differ in their views of motivation (35). One of many motivational theories is the ARCS model by Keller (36). According to Keller, motivation refers to individuals' intrinsic and extrinsic goals to achieve or avoid a given outcome, which in turn influence their choices and expenditure of effort (36). As motivation is a complex term that might be interpreted in different ways, it is hard to measure it in one question alone. Keller, therefore, broke human motivation for learning into four major categories: "*Attention", "relevance", "confidence"* and *"satisfaction"* (36), using the first letters to give the acronym ARCS. These four categories have 3 subcategories each, as displayed and described by instructional questions and the strategies used to achieve them (Table 1). All of the content in the table is gathered from Keller's book regarding the ARCS-model approach (36).

Table 1. Details of the ARCS model.

Major category	Sub-category	Instructional Questions	Strategies/Tactics
Attention	1. Perceptual Arousal	1. What can I do to capture their interest?	1. Create curiosity and wonderment by using novel approaches, injecting personal and/or emotional material.
	2. Inquiry Arousal	2. How can I stimulate an attitude of inquiry?	2. Increase curiosity by asking questions, creating paradoxes, generating inquiry and nurturing thinking challenges.
	3. Variability	3. How can I maintain their attention?	3. Sustain interest by variations in presentation style, concrete analogies, human interest examples, and unexpected events
Relevance	1. Goal Orientation	1. How can I best meet my learner's needs?	1. Provide statements or examples of the utility of the instruction, and either present goals or have learner define them.
	2. Motive Matching	2. How and when can I provide my learners with	2. Make instruction responsive to learner motives and values by

		appropriate choices, responsibilities and influences?	providing personal achievement opportunities, cooperative activities, leadership responsibilities, and positive role models.
	3. Familiarity	3. How can I tie the instruction to the learners' experiences?	3. Make the materials and concepts familiar by providing concrete examples and analogies related to the learners' work and background.
Confidence/ Challenge	1. Learning Requirements	1. How can I assist in building a positive expectation for success?	1. Establish trust and positive expectations by explaining the requirements for success and the evaluative criteria.
	2. Success Opportunities	2. How will the learning experiences support or enhance the students' beliefs in their competence?	2. Increase belief in competence by providing many, varied, and challenging experiences that increase learning success.
	3. Personal Control	3. How will the learners clearly know their success is based upon their efforts and abilities?	3. Use techniques that offer personal control (whenever possible) and provide feedback that attributes success to personal effort.
Satisfaction/ Success	1. Intrinsic Reinforcement	1. How can I encourage and support their intrinsic enjoyment of the learning experience?	1. Provide feedback and other information that reinforces positive feelings for personal effort and accomplishment.
	2. Extrinsic Rewards	2. What will provide rewarding consequences to the learners' successes?	2. Use verbal praise, real or symbolic rewards, and incentives, or let learners present the results or their efforts ("show and tell") to reward success.
	3. Equity	3. What can I do to build learner perceptions of fair treatment?	3. Make performance requirements consistent with stated expectations, and use consistent measurement standards for all learners' tasks and accomplishments.

When these 4 motivational categories are fulfilled, the motivational outcome is higher, hence increasing the educational outcome (37-39).The ARCS model is suitable to assess learners'

motivation for a Serious Game as it has been applied in teaching and Serious Games before and has been validated in several studies at all educational levels (36, 40-42).

1.3 Experience with the medical content in a Serious Game

During medical school, the students increase their competency level through getting more and more experience with medical knowledge and practice. According to Harter's competence motivation theory, people are more motivated to improve their competence when they successfully master a task (43). Thus, students' motivation for learning might depend on their competency level relative to the medical content of the learning activity. Before implementing Serious Games in medical education, it is therefore of interest to know if students that are more experienced with the medical content covered in a Serious Game have a different benefit of playing it than students that are inexperienced with the content. One study on the clinical Serious Game EMERGE found that students in lower semesters had a more positive impression of EMERGE than students in higher semesters (44), indicating that being less experienced with the medical content in a serious game can increase motivation. We have not found any other similar studies that answers this question, despite a thorough search in scientific literature.

2. Aims

To our knowledge there are no studies investigating Serious Games concerning different patients typically seen during a day in a GPs office, and whether playing such a game has an effect on medical students' engagement and motivation for learning.

The overall aim of this study was to contribute with knowledge about the experience of using Serious Games in medical education. This was done by answering two research questions:

1. How will two groups of fourth year medical students, who differ in how far in the curriculum they have come, rate categories of motivation for learning after having played a Serious Game mirroring treatment of patients typically seen during a day in a GPs office?
2. What elements do fourth year medical students consider valuable in a serious game?

3. Methods

3.1 Design

The study was performed as an observational study of two groups of fourth-year medical students who differed in how far in the curriculum they had come, who answered a questionnaire after 30 minutes playing sessions of the self-developed Serious Game PlayMedico. The data collection was carried out between December 2019 and March 2020.

3.2 Ethical aspects

No personal questions that could identify the participants, e.g., gender and age, were included.

The study falls outside of the domain of the Norwegian national system for ethical approval, due to not collecting health information from the participants.

A Data Protection Impact Assessment (DPIA) was assessed to identify and minimize the data protection risks of the project. By utilizing eSurvey-questionnaires, the answers received were anonymous, and no personal information was saved. This was confirmed through email-correspondence with eSurvey. The participants consented to their responses being applied in research by completing the survey.

3.3 Setting

The study was performed at the Faculty of medicine and health sciences, Norwegian University of Science and Technology (NTNU), campus Trondheim. The medical education at NTNU is a 6 year program. One-hundred-and-twenty students were admitted in 2016 when the students participating in this project started their medical education.

Due to limitations in the number of students that can be on clinical rotation in the same hospital department at the same time, the students´ are divided into two groups for the third-, fourth- and fifth year. When the students are divided into these groups, they are asked for their wishes of classmates to be grouped with, and these wishes are respected as far as possible. Thus, the students are not randomly assigned to these groups, but neither can the students self-select their group.

When the students are in these groups, each year consists of two semesters. Different medical subjects are being taught in each semester, and one of the groups takes one semester first, while the other group starts on the other semester. After a year, both groups have been through the same curriculum.

This study was conducted in what is called the "IIC semester", which, among other medical topics, include dermatovenereology, psychiatry, orthopedics, rheumatology, and infection medicine. In the IIC-semester where we included our participants to the study there were 58 students (26 males and 32 females) during fall 2019, and 57 students (15 males and 42 females) during spring 2020, i.e. 115 students in total.

3.4 Study population

The eligibility criteria to participate in the study were being a medical student at NTNU starting his/her fourth year in August 2019, and either in the group soon to end the IIC semester or the one just starting the IIC semester.

3.5 Recruitment

To recruit students the supervisor of this thesis, who also is a teacher in the IIC semester, posted information about the study in the learning management system some days before the intervention. This information included a brief description of the game and the study. The students were told that the game had topics relevant for their exams and that it would be provided free pizza after participation.

3.6 Allocation

The students that attended the IIC semester during fall 2019 were asked to participate in the trial late in their semester, in December, which was just a few days before their exam. They had completed all the teaching activities and were reviewing this for their exam. They are from now referred to as the Experienced group (EXP group) as they had been through all the medical topics covered in the game (see below)

The students that attended the IIC semester during spring 2020 were asked to participate in February/March, three to six weeks after they had started the semester. Thus,

they were rather inexperienced in the medical topics presented in the game and are hereafter referred to as the Inexperienced group (IEXP group). Due to the low number of participants on the allocated day in February, those not participating were invited to do so in early March to increase the number of participants in the IEXP group.

3.7 Development and description of the game PlayMedico

Playmedico is a web-based simulation game where the participants play doctors at a GP's office on a normal busy workday (45). It is freely available on www.playmedico.com. It can be accessed by using any web browser, preferably on a smartphone, as it is formatted for smaller devices.

3.7.1 Development of the game

The development of the game was mainly done by the two students doing this thesis, one of the supervisors (BP) and a Norwegian game company called 4BitGames.

The overall goal was to develop a Serious Game covering topics in the IIC semester that the medical students would find motivating and engaging to learn. It was also desired to make sure the content was correct from a medical perspective as well as relevant and realistic in order for the medical students to feel better prepared for their exams and practicing as doctors. Furthermore, it was desired to include cases within different medical fields.

To ensure all of this, elements in Serious Games that medical students have regarded beneficial, as presented in the introduction, were carefully strived to be included throughout the process. An element where the player had to prioritize the patients after the cause of admission was also implemented, which to our knowledge has not been included in medical Serious Games earlier.

The clinical cases built into PlayMedico were developed in collaboration with students and teachers in medical education at NTNU. Nine distinct clinical cases were made covering the medical fields psychiatry (2 cases), dermatovenereology (3 cases), orthopedics/rheumatology (3 cases), and infection medicine (1 case). In order to keep a high quality of the medical content in the game, we carefully searched through earlier exams at NTNU within a period of the last five years while developing the cases. These exams have been looked through by many clinicians before the exams to ensure that they hold a certain standard from a clinical perspective.

Regarding the technical development, PlayMedico was programmed by 4BitGames (https://www.4bitgames.com/), a Norwegian game company, with funding from the Thon foundation (https://olavthonstiftelsen.no/). The software, mEditor (a downloadable game design software, developed by 4BitGames) was used to create the flow of the medical cases in the game (45). This software made it possible for the game's story-driven focus to be presented through specialized game mechanics such as branching narrative, dialogue trees, and multiple endings. By using this software, the case-developer could choose which on-screen events that were to be responding to the users' decisions in the actual game, as displayed in figure 1. The player could then experience that each choice he/she made led to another on-screen image that corresponded to the action he selected, followed by possible subsequent steps.

Figure 1: Parts of the decision tree developed in mEditor.

3.7.2 Testing the cases

All of the cases were reviewed by us and the supervisor both through mEditor and by playing through the cases after it was programmed. Further, other teachers and doctors at NTNU looked through the cases together with us and came with corrections and suggestions for improvement to ensure that they were clinically correct. We also let some of our friends and family members play through the cases and asked them to look for improvement potential and errors, i.e. mostly the technical parts. They reported mainly grammar errors. These were corrected before the release of PlayMedico.

3.7.3 Description of the game

Each of the nine cases differs with regards to length, implementation of multimedia, and amount of questions and feedback. The patient case shown in the figures 2 to 7 below, (a male patient consulting for painful urination) is one of the shortest cases in the game. The figures 8-10 demonstrates different parts of other patient cases.

The players are first welcomed by a start page with a brief explanation of how to play the game (Figure 2).

Figure 2: the start page of the game

By pushing the button “play” (Figure 2), they are introduced to a waiting room where they meet patients in groups of three (Figure 3). For each group, the players must prioritize which patient they want to treat first, second, and last. To do this, they must hold the pointer over each patient to get his/hers presenting complaints. The order of the patient groups presented is random, but the developers have chosen which three patients to be in each group so all groups contain patients with different disease severity. This makes it possible to prioritize cause of admission from degree of severity (Figure 3).

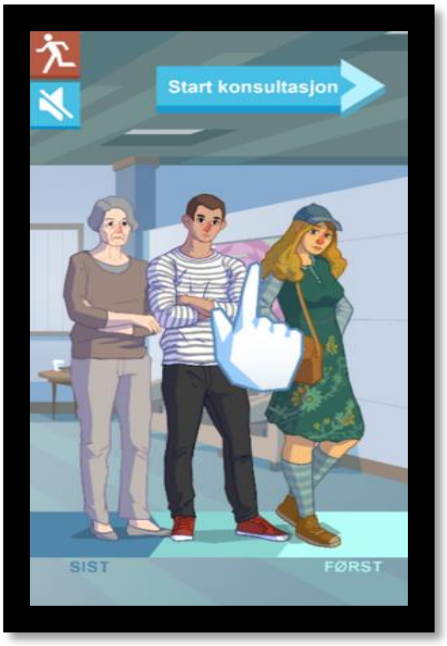


Figure 3: The first three patients

To prioritize which patient to see first, i.e. deciding which cause of admission the player consider most urgent to treat, he or she must click on the patient and move the patient back or fourth in the line. The most urgent patient to treat, according to the players judgement, is placed farthest to the right, while the least urgent is placed farthest to the left. The patient in between is regarded as a medium priority.

Figure 4 shows the player moving the male patient with "*painful urination,*" as cause of admission to the front (which the player later will get feedback was not correct as there was a patient with an acute fracture in the line which should have gotten highest priority.)

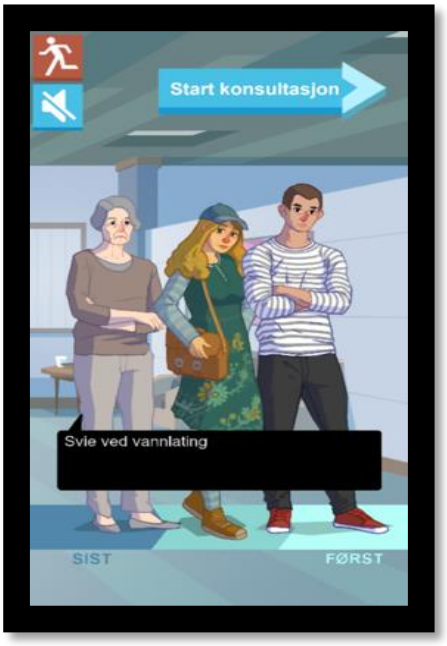


Figure 4: Cause of admission of the male patient. The player has regarded him as the most urgent to treat and therefore placed the patient farthest to the right.

At the top right corner (Figure 4), there is a button shaped as an arrow for starting the consultation. To the left for this button, there are to distinctive buttons, the top one in red is to exit the game, while the one underneath is to enable sound effects, not yet available in the pilot. When the patient has entered the doctor's office, the player is provided information about the patient's symptoms.

In some cases, a box pops up as shown in figure 5 where the patient himself describes his symptoms, but for other cases it is more like a conversation where the doctor can choose among a limited set of questions to ask the patient and the patient will reply to the specific question. Furthermore, the player might get information through the patient's journal.

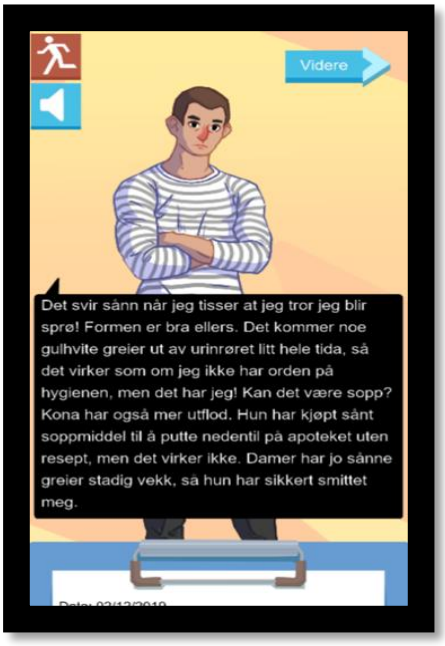


Figure 5: Patient describing his symptoms.

During the consultation, the player has access to the patients´ journal, which gives updated information on the patients' medicines and their medical history (figure 6). This is accessible by clicking on the journal at the bottom of the screen.

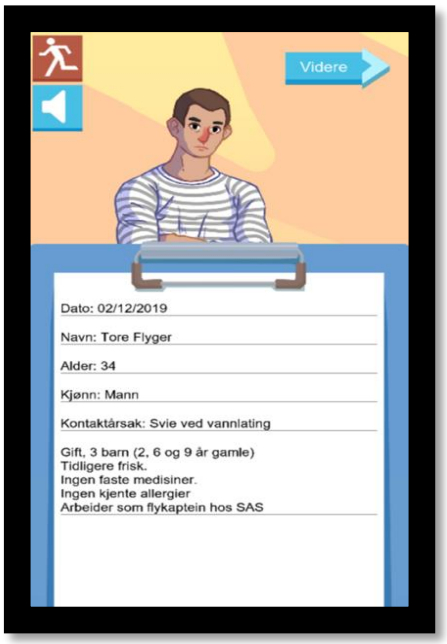


Figure 6: Medical record including date, patient name, age, gender, cause of admission and medical history.

To take the medical history, patient examination, diagnostic test orders, and establish a diagnosis and treatment, the player is provided with a limited set of options and must click what the player regards as the correct choice of action (Figure 7).

Figure 7: Example of treatment options.

In text boxes with a lot of text, the player must scroll in the text box to see all the text. Features like x-ray images, clinical images of the patients pertaining to their medical condition, lab results, and ECG are provided in some of the cases. The player is automatically directed to these multimedia features by clicking the NEXT (“Videre”) arrow, just like any other page in the game.

Each choice the player makes has its own set of consequences. For example, if the right treatment is chosen, the player might read in the dialog box belonging to the patient that the patient says he is grateful for the help. If, however, a wrong decision has been made, a dialogue box might display complaints from the patient, demonstrated by two other patient cases in figure 8. The player is in some cases provided a textbox of feedback, especially if a severe mistake has been performed. This feedback informs the player about the outcome of choice, for instance if the patient dies, together with information regarding what he should have done. Thereafter, the player must retry the medical case.

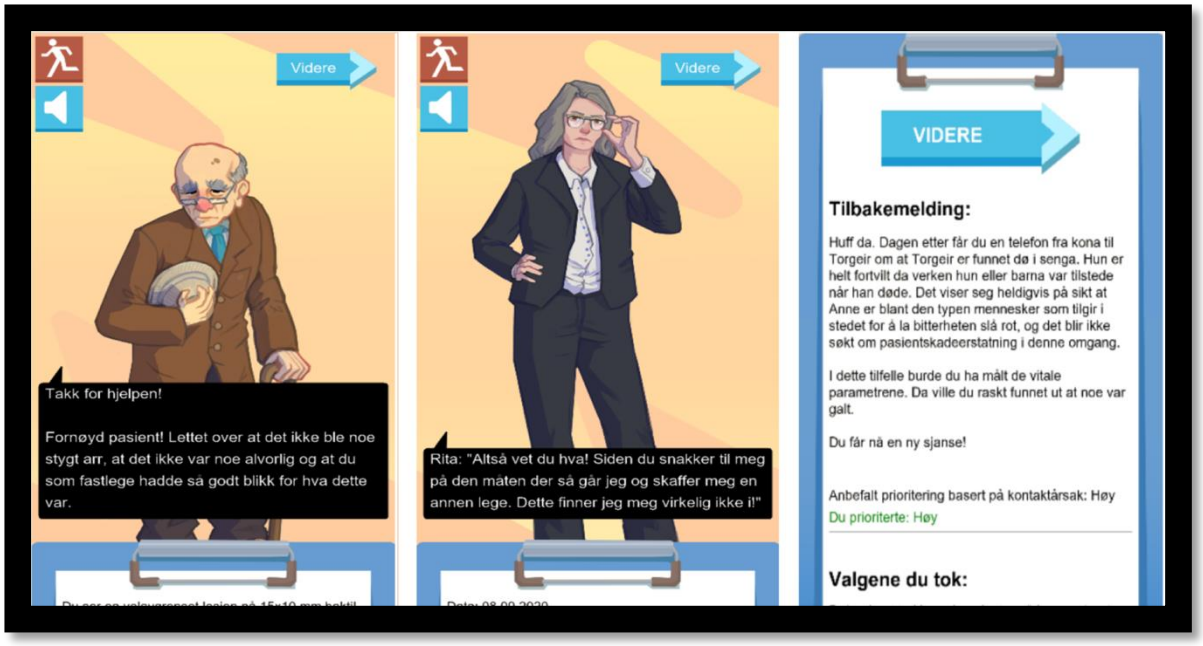


Figure 8: Examples of feedback

In other cases, when the player has made the wrong decision, immediate feedback is provided as to why the option is wrong, eventually followed by a chance to make another try (figure 9: illustrated by another patient case), and the player is returned to the previous list of options to make another try.

Figure 9: Example of feedback with a chance to retry the last.

After each patient case, the students are debriefed by an information page that informs them about the correct diagnosis and treatment for each patient, as well as the outcome of their decisions (figure 10). When pushing the button “videre,” which means “next,” the next patient shows up at the doctor's office. After the first three patients, the subsequent group of patients is presented similarly in the waiting room, and again the player must prioritize which of the following patients has the most urgent admission cause.

Figure 10: Example of final feedback. Green equals correct. Red equals incorrect.

3.8 Intervention

The intervention consisted of playing the game PlayMedico in 30 minutes, and was delivered in the same way for both groups.

As the instructions for how to play PlayMedico were not completed at the time of the trial, the participants got a brief explanation of how to play the game before they started. Thereafter, the students began their 30-minute playing session with PlayMedico.

We were present when the students played the game to keep track of the time and assist if anyone needed help. During the trial in December, many of the students contacted us as they experienced start-up issues and lagging throughout the game. This was due to a technical problem with the server which got overloaded. During the last two trials of the IEXP group, however, we were not contacted even once.

3.9 Data collection

After the participants had played through the game, they got 10 minutes to fill out the questionnaire before pizza and beverage was served.

eSurvey(46), an online-based survey and questionnaire creator, was applied to compile the survey and collect the data. All questions were made mandatory to answer. The link to the survey was made available for the students in their learning management system to be easily accessible for all participants.

3.10 Outcome measures

The students were not asked about baseline information (i.e., there were no questions about age, gender, former education, preferences for learning, and experience with gaming).

To explore what elements the medical students considered valuable in the serious game PlayMedico, we used two self-made open-ended free text questions: "*What did you like about the game?*" and "*What is your suggestion for improvement?*".

To measure how many students played through all nine game cases within the intervention time of 30 minutes, we asked the yes-or-no question: "*Did you play through all of the nine patient cases*?".

To measure their overall experience with the game and motivation after playing the game, the students were provided with ten statements (appendix 1). A Likert scale, with the answering categories not true (1) to very true (5), was used to measure the level of agreement or disagreement with the ten statements (47).

Three statements were used to measure the students' overall engagement, experience and motivation. To investigate whether the game increased the students' engagement, which positively effects learning (37-39), the statement "This game was engaging" was used.

Further, as intuitive user interfaces are important in Serious Games for effective learning (48), the statement "I easily understood how to play the game" was included. A systematic review on Serious Games states that "no matter how captivating the game, learners will not step away from a game with the desire to learn more about the game's subject material" (49). Therefore, the statement: "The game increased my motivation for at least one subject" was included to get an impression regarding whether this was correct for our Serious Game as well.

Seven statements were used to measure motivation in more detail. These statements were taken from a former graduate thesis performed at NTNU that investigated student motivation for learning after watching a 360 video of a clinical situation using Virtual Reality goggles (50). This graduate thesis applied Keller's ARCS motivational model as a theoretical background for their questionnaire to evaluate student's motivation (36). Thus, they used the ARCS model (Table 1) as a starting point, and made their own statements based upon this. To adapt these statements to the specific game in this study (PlayMedico), the statements in our questionnaire were slightly adjusted as described below.

As presented in the introduction, Keller's ARCS motivational model is a model that states that the following four categories encompass the major factors that influence the motivation to learn (36).

- *"Attention":* Attention in a learning situation is about capturing the learners' interest and curiosity in order to stay focused.
- *"Relevance":* Relevance is among others about making sure the students believe that what they learn is related and relevant to accomplish personal goals, such as passing an exam and working as a doctor.
- *"Confidence":* Confidence is boosted when the students are aware of the learning requirements, when they have personal control and when learning have success opportunities. An example of success opportunity is frequent feedback, which confirms the students' success and motivates the student. Also, if the game teaches the students how to diagnose and treat specific illnesses, their sense of personal control might be enhanced.
- *"Satisfaction":* As Keller has stated, "If you are successful in achieving these first three motivational goals (attention, relevance and confidence), then the students will be motivated to learn. Next, in order for them to have a continuing desire to learn, they must have feelings of satisfaction with the process or results of the learning experience."

Each of the seven 7 statements in the questionnaire concerns one of the mentioned categories, according to Keller's description of these, as displayed in the table below (Table 2).

Table 2: The seven statements about motivation, sorted according to the different categories of motivation in the ARCS model

Aspect of motivation	Statement number	Statements
Attention	1	I think it's easy to stay focused during this game
Relevance	2	This game is relevant for my exams
	3	This game is relevant for my future work as a doctor
Confidence	4	This game has taught me how to diagnose and treat specific illnesses
	5	I get enough feedback to know how well I am doing
Satisfaction	6	I feel satisfied with what I am learning from this game
	7	The learning outcome of this lesson is appropriate to the work and energy I put into it

3.11 Analysis of quantitative data

The collected responses were downloaded from eSurvey in an excel file, and data was imported to SPSS version 25 for statistical analysis.

Data was reviewed manually to eliminate errors. We tested the questionnaire online and found two errors It was found that two answers from us testing the questionnaire online before the intervention were included. These were deleted before analyzing the data further. Otherwise no other errors were identified.

Descriptive statistics, with frequencies, averages, and standard deviation for each of the groups, and both groups combined were used to present the data.

An independent sample T-test was performed to compare the groups for each question in the survey and with respect to the four categories of ARCS.

3.12 Analysis of answers to free-text questions

Data for the analysis of the free-text answers were manually compiled into a table in MS word for further analysis. When analyzing the free text replies, the aim was to answer the research question: "What elements do fourth year medical students consider valuable in a serious game?

At first, all the transcripts that answered the first and second questions were read with an aim of getting an overall understanding of the content. Then we made notes about our first impressions, discussed these with each other, and compiled a list of themes that were found relevant to enlighten the research questions.

The material was thereafter systematically read through to identify meaning units, while the research question and the list of themes were considered. Meaning units were the smallest parts of the free text that said something about the research question. When what the students had written covered more than just one theme, they were divided into more parts. The response: *"I liked that the cases seemed very realistic and relevant,"* was, for instance, divided into the two sentences (meaning units) *"I liked that the cases seemed very realistic,"* and *"I liked that the cases seemed very relevant."* As the entities were systematized, some of the original themes were adjusted.

Finally, we counted how many meaning units that were categorized in each of the themes. Thus, what was counted was not the number of students, but the number meaning units.

Table 3: Initial and final themes

Initial theme	**Final theme**	**If changed, based on initial theme**
Case-based	Case-based	
Prioritizing	Prioritizing	
Interactive learning	Interactive learning	
Feedback	Feedback	
Multimedia	Multimedia	
Variation in patient cases	Variation	Variation in patient cases & Dynamics in the game
Educational	Educational	
Updated according to current the national guidelines	Relevant	Relevant
Engaging	Engaging	Engaging
Relevant	Relevant	
Close to reality	Realistic clinical setting	
Motivational	Motivational	
Dynamics in the game	Variation	Variation in patient cases & Dynamics in the game
Fun	Engaging	Engaging
Repetition	Repetition	
Other	Other	
Absence of technical issues	Absence of technical issues	
Possibility to go back in the game	Ability to see the aforementioned information regarding the patient	
Add a scoring system	Add a scoring system	
Reveal the correct answer independently of the decisions made	Reveal both correct and wrong answers	
Better game instruction	Intuition of the game	
Informative summary of the patient case and the disease presented.	Informative summary of the patient case and the disease presented.	

4. Results

As shown in the flow chart below, a total of 115 fourth-year medical students were invited to participate in the study, 58 students during late fall 2019 (EXP group), and 57 students during early spring 2020 (IEXP group). Fifty-one students in the EXP group and 35 students in the IEXP group played through the game. Forty-six (90.2%) students in the EXP group and 35 students (100%) in the IEXP group returned the questionnaire.

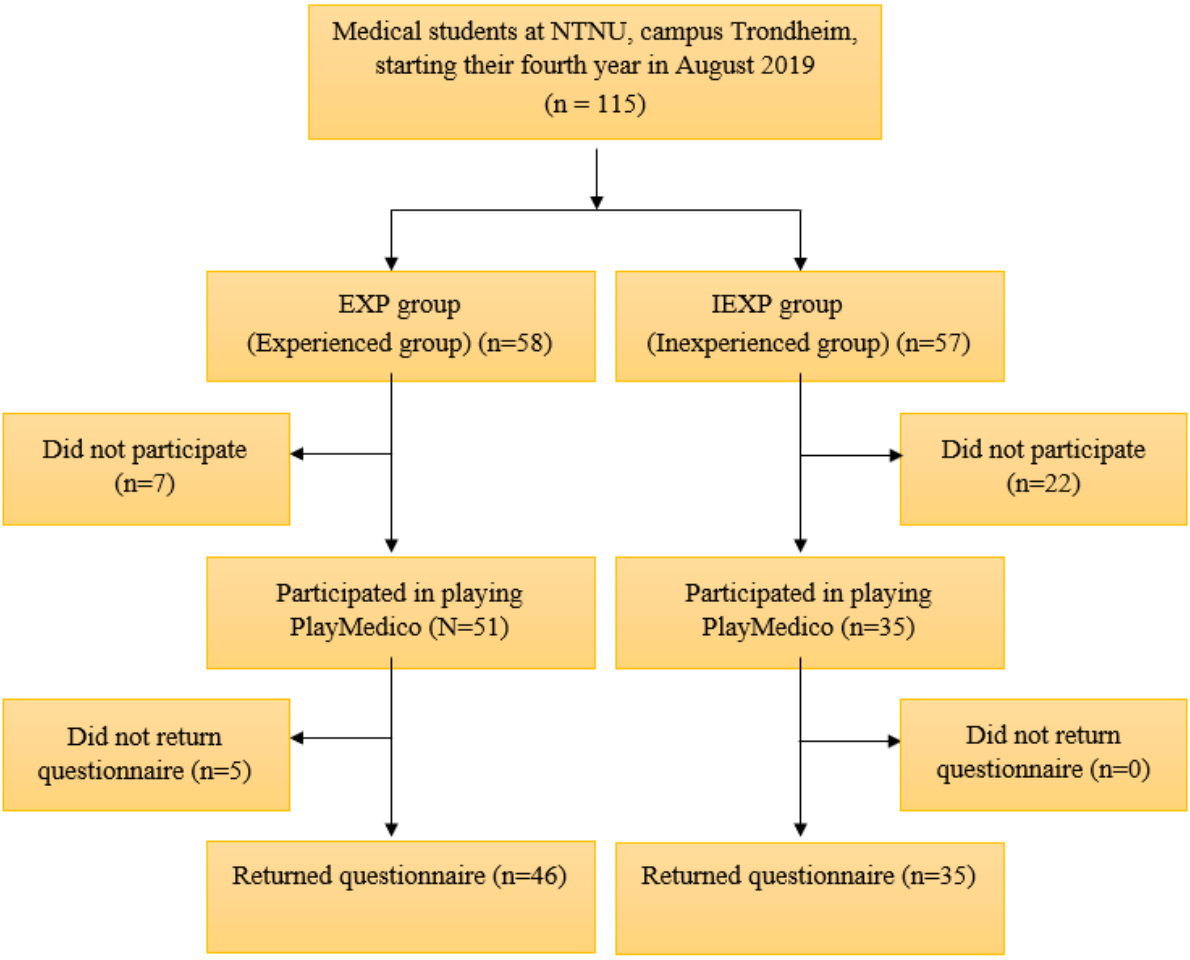


Figure 11: Flow chart displaying participants and final study population

4.1 Outcome

4.1.1 Proportion playing all nine cases

In the EXP group, 18 of 46 participants (39%) played through all cases (9), while 13 of the 35 participants (37%) did the same in the IEXP group (appendix 2). This means that a total 31 out of 81 (38%) played through all the cases during the intervention time of 30 minutes.

4.1.2 Overall experience with the game

The overall mean, each group's mean, and the mean difference between the two groups for the three overall statements are presented in table 3. Looking at both groups combined, they agreed most with statement 1, "The game was engaging", with an overall mean of 4.31 (mean diff 0.21, 95% CI -0.10 to 0.52). It was measured rather similar response on statement 2, "The game increased my motivation for at least one subject," and 3, "I easily understood how to play the game," with an overall mean of 3.64 (mean diff 0.73, 95% CI 0.27 to 1.19) and 3.57 (mean diff 1.26, 95% CI 0.80 to 1.72) respectively, significant for both.

The IEXP group, the students with less experience on the covered topics, had a higher mean than the EXP group on all statements. The difference in mean between the two groups were significant in statement 2 and 3.

Table 1. Overall mean, each group's mean, and the mean difference between the two groups for the statements about overall engagement, motivation and experience (answering options 1 to 5, with 5 being "very true").

	Statements	**Overall mean (SD) N: 81**	**EXP group Mean (SD) N: 46**	**IEXP Group Mean (SD) N: 35**	**Mean diff (95% CI)**	**p-value**
1	This game was engaging	4.31 (0.70)	4.22 (0.70)	4.43 (0.70)	0.21 (-0.10 to 0.52)	0.181
2	The game increased my motivation for at least one subject	3.64 (1.09)	3.33 (1.12)	4.06 (0.91)	0.73 (0.27 to 1.19)	0.002
3	I easily understood how to play the game	3.57 (1.24)	3.02 (1.22)	4.29 (0.86)	1.26 (0.80 to 1.72)	<0.001

4.1.3 Motivation after having played the game

The overall mean, each group's mean, and the mean difference between the two groups for the seven statements regarding motivation are presented in table 4.

Looking at both groups combined, they agreed most with statement 2 and 3, regarding relevance for exams and the future work as a doctor, with an overall mean of 4.57 on statement 2 (mean diff 0.006, 95% CI -0.25 to 0.26) and 4.41 on statement 3 (mean diff 0.04, 95% CI -0.26 to 0.34).

The IEXP group had a higher mean than the EXP group in all the statements except for statement 2 and 5 regarding perceived relevance for exams (where the groups scored the same) and degree of feedback. The difference in mean between the two groups was significant in statement 1 and 7 regarding attention and learning outcome.

Table 5: Showing the mean of the experienced group (EXP) and the inexperienced group (IEXP), and both groups combined (overall mean) with 95% confidence interval for each of the statements.

	Statements	**Overall Mean (SD) N: 81**	**EXP group Mean (SD) N: 46**	**IEXP group Mean (SD) N: 35**	**Mean diff (95%CI)**	**p-value**
1	I think it's easy to stay focused during this game	4.09 (0.78)	3.89 (0.82)	4.34 (0.64)	0.45 (0.12 to 0.79)	0.009
2	This game is relevant for my exams	4.57 (0.57)	4.57 (0.58)	4.57 (0.56)	0.006 (-0.25 to 0.26)	0.962
3	This game is relevant for my future work as a doctor	4.41 (0.67)	4.39 (0.65)	4.43 (0.70)	0.04 (-0.26 to 0.34)	0.805
4	This game has taught me how to diagnose and treat specific illnesses	3.59 (1.03)	3.50 (1.05)	3.71 (1.02)	0.21 (-0.25 to 0.68)	0.359
5	I get enough feedback to know how well I am doing	3.31 (1.17)	3.43 (1.15)	3.14 (1.19)	-0.29 (-0.81 to 0.23)	0.268
6	I feel satisfied with what I am learning from this game	3.79 (1.00)	3.67 (1.03)	3.94 (0.94)	0.27 (-0.18 to 0.71)	0.231
7	The learning outcome of this lesson is appropriate to the work and energy I put into it	4.04 (0.93)	3.78 (1.01)	4.37 (0.69)	0.59 (0.19 to 0.98)	0.004

4.1.4 Comparison of the categories in the ARCS-model

The seven statements regarding motivation were categorized with respect to the ARCS-model, as displayed in table 2. The overall mean, each group´s mean, and the mean difference between the two groups (according to the 95% CI) for each category of the ARCS-model are presented in table 5 and Figure 12.

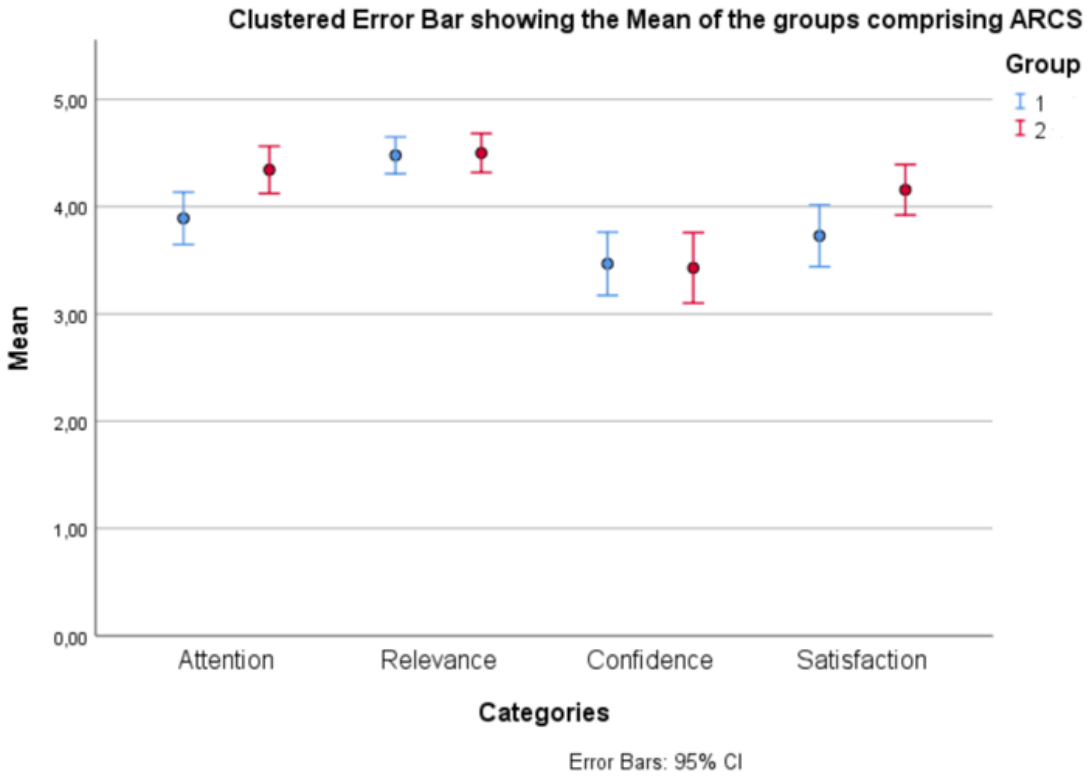
Looking at all respondents (both groups combined) (Table 6), the students scored highest on relevance, 4.5 out of 5 (mean diff 0.02, 95% CI -0.23 to 0.27). They scored lowest on confidence, 3.5 out of 5 (mean diff -0.04, 95% CI -0.47 to 0.40).

Comparing the groups, the IEXP group had a higher mean than the EXP group on attention (mean diff 0.45, 95%CI 0.12 to 0.79) and satisfaction (mean diff 0.43, 95%CI 0.05 to 0.81). For the two categories, there was no difference between the groups.

Table 6: Showing the mean with 95% confidence interval for each of the ARCS-categories of the experienced group (EXP) and the inexperienced group (IEXP), and both groups combined.

Category	**Overall Mean (SD)**	**EXP group Mean (SD)**	**IEXP Group Mean (SD)**	**Mean diff (95%CI)**	**p-value**
Attention	4.09 (0.78)	3.89 (0.82)	4.34 (0.64)	0.45 (0.12 to 0.79)	0.009
Relevance	4.49 (0.55)	4.48 (0.58)	4.50 (0.53)	0.02 (-0.23 to 0.27)	0.862
Confidence	3.45 (0.97)	3.47 (0.99)	3.43 (0.96)	-0.04 (-0.47 to 0.40)	0.860
Satisfaction	3.91 (0.88)	3.73 (0.97)	4.16 (0.68)	0.43 (0.05 to 0.81)	0.029

Figure 12: The experienced group (EXP– 1 / blue in the figure) and the inexperienced group (IEXP – 2 / red in the figure) mean with 95% confidence interval for each of the ARCS-categories, displayed with 95% CI error bars.



4.2 Results from the free text questions in the questionnaire

4.2.1 Classification of themes

The participants´ answers were categorized into the themes/codes presented in Tables 7 and 8. Table 7 shows the themes found in the students' replies to: *"What did you like about the game?"* whereas table 8 shows the themes from the answers of question 2: *"What is your suggestion of improvement?".* Furthermore, the tables display descriptions of each theme and examples of meaning units within each theme. Examples of student answers are translated from Norwegian to English.

Table 7: Classification of themes from the question 1 of free text replies

Themes from the answers of question 1: "What did you like about the game"		
Theme	**Description of theme**	**Examples**
Case-based	To work through a complete patient case, from the beginning, until the patient is discharged from the doctor's office.	• "*This is different from multiple-choice questions. It is more realistic to follow a patient and make decisions during the patient pathway."* • *"Case-based with "real patients" with information on their previous health situation."*
Prioritizing	To decide which patient to receive medical care first, in regard to the severity of symptoms at admission.	• "*During medical school so far, we have not practiced anything, particularly on prioritization, which this game gave the opportunity to do*."
Interactive learning	That the player is an active participant in the learning process.	• *It was fun that the game was interactive; the choices you make come with different consequences, just like in reality."* • *"The game stimulates you to utilize your knowledge. I consider it a nice break from the reading where the aim is to get knowledge and not actually utilize .it"*
In-game feedback	That the player receives an evaluation based on the decisions made in the game.	• "*There was good feedback during the game."*

Multimedia	The implementation of features such as x-ray images, clinical images pertaining to medical conditions, lab results, ECG, a journal that updates throughout the game, and music. It also includes graphics and layout.	• "*The game is fun with nice illustrations and a good user interface, which mostly functions*." • *"It is nice that the journal always is available."* • *"I liked that you get x-rays and lab results on the screen."*
Variation	This includes variation in the patient cases and the medical fields, as well as variation in the game (dynamics).	• *"It's got a nice spread of patient cases."* • *"It was nice that a variety of medical disciplines were included."* • *"I liked that the game was so "dynamic" – that you first have to prioritize the patients and thereafter have consultations one by one."*
Educational	That the game serves to educate or enlighten.	• *"I learned a lot from the game."*
Engaging	That the game engages the player in a positive manner.	• "*It was fun to actually get to play a doctor*."
Relevant	That the students experience the cases in the game as relevant for their exams and/or professional clinical work.	• *"I liked that the cases seemed very realistic and relevant. This prepares us for what we will meet in our practical rotations and residency."* • *"I find it very motivational that things are put into a clinically relevant setting."* • *"Relevant for exam."* • *"I liked that the game was updated according to the current guidelines"*
Realistic clinical setting	That the players perceive the clinical setting as realistic.	• *I liked that it shows a situation at the doctor's office.* • *"It seemed realistic!"*
Motivational	That the game was motivating and/or stimulated the students' desire to learn more.	• *"It was motivating"* • *"The game made me want to learn more"*
Intuition	That the game is easy to understand	• *"The game was easy to understand"*

Repetition	That the player is provided another chance to answer if they have chosen the wrong answer.	• *"I liked when I got the opportunity to answer one more time after making a wrong option, because then I remember more".*
Other	Responses that were considered to not fit under any of the themes above.	• *"The medical cases were good!"* • *"I got a lot of confidence when I was doing well in the game."* • *"It is positive that you get different problems to solve without knowing which medical field the problem belongs to in advance."* • *"I liked that it was moderately challenging."*

Table 8: Classification of themes from question 2 from the free text replies.

Themes from the answers to question 2 "What is your suggestion for improvement"?		
Theme	**Description of theme**	**Examples**
Absence of technical issues	This includes technical bugs, slow response from the game.	• "*There are several small technical bugs that need to be fixed."*
Multimedia	See the description in table 6	• *"The text should be of better quality. Is it possible to enlarge the text?"* • *Better graphic flow*".
Ability to see the aforementioned information regarding the patient	To have the opportunity to go back in the game to review the conversation and choices that have been made, for instance, by adding a go-back button or by a continuously updated journal.	• *"All of the information was not added to the journal. Therefore, I would have liked the ability to go back to review what has been said earlier in the consultation".* • "*It should be possible to go back to look at what was said or have all the information summarized in the journal."*
Add a scoring system	To be rewarded with points whenever accomplishing a task in the game.	• *"A scoring system might stimulate the player to come back to play more. In the future, it might be an idea to be able to connect to other players to introduce a competition element."*

		• *"It might engage the player even more with competition where you earn points."*
Reveal both correct and wrong answers	That the correct and/or wrong answers are revealed independently of the decisions made, for instance, on the summary page.	• *"At the last page, when you get feedback on whether you have answered right or wrong on the questions, it should also be possible to see what was the correct answer if you have chosen the wrong answer."*
Informative summary of the patient case and the disease presented	That the player after each case gets a more descriptive reply on the choices made in order to understand better why an answer was right or wrong.	• "*It would have been nice with a little "box of facts" in the end, which shows the etiology, the medical assessment, treatment, and prognosis of the relevant diagnosis."* • *"Better feedback when you choose incorrectly."*
Intuition	See the description in table 6	• *"An easier way to understand the concept when the game is over or not."* • *"It was intuitively hard to understand that you were supposed to triage the patients before the consultation."* • *"Make it more intuitive that you can push the journal to get information.*"
Other	Responses that were considered to not fit under any of the themes above.	• *"Add a zoom-in button."* • *"Increase the size of the text and make it clearer."* • *"Could have worked better in an application."* • *"To get a signal when information is added in the journal."* • *"Less text in text-boxes could make it easier to focus."*

4.2.2 Frequency of meaning units

In the free-text questions, the students could give multiple responses as to what they liked about the game and what they thought should be improved. Each of these were coded as a meaning unit. Table 9 displays the number of meaning units in the free text replies from question 1 and 2 combined, divided into how many times each codes' meaning units are mentioned as a positive feature or as a point of improvement. When an element in the game is mentioned as a point for improvement, it does not indicate that the participant considers the element as negative, but that the game should include more of this element.

Table 9: Showing frequency of meaning units mentioned in the free text replies from question 1 and 2 combined.

Theme	Number of meaning units with a positive feature	Number of meaning units concerning points for improvement
Case-based	11	0
Prioritizing	20	0
Interactive learning	14	0
Feedback	13	3
Multimedia	19	7
Variation	19	1
Educational	11	0
Engaging	35	0
Relevant	27	0
Realistic clinical setting	11	1
Motivational	3	0
Repetition	4	0
Absence of technical issues	1	32
Ability to see the aforementioned information regarding the patient	2	17
Add a scoring system	0	4
Reveal both correct and wrong answers	0	21
An informative summary of the patient case and the disease presented.	2	12
Intuition	4	27
Other	10	4

5. Discussion

5.1 Discussion of methods

5.1.1 Reflexivity

Reflexivity can be explained as how the researchers affects every part of the research process e.g. by their perspectives, choice of investigation and how the conclusions are presented (51). Our knowledge level about Serious Games was non-existing prior to the introduction of the topic from the supervisor. The only experience we had with games in general were ordinary video games. Nonetheless, we found it compelling to be part of developing a Serious Game for implementation in medical school. We felt early on convinced that such a game could be a useful supplement to traditional teaching methods, thus our preconception was that it would receive a positive response from the students. We had no clear idea of whether there would be any difference between students with little or much experience with the medical content in the game. Our reflections identified two areas where we believe that our preconceptions might have been influential. These are:

1. The development of the game
2. The process of developing and choosing questions to measure outcome.

Our involvement in the development of medical content and the technical features in close cooperation with 4BitGames meant that we had significant influence on the end result. Thus, our low competency level in Serious Games in advance of the study could be a major limiting factor. However, to learn more about Serious Games in medical education, we studied books and research articles. In this way, we could come up with suggestions on elements to be implemented in the game. We strived to include elements that have been emphasized as valuable among medical students as presented in chapter 1.1, such as the ability to prioritize patients, that to our knowledge have not been investigated before. Unfortunately, there were limitations in time and costs to achieve all the desired elements such as achievement systems, leaderboards, points and time pressure. From the self-reported feedback, the current version of PlayMedico has valuable elements but can still be further improved. However, we believe the feedback we got from the participants regarding improvements were mainly due to limitations in time and costs and an unexpected overloaded server rather than our low competency level in Serious Games in advance of the development of PlayMedico.

Regarding the process of developing and choosing questions to measure outcome, we were aware that while we emphasized some questions in our questionnaire, other researchers could have chosen other questions. We consider this likely since at the time of developing the questionnaire our knowledge level about research on motivation and learning was to be considered very low combined with limitations in time where we did not get to read as many research papers as desired to feel well enough prepared for this study. However, as an attempt of avoiding that our low knowledge level and the time limitation weakened the intervention, we based our questionnaire upon another motivational questionnaire that was stated to be validated. More information about this is provided under chapter 5.1.6. In this way, we aimed to say something about medical students' motivation for learning after having played the game PlayMedico.

5.1.2 Generalizability

Generalizability refers to if findings in a study are applicable to a larger population (52). In this situation, this would be if the outcome would have been similar if the present study was performed among medical students outside of Trondheim with similar clinical subjects. However, it could also be if the results would be transferable to medical students with other clinical subjects.

To be able to say anything about the generalization of the results from this study, we first must know whether our respondents reflects the target population. Eighty-one out of the potential 115 fourth year medical students participated, which gives a total response rate of 70,4%. The relative high response rate and the similarity in the characteristics of the population and the sample indicates that the findings are representative for all fourth-year medical students in Trondheim.

Further, we must argue as to whether these findings can be generalized to medical students outside Trondheim and the country border with or without the same clinical subjects. Medical students in general is a group of highly motivated and intelligent candidates (53). It is reasonable to assume that medical students in Trondheim are not likely to score different on motivational statements than medical students in other parts of the world. The medical education throughout the world shares the same curriculum (54). Thus, it is likely that the medical content in this specific game is of relevance also for students in other parts of the world, even if they are at different stage in their medical education. Further, teaching methods

differs between medical schools within and outside country borders (54). However, as our study did not compare the game to other teaching methods but simply asked the students how they experienced the specific game, we do not find this an obstacle on regard to generalizing the results.

However, the fourth-year medical students in Trondheim have gone through clinical training from the very first months of the start of the study, which is different from many other schools that divide the education in preclinical- and clinical years. Therefore, the students in our study might have more clinical experience with patients, and thereby the medical cases covered in this game, than students who have not gone through any sort of clinical practice.

Our conclusion is that the results are generalizable towards medical students with the same level of competency if they have had early clinical training through their school. Furthermore, as the IEXP group were inexperienced with the topics covered in the game, we find it reasonable that their results might be generalized to other medical students in the world who are not yet familiar with the topics in the game, given that they have had early clinical training. And, as the EXP group were experienced with the topics in the game, it is a possibility that their results might be generalized to other medical students who have learned about the clinical subjects covered in the game, given that they have had early clinical training.

5.1.3 Can the groups be compared?

An important limitation in this study is the lack of randomization. As mentioned in the section of Setting, the students were not completely randomly assigned to the groups comprised in this study. Ideally, we should have randomized the group, however, because of practical considerations such randomization would have been difficult to perform. Here it will be discussed to which degree the group who had completed more of the relevant curriculum could be considered comparable to the group with almost none experience with the curriculum, and thus the validity of the comparative analysis done in the result section.

The only variables that can be used to compare the groups are gender and age. As presented in the methods section, there were 58 students (26 males and 32 females) in the group from which the EXP-students were recruited, and 57 students (15 males and 42 females) in the group from which the IEXP-students were recruited. If there had been a

random distribution, the percentage of females in both groups could be expected to be 64%. However, in the EXP-group there are 55% females and in the IEXP-group 73% females. In other words, the variance regarding gender between the two groups confirm that there was no random distribution. However, in both groups the majority were females and the differences not alarmingly large, strengthening the argument that it was reasonable to compare the two groups.

The intended differences between the groups were the difference in experience with the curriculum. The question then becomes if there were other differences outside gender between the groups that could explain the observed differences in the results. We do not think so. Our main argument is built on our own experience as fifth-year medical students at NTNU. Our class was also divided in the same manner as those in the present study. Other than an unequal distribution of gender, similarly to the study population, we have an impression that the two groups in our own class are relatively identical, thus comparable, when it comes to e.g. age, personal characteristics and experience in the health sector. Based on figures from the Faculty, the average age in the IIC-class during the fall 2018 was 24 years, whereas the average age during the IIC class during the spring 2019 was 26 years, also the same for the study population. However, when accounting for that half of the students in the class during the fall 2018 would have been one year older if this estimation was performed during spring 2019, their average age would be 25 years. Thus, the difference in age might be considered minimal. Based upon the observations from the two groups in our class, a possible explanation for the difference in gender between the two groups, but not age and personal characteristics, is that the students base their wishes of classmates more upon gender than age, and that medical students in general share many similar personal characteristics.

The question remains if difference in gender outweigh the difference in experiences between the groups due to how far they had gotten in the semester. We still find it reasonable that different experience with the curriculum is more likely to explain the difference in outcome than a deviation in gender between the two groups, thus the groups are comparable.

As stated earlier, no baseline data concerning the groups were collected. If this had been done, it would have been possible to describe the differences between the groups and to adjust the analysis. In this way, it would have been possible to clarify whether the experience with the curriculum canceled out the other differences in background variables. Then one could also explore e.g. whether females are more, or less motivated to play serious games than males.

5.1.4 The quality of the game

The game was not entirely finished by the time of trials. Due to time limitations, a scoring system was not incorporated and the game had flaws such as incomplete instructions and an ending where the player was left in an empty waiting room. To compensate for poorly instructions throughout the game, the participants were informed how to play the game in advance of the session. Despite the lack of a scoring system and a logical ending, we found the pilot of the game completed enough for the results to be valuable and representable for the final game.

5.1.5 Was the implementation of the intervention equal?

Regarding implementation of the intervention, the aim was to keep this similar for both groups. However, during the intervention on the EXP group especially, the server got overloaded and the players experienced startup issues and lagging through the game. This was also reflected in the free-test replies where 51% students in the EXP group mentioned absence of technical problems as a point of improvement, whereas only 28% in the IEXP-group. This deviation from the intended intervention could have affected the EXP group's responses in the questionnaire negatively, which consequently would make results in favor of the IEXP group less trustable. We have not found any studies showing that the occurrence of technical problems in Serious Games affect players' sense of motivation and engagement, and it is therefore challenging to give any information on this influence, although it is a probability to be aware of. However, for all statements except for the one regarding how easy it was to stay focused, we find it more reasonable that different experiences with the curriculum, rather than the imbalance in technical problems during the interventions, explain the differences in outcome between the two groups.

An additional argument for this conclusion, was that the proportion completing all nine cases during the 30 minutes they played was similar in the two groups. In the EXP group 39% reported to have played through all cases, in comparison with the IEXP group where 37% reported the same. This can indicate that the occurrence of technical issues in the EXP group did not result in fewer participants completing the game. Thirty minutes is also a limited amount of time for 9 cases in need of concentration and reasoning. If the study was performed again, more time would be advantageous.

5.1.6. The validity of the outcome measure for the motivational statements

It was decided to use a questionnaire used in an earlier medical student thesis at NTNU from 2019 also measuring motivation. In the thesis, it was stated that the questionnaire was validated (50). However, as we looked closer at the questionnaire after having started the study, it turned out that it was not entirely so. Rather, they had used Keller's ARCS model and probably some questionnaires based on the model to make their own statements. As can be seen from the description of the ARCS model in the introduction and the statements in our questionnaire, it was a good overlap. Still, the statements we used and how they were grouped according to the ARCS model has not been formally validated. Thus, we used an unvalidated outcome measure.

We have in retrospect done an explorative factor analysis which we will briefly describe here. Varimax with Kaiser normalization was used. Analyzing the two groups separately, three factors were found for the EXP group and two for the IEXP group. Kaiser-Meyer-Olkin was above 0,6 combined with a significant Bartlett's test of sphericity. Thus, the explorative factor analysis did not support the four factor assumptions in the ARCS model. Even so, the results where the same both when analyzing the statements separately and when grouping them according to the ARCS model, indicating that the lack of validity was not likely to influence the results. However, due to the questionnaire not being validated and used in other studies, the actual values and what they mean cannot be considered in any meaningful way.

In hindsight, the best solution given our aim, would have been to apply another well-known validated questionnaire, like for instance the instructional Materials Motivation Survey (IMMS) which can be found in Keller's book (36).

5.1.7 Coding of free-text answers

During the qualitative analysis of free text answers, we followed principles of qualitative analysis (24, 55-58). Even though we followed these principles, we were aware that while we categorized the codes in one specific way, others could have done it differently. As far as possible, it was attempted to not let our own perspectives influence the handling of the data, among other by describing the codes with the student's own words. However, for some codes, the students answered in very short terms or unclear, and definitions were made from our understanding of the answers. In these cases, we discussed the definitions critical with each other.

The open-ended free-text questions applied in this survey made it possible for us to gain a broad insight on opinions on the Serious Game PlayMedico. However, free-text questions of this type can only elicit what the respondents think of at that moment. Having interviewed the students could have given a deeper understanding of their experiences. Also, to be mentioned, the process of finding which areas that are commented and thereafter adding up how many have mentioned them is of limited value. It gives indications as to areas many of the students are thinking of but cannot be applied to generalize any results. To be able to do this a quantitative questionnaire, for instance where the respondents have to answer “yes” or “no” to comments on a list, would have been a better choice.

5.2 Discussion of findings

5.2.1 Summary of the findings

Most of the medical students found the game engaging and a positive motivational influence. The medical students in both groups combined scored highest on the motivational category relevance and the statement regarding how engaging PlayMedico was and lowest on the motivational category confidence. Further, the students who had completed less of the relevant curriculum, and thus were inexperienced, gave a significant higher score on the remaining motivational categories regarding attention and satisfaction, and they scored higher on all of the statements that represented the overall experience with the game. In the written feedback, the students valued that the game was relevant and engaging, and highlighted elements like active participation, feedback, prioritizing, case-based, multimedia, realism and variation. The most important suggestions for improvement were more extensive feedback and removing technical issues.

5.2.2 Inexperienced or Experienced – Does it matter?

With the limitations mentioned in the methods section and discussion of methods about the comparability of the two observed groups, the following discussion is about the observed differences.

It was observed that the IEXP group, the students with less experience on the covered topics in the game, scored higher than the EXP group. This can point to that being less experienced with the medical content in the game, makes the game more motivating, engaging and a better experience. These results are in line with the finding from, to our knowledge, the only other study similar to the present, which investigated the clinical Serious Game EMERGE (44). They found that students in lower semesters, thus with less experience with the Serious Game's medical content, had a more positive impression of the game than students in higher semesters (44). Thus, given these findings, the current state of knowledge seems to be that Serious Games bring about more motivation if the medical content is new to the players. We consider this an interesting finding as Harter's competence motivation theory states that people are more motivated to increase their competency level when they successfully master a task, but in this study, those that were less competent with the topics seemed to be more motivated.

Looking at this in some more detail, it was observed that the IEXP group scored significantly higher on the categories: “attention” and “satisfaction”. Regarding “*satisfaction*”, one of its belonging statements was “*The learning outcome of this lesson is appropriate to the work and energy I put into it*”. The students in the EXP group were about to have their exams and possessed more knowledge regarding the topics in the game compared to the IEXP group. It is therefore likely that the EXP group did not have the same level of learning outcome from the game, as they had gained this knowledge previously, and one can therefore find it reasonable that the IEXP group had more potential to increase their learning outcome as reflected in the score, and thereby were more satisfied.

Regarding attention, this category included the statement “I think it is easy to stay focused”. According to Keller, two of the three subcategories of “attention” are perceptual arousal and inquiry arousal (36). To stimulate the perceptual arousal, emotional and personal material was added in PlayMedico. The player was, however, more likely to receive an emotional outbreak from a patient or his next of kin if a wrong decision had been made instead of a correct one. The EXP-group had gained more knowledge previously, thus were more likely to make a correct decision. Less mistakes led to less received emotional outbreaks in the game, and it is possible that their degree of perceptual arousal was less stimulated than the IEXP-group’s because of this. Further, inquiry arousal is about stimulating the players by providing thinking challenges (36), as the decision-making in the game does. Medical content from earlier exams at NTNU were applied in some of the cases. It is feasible that some cases were considered easy in the EXP-group who perhaps already had completed these exams. It is therefore a possibility that inquiry arousal was stimulated in higher degree among the IEXP-group. However, it is still uncertain whether the different experiences with the curriculum explains the difference in attention, as we do not know the impact of the imbalance in technical problems on this category.

5.2.3 Is it motivating to play PlayMedico?

As stated in the discussion of methods, using a non-validated questionnaire means that there are no data that can be used to say anything about the specific meaning of the observed values. Still, it is of interest to at least try to shed some light on the question about the games ability to influence motivation.

Previous studies have shown that Serious Games can be engaging and motivating, which in turn have a positive effect on their learning and their eager to acquire new knowledge (37-39). However, after a thorough search in scientific papers, we have not found any studies that have applied the ARCS-model of Keller to assess learners' motivation for a Serious Game. Furthermore, unlike PlayMedico, few of the games evaluated in these studies have provided learning about patients typically seen during a day in a GPs' office, and many lack accurate medical content (26, 27). Our total impression from this study was that the students found PlayMedico to be a positive motivational influence.

As mentioned in the introduction, Keller broke human motivation for learning into four major elements: "*Attention", "relevance", "confidence"* and *"satisfaction"* (36). When these dimensions are fulfilled, the motivational outcome is higher, hence increasing the educational outcome (37-39). The results on these four major categories in all participants will now be discussed in more detail.

Relevance

Looking at all respondents, they considered the game as notably relevant (4.5 out of 5), both for their exams (4.6 out of 5) and for their future work as a doctor (4.4 out of 5). "Relevant" was also mentioned second most frequent as a positive element in the game in the free-text replies. This both reflects and strengthens the conclusion from the quantitative analysis that the students experienced the game as highly applicable. In comparison, in another study concerning the clinical Serious Game EMERGE, the students had a mean score of 1.95 (where 1 was "very true" and 6 was "not true") on a similar statement concerning relevance: "EMERGE prepares me for clinical practice" (44). In comparison, a score of 4.5 out of 5 on relevance (where 5 was "very true" and 1 was "not true") ought to be considered a good score. Measured by percentage share of maximal positive score, this study had 87.5% and EMERGE had 81.0%. Despite EMERGE having an opposite numeric scale than this study, thus not directly comparable, the percentage share indicates that both studies resulted in predominately positive replies on "Relevance".

A potential cause of the high score on relevance could be the high degree of curricular relevance. The developers of the medical cases in the game knew the semester curriculum well as they had either been students or were teachers in these classes. Hence efforts were taken to design the cases to fit perfectly into their semester. The high score on "relevance" in

this study might suggest that medical accurate content in Serious Games and a high degree of curricular perspective play an important role regarding a game's relevance.

Further, according to Keller, for a Serious Game to be relevant "the learning process should show the usefulness of the content so that learners can bridge the gap between content and real world" (36). By letting the players apply their knowledge in a (virtual) clinical setting with continuous feedback, the game gives them experience of the real life as a doctor which in turn increases the students´ feeling of relevance, thus motivation.

Confidence

Further, the respondents in both groups combined, scored lowest on the motivational category confidence (3.5 out of 5). The students' experience of degree of feedback and learning outcome regarding diagnosing and treating specific illnesses was decisive for this score (table 2). Research suggests that learning occurs by minimizing the difference between the expected and the actual outcome, through the feedback received (32). Thus, these statements are assumed to be connected, and by providing a high amount of appropriate feedback the experienced learning outcome will possibly increase, and thereby also confidence and motivation. In the free text replies, 13 of the 81 students mentioned the feedback in the game as a valuable element in the game, whereas 3 of the 81 wrote that they wanted more feedback. Further, 12 of the 81 students wrote that "to include a more informative summary of the patient case and the disease presented" was a point of improvement. This might indicate that the game would benefit with more feedback and a more informative page after each case, thereby also increasing learning outcome and confidence.

Attention

Both groups combined scored 4.09 out of 5 on "attention". "Attention" is related to the feeling of being present in the game (59). Video games are known to enhance attention skills (55, 56), and studies of serious game have shown to improve attention (57, 58). A score on 4.09 out of 5 signifies that the students found it to be mostly true that it was easy to hold the attention, thereby increasing motivation. To maintain the player´s attention it was intended that every patient case varied in regard to length, difficulty, medical subjects, patient characteristics and multimedia. In addition, cases were made with relevant curriculum with an

adequate level of challenge and with emotional and personal material, which have shown to be key features of player engagement and attention (28, 36).

Satisfaction

Both groups combined scored 3.91 out of 5 on "satisfaction". We have not found any other studies on Serious Games assessing the same statements as in the present study. However, another study on a Serious Game simulation in nursing education found a score on 4.5 out of 5 among students on satisfaction with learning (60). It was decisive for this score that it effectively promoted the students' process of learning the curriculum. In this study, satisfaction with what they learnt, and a learning outcome appropriate to the workload put into it, was decisive for this score. Thus, satisfaction was measured in almost the same way between the two studies, and the other study had a slightly better score. Thus, there is room for improvement on regard to satisfaction.

According to Keller, if the first three motivational categories: "attention", "relevance" and "confidence" are fulfilled, the students will be motivated to learn (36). For them to have a continuing desire to learn, however, they must have feelings of satisfaction with the process or results of the learnings experience. In other words, satisfaction is tightly linked to degree of learning it provides the players. Both active learning, attention, continuous feedback and consolidation have earlier been identified in Cognitive Science as the four main pillars of learning that should be included in a serious game for health (28) . Maybe by carefully including these elements one could promote a higher degree of satisfaction in the game? In the free text replies medical students mentioned these pedagogical principles as valuable in the game. For instance, active learning was mentioned by 17,2%, repetition (consolidation) by 4,9%, and feedback was mentioned by 16%. It would have been interesting to include more of these elements in the game, and thereafter asked the respondents specifically about these pillars as well as the statements on regard to satisfaction to investigate whether they would promote a higher satisfaction.

Sub-groups of students not motivated?

As demonstrated in the descriptive statistics in appendix 2, there was also a variance in the scoring. During the quantitative analysis, it was noticed that the majority of the students gave a high score on most of the statements, whereas a few students in general gave a low

score. This could partly be explained by that some students regard games as beneficial for learning, while others prefer different ways of learning (28).

However, it could also be that someone simply disliked this particular game, and therefore disagreed with the statements. We have no data to clarify whether they usually regard serious games as beneficial, but not PlayMedico.

5.2.4 Is it engaging to play PlayMedico?

The mean score on the following statement: "the game was engaging" for both groups combined was 4.31 out of 5, in other words most of the students found the statement to be mostly true (4) or very true (5). This was also reflected in the free-text replies where "engaging" was the most frequently mentioned valuable element in the game. This indicates that the fourth-year students found PlayMedico engaging, which is in line with previous research that also find serious games to be engaging (24, 61-64). Even though this finding has been commonly reported when evaluating serious game, it is still an important finding, as creating an enjoyable Serious Game was a goal in itself.

And, as engagement has been positively correlated with educational outcome, one can resonate that the game increases the players' learning. However, as is true for the word "*motivation"*, the word "*engaging*" might be perceived in different ways by the respondents, and therefore the actual degree of engagement might be hard to capture with this statement alone. And even though engagement has been positively correlated with educational outcome, repeated studies would be necessary to draw any conclusions on this matter.

5.2.5 Was it easy to understand how to play the game?

Intuitive user interfaces are important in serious games for effective learning (48). Therefore the statement: "I easily understood how to play the game" was included. For both groups combined the mean score on this category was 3.57 out of 5. The free-text replies revealed that 27 of the 81 respondents wanted the game to be more intuitive/easy to understand. Comments on regard to this was that they wanted it to be "more intuitive that they could push the journal to get information", "make it more intuitive how to triage the patients before the consultation" and "make it easier to understand when the game was over and not".

As intuitive interfaces are an important way to ensure effective learning, one should strive to implement more of it in the upgrade of the game.

5.2.6 Prioritizing according to urgency of cause of admission

As described in chapter 5.2.1 elements such as “active participation”, “case-based”, “realism”, “variation”, “prioritizing” and “feedback” were mentioned as positive features in PlayMedico whereas points of improvement specified were “more extensive feedback” and “removing technical issues”. All the mentioned elements were consistent with results in other studies (29-31), except for “prioritizing” that to our knowledge have not been discussed in any previous studies of Serious Games for medical school. The most related study we found was Lancaster’s review of a Serious Game in pharmacology, where the nursing students highly valued the opportunity to prioritize nursing assignments and care. Regarding prioritizing this was the third frequently mentioned positive element in this study. Some students commented that they liked this element as this was something they did not practice particularly during medical school. Clinicians receive little training in health care priority settings while health care systems and administrators focus almost exclusively on priority setting (70). Future studies with better study design should further investigate how serious games can teach medical students to prioritize cases, and whether this makes the medical students better equipped to prioritize real patients.

5.2.7 Feedback

Regarding feedback, the general impression while reading through the free text replies was that the students valued the feedback they were given during the game and after each patient case. However, they wanted more of it and they wanted it to be more detailed. Feedback could be integrated in different forms: Progress bars, scoring, achievements, experience points, virtual currencies, feedback messages are some examples, and what forms of feedback that are most effective in serious gaming for health is not clear (28). Studies on serious games for health have suggested that the most effective feedback is the feedback that centers on the task rather than the learner, and that tells the learners what they are doing instead of simply telling them what to do (65, 66). In PlayMedico in-game feedback was mainly given as comments on task after a player made a non-correct decision, and it explained

what they were doing wrong. Medical students seemed to appreciate this type of in-game feedback, but whether this is enough more research is needed tailored to the topic.

Feedback on how others perform can also be important. Studies have suggested that competition is a positive motivational influence (29, 35, 67, 68). Many medical students are very competitive (35), and to add a scoring system or some kind of competition element was mentioned as a point of improvement. It was, however, only mentioned four times and what type of scoring they would appreciate was not mentioned. Implementation of real-time scoring in cognitive training games has shown to negatively impact training improvements of the participants (69). It may distract them. Therefore, to include this type of feedback in serious game deserves further investigation.

On the other hand, in the free-text replies it was commented 33 times that the informative summary after each patient-case should be more detailed and/or reveal all correct and wrong answers that had been made throughout the patient pathway. In this way, the students could have seen the proportion of options that were correct, combined with getting a deeper understanding of how they best could have taken care of the patient. An approach to all of this could be to include a score in the informative summary, thus creating a sense of competition that motivates the player without the distraction a real-time scoring could cause. More research is, however, needed to make any conclusions as to what the best approach is.

6. Conclusion

This study found that PlayMedico was favored by the students who had completed less of the relevant curriculum (IEXP group) over the experienced students (EXP group). The students valued elements like “to prioritize after cause of admission”, “case-based learning”, “multimedia”, “variation”, “a realistic clinical setting”, “active participation” and “feedback” in the serious game. These findings are in line with previous research, except for the element “to prioritize after cause admission” that we have not found mentioned in any other similar study.

Due to the design, caution must be taken when interpreting and applying the results from this study. Nonetheless, our findings can contribute with insight about experience of playing Serious Games in medical education. Studies with a better study design, and where the game is compared to traditional learning methods, should be carried out to figure out whether the game should be a part of the curriculum. Prospective studies are necessary to get a greater level of understanding on how serious games can educate medical students to prioritize patients and analyze whether they make them better skilled in prioritizing real patients or not. Serious games come at a high economical cost, and evaluation of cost-benefit must always be considered as part of the process.

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Appendix

Appendix 1: The questionnaire

Evaluation PlayMedico

Page 1

Thank you for participating in the trial of PlayMedico. We hope you will fill out this questionnaire in order for us to improve the game.

Page 2

This survey saves neither e-mails nor IP-addresses. The survey will, therefore, be anonymous.
Do you give us your consent to store and utilize your data in our research? *

- ◯ yes
- ◯ no

Page 3

To what extent do you agree with the following statements: *

	Not true	Slightly true	Moderately true	Mostly true	Very true
1. I think it's easy to stay focused during this game	◯	◯	◯	◯	◯
2. This game was engaging	◯	◯	◯	◯	◯
3. This game is relevant for my exams	◯	◯	◯	◯	◯
4. This game is relevant for my future work as a doctor	◯	◯	◯	◯	◯
5. This game has taught me how to diagnose and treat specific illnesses	◯	◯	◯	◯	◯
6. I get enough feedback to know how well I am doing	◯	◯	◯	◯	◯
7. I feel satisfied with what I am learning from this game	◯	◯	◯	◯	◯
8. The learning outcome of this lesson is appropriate to the work and energy I put into it	◯	◯	◯	◯	◯
9. The game increased my motivation for at least one subject	◯	◯	◯	◯	◯
10. I easily understood how to play the game	◯	◯	◯	◯	◯

Page 4

What did you like about the game? *

Page 5

What is your suggestion for improvement? *

Page 6

Were there specific patient cases that you preferred? In this case; Which ones and why?

Page 7

Did you play through all of the nine patient cases? *

- ◯ yes
- ◯ no

You have completed the survey. Thank you very much for your participation.

You can now close the window.

Appendix 2: Frequency distribution for each group on the different statements

Figure 1: Showing frequencies, averages and standard deviation for the first group.

1. To what extent do you agree with the following statements: *

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Number of participants: 46

	Not true (1)		Slightly true (2)		Moderately true (3)		Mostly true (4)		Very true (5)			
	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Ø	±
1. I think it's easy to stay focused dur...	-	-	4x	8.70	6x	13.04	27x	58.70	9x	19.57	3.89	0.82
2. This game was engaging	-	-	1x	2.17	4x	8.70	25x	54.35	16x	34.78	4.22	0.70
3. This game is relevant for my exams	-	-	-	-	2x	4.35	16x	34.78	28x	60.87	4.57	0.58
4. This game is relevant for my futur...	-	-	-	-	4x	8.70	20x	43.48	22x	47.83	4.39	0.65
5. This game has taught me how to di...	2x	4.35	5x	10.87	15x	32.61	16x	34.78	8x	17.39	3.50	1.05
6. I get enough feedback to know ho...	2x	4.35	8x	17.39	14x	30.43	12x	26.09	10x	21.74	3.43	1.15
7. I feel satisfied with what I am lear...	2x	4.35	5x	10.87	7x	15.22	24x	52.17	8x	17.39	3.67	1.03
8. The learning outcome of this lesso...	1x	2.17	4x	8.70	11x	23.91	18x	39.13	12x	26.09	3.78	1.01
9. The game increased my motivation...	5x	10.87	4x	8.70	12x	26.09	21x	45.65	4x	8.70	3.33	1.12
10. I easily understood how to play th...	4x	8.70	15x	32.61	9x	19.57	12x	26.09	6x	13.04	3.02	1.22

Figure 2: Showing frequencies, averages and standard deviation for the second group.

2. To what extent do you agree with the following statements: *

.png .pdf .xls .csv

Number of participants: 35

	Not true (1)		Slightly true (2)		Moderately true (3)		Mostly true (4)		Very true (5)			
	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Ø	±
1. I think it's easy to stay focused dur...	-	-	-	-	3x	8.57	17x	48.57	15x	42.86	4.34	0.64
2. This game was engaging	-	-	-	-	4x	11.43	12x	34.29	19x	54.29	4.43	0.70
3. This game is relevant for my exams	-	-	-	-	1x	2.86	13x	37.14	21x	60.00	4.57	0.56
4. This game is relevant for my futur...	-	-	-	-	4x	11.43	12x	34.29	19x	54.29	4.43	0.70
5. This game has taught me how to di...	1x	2.86	3x	8.57	9x	25.71	14x	40.00	8x	22.86	3.71	1.02
6. I get enough feedback to know ho...	4x	11.43	6x	17.14	10x	28.57	11x	31.43	4x	11.43	3.14	1.19
7. I feel satisfied with what I am lear...	-	-	3x	8.57	7x	20.00	14x	40.00	11x	31.43	3.94	0.94
8. The learning outcome of this lesso...	-	-	-	-	4x	11.43	14x	40.00	17x	48.57	4.37	0.69
9. The game increased my motivation...	-	-	3x	8.57	4x	11.43	16x	45.71	12x	34.29	4.06	0.91
10. I easily understood how to play th...	-	-	2x	5.71	3x	8.57	13x	37.14	17x	48.57	4.29	0.86

Figure 3: Showing the percentage of players that completed all patient cases for the first group.

5. Did you play through all of the nine patient cases? *

Number of participants: 46

18 (39.1%): yes

28 (60.9%): no

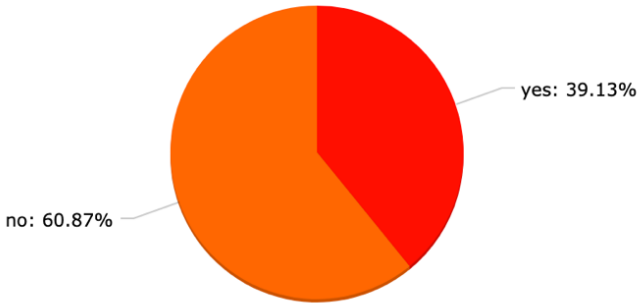


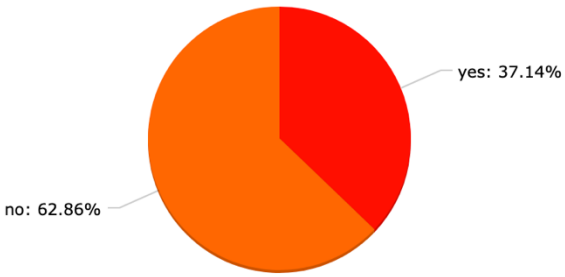
Figure 4: Showing the percentage of players that completed all patient cases for the second group.

6. Did you play through all of the nine patient cases? *

Number of participants: 35

13 (37.1%): yes

22 (62.9%): no



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