UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ODONTOLOGIA DE PIRACICABA

LAIS TONO CARDOZO

CONTRIBUIÇÃO DE JOGO EDUCACIONAL ASSOCIADO A AVALIAÇÕES FORMATIVAS PARA O APRENDIZADO DE FISIOLOGIA CARDÍACA, NO ENSINO PRESENCIAL E REMOTO

CONTRIBUTION OF EDUCATIONAL GAME ASSOCIATED WITH FORMATIVE ASSESSMENTS TO THE LEARNING OF CARDIAC PHYSIOLOGY, IN PRESENTIAL AND REMOTE TEACHING

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Tese apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do título de Doutora em Odontologia, na Área de Fisiologia Oral.

Thesis presented to the Piracicaba Dental School of the University of Campinas in partial fulfillment of the requirements for the degree of Doctor in Odontology, in Oral Physiology area.

Orientadora: Profª Dra. Fernanda Klein Marcondes

Este exemplar corresponde à versão final da tese defendida pela aluna Lais Tono Cardozo, e orientada pela Profa. Dra. Fernanda Klein Marcondes.

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Faculdade de Odontologia de Piracicaba

A Comissão Julgadora dos trabalhos de Defesa de Tese de Doutorado, em sessão pública realizada em 20 de julho de 2022, considerou a candidata LAIS TONO CARDOZO aprovada.

PROFª. DRª. FERNANDA KLEIN MARCONDES

PROF. DR. ANGELO LUIZ CORTELAZZO

PROFª. DRª. ADRIANNE CHRISTINE PALANCH

PROFª. DRª. SILVIA MARIA RICETO RONCHIM PASSERI

PROFª. DRª. VÂNIA GALINDO MASSABNI

A Ata da defesa, assinada pelos membros da Comissão Examinadora, consta no SIGA/Sistema de Fluxo de Dissertação/Tese e na Secretaria do Programa da Unidade.

DEDICATÓRIA

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RESUMO

Nas instituições de ensino, construir o conhecimento exige que os estudantes assumam a responsabilidade e saiam da posição passiva e sejam protagonistas de seus processos de aprendizagem, participando ativamente de todo o processo. Neste contexto as metodologias ativas de ensino são consideradas úteis para o aprendizado, e uma das estratégias ativas que temos utilizado nas aulas de fisiologia humana do curso de graduação em Odontologia da FOP-UNICAMP, são os jogos educacionais, como o quebra-cabeça do ciclo cardíaco. Este jogo combinado com avaliações formativas, já foi avaliado pelos alunos como sendo útil para o aprendizado, e também observamos, em outro estudo, que a utilização desta estratégia melhorou o desempenho dos alunos em uma avaliação, comparado com o desempenho de alunos que tiveram apenas aula teórica. Considerando o efeito positivo sobre o aprendizado, um dos objetivos deste estudo foi avaliar a hipótese de que, se o uso do jogo educacional aumenta o aprendizado sobre fisiologia cardíaca, este efeito poderia reduzir a ansiedade e o estresse do estudante antes de uma avaliação acadêmica, sobre este tema. Durante a pandemia de COVID-19, uma versão digital foi desenvolvida para o ensino remoto, e também são objetivos desta tese descrever as adaptações realizadas para a utilização desta versão digital e avaliações formativas *online*, à luz da pedagogia universitária, e avaliar a percepção discente sobre o jogo digital. Os resultados obtidos neste estudo sugerem possíveis fatores relacionados ao uso de metodologias ativas, que podem promover mudanças no comportamento dos alunos, contribuindo para o aprendizado presencial ou remoto.

Palavras chaves: aprendizagem, ensino, jogo educacional, fisiologia, pedagogia universitária.

ABSTRACT

In educational institutions, building knowledge requires students to take responsibility and leave the passive position to be protagonists of their learning processes by actively participating in the entire process. In this context, active teaching methodologies are considered useful for learning. Therefore, one of the active strategies used in human physiology classes in the Dentistry course of FOP-UNICAMP are educational games, such as the cardiac cycle puzzle. This game, combined with formative assessments, has already been evaluated by students as being useful for learning. In addition, we also observed in another study that the use of this strategy improved the performance of students in an assessment compared to the performance of students who had expositive classes. Considering the positive effect on learning, one of the objectives of this study was to evaluate the hypothesis that if the use of educational game increases learning about cardiac physiology, this effect could reduce student anxiety and stress before an academic assessment, on this topic. During the COVID-19 pandemic, a digital version was developed for remote teaching, and the objectives of this thesis are also to describe the adaptations made to the use of this digital version and online formative assessments, in the light of university pedagogy, and to assess student perception about the digital game. The results obtained in this study suggest possible factors related to the use of active methodologies, which can promote changes in students' behavior, contributing to the face-to-face or remote learning.

Keywords: learning, teaching, educational game, physiology, university pedagogy.

SUMÁRIO

1 INTRODUÇÃO

A ciência e as tecnologias de informação e comunicação (TIC), desde o século XIX, têm avançado muito rapidamente, tornando o acesso às informações universal, prático e fácil. Apesar disso, os métodos de ensino tradicionais de séculos passados continuam presentes na atualidade, com prevalência do uso de aulas expositivas (Lázaro et al., 2018; Nasre-Nasser et al., 2022). Em todos os níveis educacionais, as tecnologias são predominantemente empregadas para a transmissão de conteúdos ao invés de serem utilizadas como uma ferramenta de ensino: a lousa e o giz foram substituídos por apresentações em PowerPoint repletas de textos, e os alunos continuam em uma posição passiva, recebendo informações (Lázaro et al., 2018).

Para que os alunos possam realmente construir o conhecimento, precisam sair da posição passiva e serem protagonistas de seus processos de aprendizagem, participando ativamente do mesmo. Adicionalmente, torna-se crucial a avaliação constante do docente sobre o processo educacional de cada disciplina, a fim de melhorar o aprendizado dos alunos (Nasre-Nasser et al., 2022).

O termo “metodologias ativas” tem se tornado muito popular, nos últimos anos no Brasil, mas observa-se mais um ativismo metodológico do que, de fato, mudanças paradigmáticas dos professores, frente a suas práticas pedagógicas que continuam sendo tradicionais. Neste sentido, é necessário que o professor tenha clareza da proposta formativa do curso que atua; planeje sua disciplina com objetivos de aprendizagem bem definidos; adote metodologias que contemplem estratégias e recursos didáticos que mobilizem o estudante, e avaliações processuais, com critérios e instrumentos compatíveis com a proposta formativa pretendida (Marcondes et al., 2020, 2021). E, no ensino superior, esta situação é agravada porque o professor muitas vezes, não tem formação para a docência, o que impacta seus conhecimentos teóricos sobre o processo ensino-aprendizagem e outras habilidades necessárias aos educadores (Cortelazzo et al., 2018; Marcondes et al., 2021).

Metodologias ativas de ensino são consideradas úteis para o aprendizado, por promoverem a autonomia dos estudantes, e estimularem o desenvolvimento de habilidades de comunicação e pensamento crítico (Mitre et al., 2008; Berbel, 2011; Borges e Alencar, 2014). Uma das estratégias ativas de ensino que temos utilizado nas aulas de fisiologia humana do curso de graduação oferecido pela Faculdade de Odontologia de Piracicaba – UNICAMP tem sido o uso dos jogos educacionais (Marcondes et al., 2015; Luchi et al., 2017; Cardozo et al., 2020b; Pessoa et al., 2021).

No ensino de fisiologia do sistema cardiovascular, o quebra-cabeça do ciclo cardíaco (Marcondes e Amaral, 2014), tem sido utilizado por nós, desde 2002, combinado com avaliações formativas (*quizzes* e exercícios escritos). Este quebra-cabeça foi compartilhado com professores de Fisiologia de outras instituições de ensino superior no Brasil, e alunos de diferentes cursos da área da saúde (Odontologia, Medicina, Biologia, Fisioterapia, Enfermagem e Farmácia) avaliaram que o seu uso foi útil para o aprendizado, por esclarecer dúvidas e facilitar a compreensão das relações entre a morfologia e fisiologia do coração (Marcondes et al., 2015). Com o objetivo de avaliar se esta percepção dos alunos era acompanhada de efeito real sobre o aprendizado, durante o mestrado, observamos que acadêmicos de Odontologia, que haviam realizado a atividade com o jogo educacional apresentaram maior nota, e menor número de respostas erradas, em comparação com os alunos que haviam assistido apenas a uma aula teórica (Cardozo et al., 2016).

Considerando este efeito positivo sobre o aprendizado, e que jogos educacionais contribuem para o desenvolvimento de habilidades para a resolução de problemas, comunicação, trabalho em equipe, integração e aplicação de conceitos (Marcondes et al., 2015; Cardozo et al., 2016), um dos objetivos desta tese foi avaliar a hipótese de que, se o uso do jogo educacional aumenta o aprendizado sobre fisiologia cardíaca, este efeito poderia reduzir a ansiedade e o estresse do estudante antes de uma avaliação acadêmica, sobre este tema.

A versão original do quebra-cabeça do ciclo cardíaco é utilizada, de forma impressa no ensino presencial e, durante a pandemia de COVID-19, foi desenvolvida, em colaboração com professores de outras instituições de ensino superior, uma versão digital para uso remoto (Cardozo et al., 2021b). Assim, também são objetivos desta tese descrever as adaptações realizadas para a utilização desta versão digital e avaliações formativas *online*, à luz da pedagogia universitária, e avaliar a percepção discente sobre o jogo digital.

A apresentação da fundamentação teórica dos estudos, delineamentos, resultados e respectivas discussões serão apresentados no formato alternativo, nos artigos 1, 2 e 3, respectivamente, e de acordo com as normas estabelecidas pela deliberação 001/2015 da CCPG da UNICAMP.

2 ARTIGOS

2.1 Effect of an active learning methodology combined with formative assessments on performance, test anxiety, and stress of university students.

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Lais Tono Cardozo, Maria Antonia Ramos de Azevedo, Maeline Santos Morais Carvalho, Rafaela Costa, Patricia Oliveira de Lima, Fernanda Klein Marcondes

Autorização para inclusão do artigo publicados na tese disponível no Anexo 2.

Effect of an active learning methodology combined with formative assessments on performance, test anxiety, and stress of university students

Lais Tono Cardozo[1], Maria Antonia Ramos de Azevedo[2], Maeline Santos Morais Carvalho[1], Rafaela Costa[1], Patricia Oliveira de Lima[1], Fernanda Klein Marcondes[1]

[1]Department of Biosciences, Piracicaba Dental School, University of Campinas, Piracicaba, SP, Brazil

[2]Department of Education, Institute of Biosciences, São Paulo State University (UNESP), Rio Claro, SP, Brazil

Running head: Active methodology: performance, test anxiety, and stress

Correspondence to:

Dr Fernanda Klein Marcondes

Department of Biosciences, FOP-UNICAMP

Av. Limeira 901, 13414-903, Piracicaba, SP, Brazil

Phone: 55 19 21065380

ferklein@unicamp.br

Abstract

The aim of this study was to evaluate the effect of an active methodology combined with a lecture on undergraduate student learning and levels of stress and anxiety. The active learning methodology consisted of a lecture of 50 minutes of duration, study at home using a textbook, an educational game activity, and three formative assessments on the topic of cardiac cycle. In a following class, the students provided saliva samples to evaluate their levels of stress, answered an anxiety test, and then undertook an exam to assess their understanding of cardiac cycle. The traditional teaching methodology consisted of two lectures (approximately 2 hours of duration) on blood pressure control systems, delivered orally. In the third class, the students provided saliva samples, answered an anxiety test, and then undertook an exam to assess their understanding of blood pressure control systems. The level of stress was assessed using the concentrations of the stress biomarkers cortisol and alpha-amylase in saliva. Anxiety was assessed using the State-Trait Anxiety Inventory (STAI) questionnaire. The students achieved significantly higher average scores in exams when the active learning strategy was applied, compared to the use of traditional theoretical classes. The active methodology resulted in significantly lower levels of stress and anxiety, as well as improved student performance, compared to the use of traditional lectures.

Snapshot

Evaluation was made of students' learning and levels of stress and anxiety, comparing the use of an active learning methodology with the use of traditional lectures. The active methodology resulted in significantly lower levels of stress and anxiety, as well as improved student performance, compared to the use of traditional lectures.

Keywords: Academic stress; Active learning; Active methodologies; Educational game; Formative evaluation.

Introduction

During their time at university, students encounter a variety of stressful situations. For new arrivals, the challenges include the process of adaptation to the different reality, such as living away from home, interacting with new colleagues, balancing their academic responsibilities and their social life, heavy workloads of the disciplines, work, studying, and exams (47, 66). Furthermore, many students may not enter university with sufficient maturity to cope with the new circumstances and responsibilities (56).

Many of the skills that are required from new students, such as being capable of autonomy and critical thinking, being motivated to learn, and knowing how to organize their study, are not developed during their time at elementary and secondary schools (52). In courses in the area of health, one of the factors causing stress, according to the students, is the need to memorize, in a short time, substantial amounts of information concerning anatomy, physiology, and biochemistry (60). This is because many universities still use traditional teaching methods where the student receives information passively, during a series of theoretical classes in which there is little student participation, consequently hindering meaningful learning and the development of critical and reflective thinking (23, 46).

Maintaining attention during lengthy lectures is a challenge for the new generation of students, because from an early age they have access to information and communication technologies, so they feel the need to be constantly connected to a network of contacts, desire immediate gratification, and have difficulty in concentrating (1, 54). An additional challenge related to the traditional teaching method is the use of tests at the end of a series of lectures, since during the teaching-learning process, the students are unable to identify their doubts and correct concepts that have been misunderstood, often only perceiving them at the time of the test (29).

Undertaking tests is one of the main factors that cause stress in students. The inability of the student to master certain topics, the fear of failure, or the frustration of not achieving the expected goals (28, 47, 49) can generate fear and anguish (40), leading to academic stress (28, 47).

The term academic stress is used to describe stress related to study, with the associated negative impacts on the academic performance of students (2, 28). Stress factors are perceived differently by each individual, resulting in different individual responses to the same stressor, with or without associated symptomatic manifestations (7). Academic stress can be

aggravated when the student feels incompetent in the face of challenges (14), resulting in anxiety disorders (11, 39), and can continue throughout the undergraduate program and during later professional life (50).

During the stress reaction, there is increased secretion of catecholamines by the sympathetic nervous system and the medulla of the adrenal gland, together with the release of cortisol from the adrenal cortex. These stress reaction mediators activate physiological responses whose function is to enable the individual to cope with, or adapt to, the stressful situation (26, 59, 68). However, when the stress is very intense or is maintained for a long period, the levels of stress hormones remain high and adaptation may not occur, favoring the appearance of pathologies (44, 59, 64).

Positive correlations are observed between blood and saliva cortisol concentrations (70), as well as between the level of stress and the concentration of cortisol in saliva (27, 43). Consequently, cortisol in saliva can be used as a biological marker for stress (27, 30, 58). In addition, the secretion of alpha-amylase is increased by sympathetic stimulation of the salivary glands (48) during the stress reaction, so the concentration of alpha-amylase in saliva can be used as a marker for the activity of the sympathetic nervous system (27, 30, 31, 58).

Studies have found that the stress caused by academic tests led to increases of the concentrations of alpha-amylase (58) and cortisol (49, 56, 58) in the saliva of university students. It has also been observed that higher levels of stress and anxiety are associated with poorer performance of students in assessments (49, 60). Therefore, it is important to determine whether changes in teaching and evaluation methodologies might be able to reduce the stress and anxiety of students faced with tests.

The achievement of educational objectives requires institutional support of the student, which may include consideration of the teaching and evaluation methods used during undergraduate courses (47). From this perspective, active teaching strategies are considered useful for learning, because they favor autonomy, stimulate interest and curiosity, encourage decision-making, and make the student responsible for his/her acquisition of knowledge (5, 8).

Activities involving the use of educational games to improve learning can be used in teaching strategies in combination with theoretical lectures, or be used after lectures (4, 12, 65). Such games assist in the development of problem-solving skills, increase the interest and motivation of the student in learning a particular topic, enable the application of acquired knowledge, develop the ability to work as a team, and improve cognitive and psychomotor

development (4, 25, 38, 65). As an example, a cardiac cycle puzzle was developed for the teaching of cardiac cycle (36, 38). It was found that use of the puzzle improved the learning of university students in the first year of a Dentistry course, compared to a group that only received theoretical lectures (10). Similar results have been observed using other educational games (9, 34, 55, 62, 63).

However, the lecturer must be aware that the teaching strategy on its own, without evaluation of the process, is not sufficient for learning to actually occur. In order for the student to be responsible for his/her acquisition of knowledge, it is essential that he/she perceives what has been learned, identifying the progress that has been made, as well as any remaining doubts. It is then possible to reevaluate the study plan, adopting the strategies necessary for further clarification.

Formative assessment places value on the experiences of the students and lecturers during the teaching-learning process, enabling the students to identify what they already know and what they have not yet understood, as well as to plan future actions for learning of topics and concepts (24, 53). The use of grading is optional in formative assessment, since the objective is not to classify the student as approved or not, but rather to assist the teaching-learning process (37). In this way, it is possible to monitor the progress of the students, identifying their difficulties and avoiding the teaching-learning process ending without achievement of the learning objectives (29, 71).

In her teaching practice, the coordinator of the present study found that the use of active methodologies alone, did not enable the students to assume co-responsibility for their acquisition of knowledge. Therefore, the active teaching strategies were associated with evaluation procedures, resulting in pragmatic active teaching-learning methodologies (37). The present study was designed along these lines.

It is evident that educational games can improve learning, with formative assessments contributing to the success of the teaching-learning process, and that academic stress can compromise the performance of students in assessments of their understanding. Therefore, the objective of this study was to evaluate the effect of an educational game, combined with theoretical lectures and formative assessments, on the learning and levels of stress and anxiety of undergraduate students in the area of health.

Materials and Methods

Experimental design

This study was approved by the Research Ethics Committee of the Faculty of Dentistry of Piracicaba (FOP-UNICAMP, protocol CAAE 10859119.0.00005418). The participants in the study were 56 students enrolled in the second semester of the Dentistry course, studying the Biosciences II discipline. All the students agreed to participate in the research and signed free and informed consent declarations.

All the procedures performed were part of the discipline, so all the students participated. In order to ensure autonomy and reduce any vulnerability of the students in deciding to participate in the study (67), the students were requested to authorize the use of the research data after divulgation of the grades for the cardiovascular system topic. The invitation to participate in the research was made outside of class hours, at a specific time, by a postgraduate student.

This study included lectures and assessments performed during the integrated Biosciences II discipline, related to the cardiovascular system topic. This topic included lectures on anatomy, histology, and physiology, delivered by different lecturers. The present study only considered the physiology activities, which included two related topics with similar degrees of difficulty: cardiac cycle and blood pressure control systems. This strategy enabled the analyses to be performed with the same class of students.

The learning objectives of the cardiac cycle classes were that the students should be able to understand how the morphological and physiological characteristics of the cardiac structures contribute to the continuous pumping of blood, and how cardiac changes affect this pumping.

The learning objectives of the classes on blood pressure control systems were that the students should be able to identify changes in blood pressure caused by everyday or clinical situations, and to explain the physiological responses activated to return to resting levels of blood pressure.

The topics of cardiac cycle were taught using the active methodology (a lecture of approximately 50 minutes + educational game activity + home study + formative assessments). The blood pressure control systems topic was taught using the traditional method (lectures of approximately 2 hours each + home study). Comparison was then made of the effects of the

active methodology and the traditional method on learning (summative assessment) and the levels of stress and anxiety of the students (Figure 1).

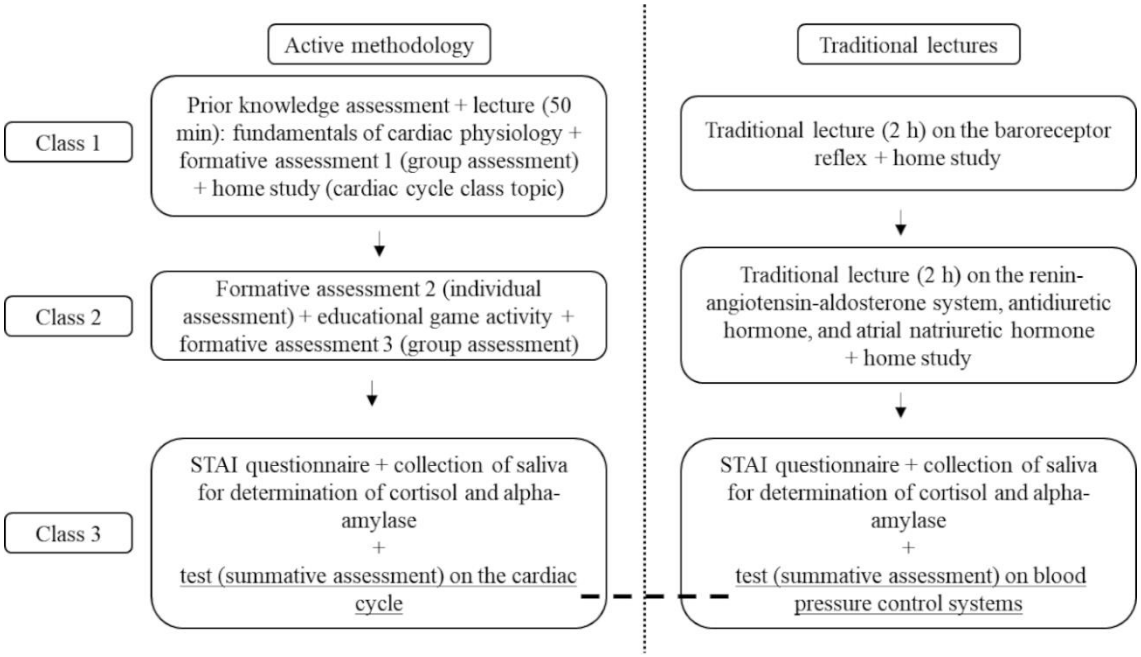

Figure 1. Description of the activities and assessments performed using the active methodology and traditional lectures.

Active methodology

In this study, the active methodology consisted of the combination of an educational game activity with evaluation procedures, which had previously been used by the coordinator in the teaching of cardiac cycle. The method consisted of the combination of a lecture of approximately 50 minutes, textbook study at home, an educational game activity (2 h), and three tests (formative assessments), as detailed below. The grades obtained in the formative assessments were not considered for the students' approval in the discipline, since the objective was to monitor the progress of the students, identifying their doubts and topics that had not been understood.

In the first class, the students completed individual prior knowledge assessment, using a free smartphone application (*Socrative Student App*), available on Android and iOS app stores. Also the grades of students in these test were not summative, and were not considered for their approval in the discipline. The tests consisted of four multiple-choice questions on physiology topics that had been taught in the previous semester (Supplemental Table S1, questions 1-3; see DOI: https://doi.org/10.6084/m9.figshare.12654059) or had been studied

previously in anatomy and histology classes of the discipline (Supplemental Table S1, question 4; see DOI: https://doi.org/10.6084/m9.figshare.12654059). For this test, all the students had access to the smartphone application that allowed the lecturer to access the responses of the students in real time (69).

The objective of this test was to determine whether the students had understood previous contents needed for the topic to be taught, enabling the lecturer to discuss and correct any errors identified. As the students responded, the lecturer checked the answers on her smartphone. Most of the students understood the trajectory of blood in the heart, action potential, and coupled excitation-contraction in skeletal muscle cells (Supplemental Table S1; see DOI: https://doi.org/10.6084/m9.figshare.12654059). These concepts are necessary for understanding the physiology of cardiac muscle contraction and the cardiac cycle. All questions were translated from Portuguese to English for this paper.

After the prior knowledge assessment, a lecture of approximately 50 minutes, was then provided, using PowerPoint slides and oral description of the fundamentals of cardiac physiology, addressing the special characteristics of cardiac cells, the physiology of pacemaker cells, the control of these cells by the autonomic nervous system, the difference between the skeletal muscle action potential and the cardiac muscle plateau potential, and the conduction and transmission of the electrical stimulus through the fibers of the heart (10). Since some incorrect answers were given in the prior knowledge assessment, in the oral presentation, the lecturer drew attention to the items corresponding to the errors that had been identified, asking if there were any doubts, and providing clarification where necessary.

In this class, held in a lecture theater, there was no explanation about the cardiac cycle and no discussion of the relationship between the morphological and functional characteristics of the heart. At the end of the class, the students answered, as a group, a test performed using the smartphone application. The purpose of this test (Supplemental Table S2, formative assessment 1; see DOI: https://doi.org/10.6084/m9.figshare.12654077) was to determine what the students had understood, immediately after the theoretical class.

The students were then instructed to use a textbook to study the topic addressed in the classroom, as well as the topic of the next class (the cardiac cycle). The lecturer explained that the content taught in the theoretical class, together with reading of the book, would enable the students to understand the topic addressed in the next class. The lecturer also informed that at the beginning of the next class, there would be a new individual test (formative assessment

2), followed by an educational game activity. The students were told that grades would be given for this test, with questions related to the content explained in the classroom having greater value than questions related to the content (cardiac cycle) that the students had studied alone at home.

At the start of the second class, the students individually performed a printed test (Supplemental Table S2, formative assessment 2; see DOI: https://doi.org/10.6084/m9.figshare.12654077), followed by the educational game activity involving a cardiac cycle puzzle (available at https://www.lifescitrc.org/resource.cfm?submissionID=11445#.X6nFX_D4B2g.gmail). A detailed description of this puzzle was provided previously by Marcondes et al. (38). For this activity, the students were divided into groups of 5 or 6 participants, defined by the lecturer, based on the averages obtained in the Biosciences I discipline in the previous semester, such that each group included students with performance above and below the average. The students were informed that the purpose of the activity in groups was for them to assist each other in understanding the topics, and that during the activity each group should act and respond according to a consensus reached by all the group members, in order to promote collaborative learning.

Each group was provided with a figure containing illustrations of the phases of the cardiac cycle, and was instructed to position the images in the correct sequence. When the group completed this task, they should ask the lecturer or the monitors (postgraduate students) to check whether the sequence was correct. If it was correct, the students could proceed to the next stage of the activity. If it was incorrect, they should again discuss it within the group, in order to identify errors (10, 38).

In the next stage, the students were provided with a table consisting of 6 columns with the following headings: phase of the cardiac cycle, figure, atrial state, ventricular state, atrioventricular valves, and pulmonary and aortic valves. The columns should be completed using the tokens provided. As in the previous stage, the students should ask the lecturer or monitors to check the table, once consensus had been reached on its completion. If it was correct, the group could proceed to the next stage. If any of the pieces were incorrectly positioned, the students should discuss within the group, in order to identify the pieces that should be repositioned, until reaching the correct solution. Throughout all stages of the activity, the role of the lecturer and monitors was not to indicate where errors lay, but to encourage the students to rethink, discuss among themselves, and solve the problem. If, after discussion, the

group was unable to find the errors, the lecturer or the monitors asked questions intended to guide the students towards achieving correct positioning of all the pieces.

At the end of this stage, the students received questions, one at a time, for them to discuss among the members of the group (10). The group discussions constituted a type of formative assessment process, since they enabled the students to identify what they knew, as well as to collectively resolve their doubts.

At the end of this activity, the students completed, as a group, a test (with grading) on the topics addressed in the activity with the educational game, using the smartphone application, *Socrative Student App* (Supplemental Table S2, formative assessment 3; see DOI: https://doi.org/10.6084/m9.figshare.12654077).

The three formative assessments enabled evaluation of the learning resulting from the lecture of approximately 50 minutes (formative assessment 1), the lecture (50 min) and home study (formative assessment 2), and the combined use of the lecture (50 min), home study, and the collaborative group activity with the educational game (formative assessment 3).

For the next class, the students were instructed to study the content taught in the theoretical class and used during the activity with the educational game, and were informed that they would take a test to assess their understanding of cardiac cycle.

At the start of the third class, the students provided saliva samples for determination of the stress biomarkers cortisol and alpha-amylase, and they were requested to complete a questionnaire to assess their level of anxiety. They then individually performed a printed test (Supplemental Table S3; see DOI: https://doi.org/10.6084/m9.figshare.12654086). This test was used as a summative assessment of the students' understanding of cardiac cycle, in order to determine whether the learning objectives had been achieved (Figure 1). It should be noted, however, that all the formative assessments were considered in the analysis of the learning achieved by the students during the period of the study.

Traditional class

Traditional classes are based on the notion that knowledge should be transmitted from the lecturer to the student, with the lecturer being the active agent who presents and "teaches" the contents. The student is a passive agent who should receive the contents and faithfully reproduce them during tests.

In this study, two traditional theoretical classes were held, each lasting 2 h, on the subject of blood pressure control systems, together with home study by the students, as described below. The classes were held in a lecture theater, using PowerPoint slides and oral presentation of the topics by the lecturer, addressing the importance of blood pressure regulation, perfusion through the tissues, venous return, and the following blood pressure control systems: local control, baroreceptor reflex, renin-angiotensin-aldosterone system, antidiuretic hormone, and atrial natriuretic hormone. At any time during the classes, the students could ask questions to clarify any doubts. At the end of the second class, the students were asked to study the topics using a textbook, prior to performing a test in the subsequent class (Supplemental Table S4; see DOI: https://doi.org/10.6084/m9.figshare.12654107).

At the beginning of the third class, samples of saliva were collected from the students for determination of the stress biomarkers cortisol and alpha-amylase. The students then completed a questionnaire to assess their level of anxiety, and individually completed a printed test on the topic of blood pressure control (Supplemental Table S4; see DOI: https://doi.org/10.6084/m9.figshare.12654107). This test was used as a summative assessment to evaluate the students' understanding of blood pressure control systems, and to determine whether the learning objectives had been achieved (Figure 1).

Saliva collection and biochemical measurements

For determination of the concentrations in saliva of the stress markers cortisol and alpha-amylase, saliva samples were collected using Salivettes®, according to the manufacturer's instructions, at three different times. The first (baseline) was during the first physiology class of the semester, when the students returned from vacation, without performing any other tests. The second collection was made immediately before the test on the topic taught using the lecture (50 minutes) combined with the cardiac cycle puzzle educational game. The third collection was made immediately before the test on the topic taught using the theoretical classes. The saliva samples were centrifuged and the supernatants were stored in tubes, at -80 °C in a freezer, prior to determination of cortisol and alpha-amylase.

Cortisol was determined using a colorimetric enzymatic assay, employing a commercial Cortisol Enzyme Immunoassay Kit (Salimetrics, PA, USA) with sensitivity of 0.007 μg/dL and coefficient of variation in the range from 7% to 11%.

Alpha-amylase was also determined by colorimetric enzymatic assay, using a commercial α-Amylase Kinetic Enzyme Assay Kit (Salimetrics) with sensitivity of 2.0 U/mL and coefficient of variation below 7.2%.

Assessment of anxiety

The State-Trait Anxiety Inventory (STAI) questionnaire was used to assess the anxiety level of the students, at the same times that the saliva samples were collected. The STAI evaluates the occurrence of feelings of tension, nervousness, worry, and apprehension. It consists of 20 questions, with positive and negative items. The student assigns a score, on a Likert-type scale, with the options 1 (none), 2 (low), 3 (moderate), and 4 (high). For quantification and interpretation of the responses, the scores for positive items have inverted weights, where the response options 1, 2, 3, and 4 are assigned the values 4, 3, 2, and 1, respectively (6). In analysis of the responses, it was considered that a score lower than 33 indicated mild anxiety, a score between 33 and 49 indicated moderate anxiety, and a score higher than 49 indicated high anxiety (3).

Evaluation of learning

The level of learning was evaluated by comparing the scores obtained in the summative assessments (tests) performed in the third class, for the different teaching methods: the active methodology (cardiac cycle) and traditional lectures (blood pressure control systems).

The topics taught were not exactly the same (cardiac cycle and blood pressure control systems) representing a limitation of this study. Therefore, in order to identify whether any differences in results could be influenced by one topic being more challenging than the other, the students were asked to give their perceptions about the level of difficulty they had to understand the both topics, according the questions presented in the Table 2. Summative assessment scores, saliva concentrations of cortisol and alpha-amylase, and anxiety indices were evaluated both from all students and, separately, from students who considered the two topics to have the same level of difficulty.

Statistical analysis

The scores obtained in the tests on the topics taught using either traditional lectures or the active methodology were compared using the Student's t-test for paired samples ($p < 0.05$).

One-way analysis of variance (ANOVA) for repeated measures, followed by Tukey's test for multiple comparisons of means ($P < 0.05$), was applied to the means for the cortisol and alpha-amylase concentrations in saliva and the scores obtained in the STAI questionnaire at the different times (baseline, before the test on the topic taught using the lecture (50 minutes) combined with the cardiac cycle puzzle educational game, and the test on the topic taught using the theoretical classes (2 hours of duration each class). The data were presented as means and standard deviations (SD). The statistical procedures were performed using GraphPad Prism v. 6.01 software.

Results

The students achieved a significantly higher average score in the test concerning the content taught using the active methodology, compared to the average score for the test about the content taught using traditional lectures (Table 1, $P < 0.05$).

The students presented higher saliva concentrations of cortisol and alpha-amylase before the test on the topic taught using traditional lectures, compared to the concentrations of these stress biomarkers observed at baseline and before the test on the topic taught using the active methodology. The values of these variables showed no difference between the baseline and before the test on the topic taught using the active methodology (Table 1).

The mean scores obtained using the STAI questionnaire to determine the levels of anxiety of the students were significantly higher before the tests on the topics taught using both the active methodology and the traditional lectures, compared to the baseline (Table 1, $P < 0.05$). The mean score obtained before the test on the content taught using traditional lectures was significantly higher than the mean score obtained before the test on the content taught using the active methodology (Table 1, $P < 0.05$).

The STAI results showed that the students presented a moderate level of anxiety at baseline and before the test on the topic taught using the active methodology, while a high level of anxiety was observed before the test on the topic taught using traditional lectures (Table 1).

Table 1. Summative assessment scores, saliva concentrations of cortisol and alpha-amylase, and anxiety indices for the students before the tests on contents taught using either the active methodology or theoretical lectures.

	Baseline	Active methodology	Theoretical lectures
Summative assessment score (total score: 10.0)	-	8.77 (1.24)*	7.22 (2.56)
Cortisol (µg/dL)	0.45 (0.22)[a]	0.44 (0.25)[a]	0.66 (0.42)[b]
Alpha-amylase (U/mL)	32.30 (20.23)[a]	33.01 (22.09)[a]	49.27 (33.87)[b]
Level of anxiety	38.59 (8.92)[a]	43.57 (9.07)[b]	51.25 (11.76)[c]

The values are shown as means (SD) (n = 56). Mean scores obtained in the summative assessment on the contents taught using either the active methodology (lecture + educational game activity + formative assessments) or theoretical lectures. Saliva concentrations of cortisol and alpha-amylase and the anxiety scores determined using the STAI questionnaire were obtained at three different times: baseline (start of the semester, in a week without tests), before a test on the content taught using the active methodology, and before a test on content taught using theoretical lectures. *significant difference relative to theoretical lectures (Student's t-test for paired samples, P <0.05). Different letters indicate significantly different groups (one-way ANOVA for repeated measures; $P < 0.05$). Saliva cortisol and alpha-amylase concentration: theoretical lectures showed higher values compared to active methodology and compared to baseline values ($P < 0.05$); Level of anxiety: active methodology and theoretical lecture showed higher values compared to baseline values ($P < 0.05$), theoretical lecture showed higher values compared to active methodology ($P < 0.05$).

The evaluation of students´ perceptions about the level of difficulty of the topics heart physiology and blood pressure control systems is presented in Table 2. From 56 students who participated in this study, 26 students considered one topic more difficult than the other one and 30 students considered both topics equally difficult or easy (Table 2). Considering only the data of the 30 students to whom the topics cardiac cycle and blood pressure control system had the same level of difficulty, the grades, salivary concentrations of the stress biomarkers cortisol and alpha-amylase, and anxiety levels, the results (Table 3) remained similar to those from the whole class (Table 1).

Table 2. Numbers and percentages of the responses of the students concerning their perceptions about the level of difficulty in the topics Physiology of the heart and Blood pressure control systems.

Options	N	%
a) The topic cardiac cycle was more difficult than blood pressure control systems.	9	16.1
b) The topic blood pressure control systems topic was more difficult than cardiac cycle.	17	30.4
c) Both topics were difficult, with similar levels of difficulty.	27	48.2
d) Both topics were easy.	3	5.4

Table 3. Summative assessment scores, saliva concentrations of cortisol and alpha-amylase, and anxiety indices for the students, who considered both subjects with the same level of difficulty, before the tests on contents taught using either the active methodology or theoretical lectures.

	Baseline	Active methodology	Theoretical lectures
Summative assessment score (total score: 10.0)	-	8.80 (1.38)*	6.74 (2.91)
Cortisol (µg/dL)	0.44 (0.25)[a]	0.41 (0.24)[a]	0.69 (0.42)[b]
Alpha-amylase (U/mL)	32.93 (17.72)[a]	37.73 (26.96)[a]	55.11 (37.84)[b]
Level of anxiety	39.33 (9.02)[a]	43.30 (7.05)[b]	51.80 (11.88)[c]

The values are shown as means (SD) (n = 30). Mean scores obtained in the summative assessment on the contents taught using either the active methodology (lecture + educational game activity + formative assessments) or theoretical lectures. *significant difference relative to theoretical lectures (Student's t-test for paired samples, P <0.05). Saliva concentrations of cortisol and alpha-amylase and the anxiety scores determined using the STAI questionnaire were obtained at three different times: baseline (start of the semester, in a week without tests), before a test on the content taught using the active methodology, and before a test on content taught using theoretical lectures. Different letters indicate significantly different groups (one-way ANOVA for repeated measures; P < 0.05). Saliva cortisol and

alpha-amylase concentration: theoretical lectures showed higher values compared to active methodology and compared to baseline values ($P < 0.05$); Level of anxiety: active methodology and theoretical lecture showed higher values compared to baseline values ($P < 0.05$), theoretical lecture showed higher values compared to active methodology ($P < 0.05$).

Discussion

The findings of the present study indicated that the active teaching methodology led to reduced stress and anxiety before the exam, and improved the learning of the university students, in comparison to traditional lectures.

The improvement in learning, as assessed by the exam results, was in agreement with other studies comparing student performance in assessments after the use of educational games or theoretical lessons about cardiac cycle (10), action potential (34), muscle system (33), integration of synapsis, muscle contraction, and autonomous nervous system physiology (9), kinesiology and applied anatomy (42), electrocardiogram (55), and emergency skills training (16). In these studies, the students reported that the activities with educational games were useful for learning, since they promoted interaction and collaboration among the individuals of the group, making the topic clearer and resolving doubts. In collaborative activities, one student explaining to another often seems to be more effective than an explanation provided by the lecturer. This is because when a student who has just learned about the topic explains to another student, emphasis can be given to the key points used to understand the content, in addition to the use of simpler language (41). The use of group activities, such as educational games, allows the students to both learn and teach, developing their ability to listen to colleagues, increasing their interest, and learning to discuss and defend their ideas (22).

Lujan and DiCarlo (35) and Savage et al. (57) suggested that the use of strategies that create a relaxed environment favors interaction among the students and with the lecturer, reducing the levels of stress and anxiety, while increasing motivation and attention, consequently improving learning. Cooper et al. (13), observed that during group activities, there was lower anxiety concerning the tasks faced, because the student realized that his/her difficulty was the same as that of a colleague, and they could work together to find the solution. However, in these studies, there was no evaluation of whether, in fact, the use of active teaching strategies led to decreased stress and anxiety, together with improved performance, compared to traditional lectures.

Other authors have observed the relationship between stress biomarkers and assessment activities. Cortisol concentrations increased in exams (56) and oral presentations (45) activities. Alpha-amylase activity showed higher levels in simulations stimulus (20). In addition, other authors evaluated both biomarkers, cortisol and alpha-amylase, in heralded real life stressors, and observed increased levels mutually (58, 66), as well as anxiety (58).

In a recent study published by our research group (32), academic stress increased alpha-amylase (55,24 U/mL – not stressed X 97,80 U/mL – stressed volunteers), but not cortisol (0,55 µg/dL – not stressed X 0,44 µg/dL – stressed volunteers) levels; similar values were found in this study.

Neuroendocrine stress response might vary depending on personality traits (such as self-esteem and extroversion) and type of stressor (real life or laboratory). The neuroendocrine stress response to an examination is characterized by an anticipatory response of the SNS and HPA axis (58), as it was observed in this study when the test was applied after classes taught by theoretical lectures.

Moreover, the students' academic performances can be impaired by the stress and anxiety caused by exams, compromising the achievement of passing grades. In a Dentistry course in Spain, Crego et al. (15) observed that increased levels of anxiety and stress were associated with poor performance of the students in assessments. Ng et al. (49) also observed an association between high levels of stress and poor exam performance in a Medicine course.

In the present study, the lower levels of stress and anxiety observed before the test about the topic that had been taught in combination with the active methodology reinforced the hypothesis that active teaching strategies can make the student feel more secure, with less stress and anxiety concerning exams. Consequently, the students showed improved performance, compared to the assessment performed after theoretical lectures. Decreased test anxiety and improved performance were also observed in an Engineering course that used the active and collaborative "three hundred" methodology developed by Fragelli (21).

The positive effect of the active methodology used in this study could be related to the knowledge assessments performed during the methodology. At most educational institutions in Brazil (both basic and higher education), the strategy adopted involves a sequence of theoretical lessons, individual home study, and an exam. At the end of this process, the student either passes or must take a new exam, in order to obtain a grade. When only this type of summative assessment is used, it is not possible to track the student's progress, because

summative assessments only allow determination of the outcome of the learning, rather than the evolution of the teaching-learning process (24). Hence, it is not possible to identify doubts and the topics not understood by the students, so that such problems could be resolved before the end of a discipline or course (51). Therefore, it is desirable to conduct formative assessments, where the assessment itself provides another opportunity for learning of the student.

In the present study, two formative assessments were applied in the form of tests, while evaluations were also made during the activity with the educational game, in the form of questions made to the groups after solving the puzzle. In addition, formative assessments also occurred as informal procedures during the activity with the educational game. For solving the cardiac cycle puzzle, the students had to identify their doubts, ask their colleagues questions, engage in argument, and compare the ideas presented by all the members of the group. In this way, they identified what they had already understood, what was not very clear, and what they had not understood at all, until the moment of the activity.

Formative assessment allows the students to identify their successes and errors, providing feedback about their progress, doubts, and difficulties with the content, as well as helping them to organize their studies and identify issues that require more attention (53). This assessment also enables the lecturer to accompany the learning of the students, modifying the classroom activities in order to meet their learning needs (29).

In addition, performing formative assessments at different times enables the students to remember concepts learned previously and to add new information. This process is important for learning, because new memory inputs become stabilized after an initial significant learning, in a process called memory reconsolidation (61). For example, in cardiovascular physiology classes, the students need to remember the anatomical or histological structures of an organ, in order to properly understand its function. The students must retrieve previous knowledge of anatomy and histology, adding new information about the function of specific organs to the existing memory.

It is important to emphasize that active strategies for teaching and the assessment of learning are inseparable. Active teaching strategies alone will not help students, unless they are accompanied by assessments that allow the lecturer to accompany the process, rather than only considering the final learning result (37). Formative assessments enable the lecturer to monitor the progress of students, modifying the classes so as to best meet their learning needs.

For the student, formative assessments enable the identification of doubts, success, errors, and issues requiring more attention, thus assisting the organization of study during the learning process (17, 19, 29). Therefore, the present study indicated that the combination of active learning strategy combined with formative assessments could make the student more confident in perform well on the summative assessment and achieve the passing grades, decreasing the student´s anxiety, as proposed by Downing et al. (18).

The limitation of this study was comparing the scores obtained in assessments of related but not same topics (cardiac cycle and blood pressure control systems). In order to evaluate if this difference could influence the results, we also evaluated only the students to whom both topics were equally difficult or easy. And this evaluation also showed that there was a decrease in the scores and increase in salivary stress markers and anxiety levels before the assessment on the topic taught with lecture in comparison to the same parameters obtained before assessment on topic taught with active methodology. Therefore, the difference in the topics seem not to have influenced the results of the present study. Despite this limitation, at least according our best knowledge, this is the first study evaluating the effect of active methodology on stress and anxiety induced by assessment.

In a future study, we aim to use another possible experimental design by comparing the two methods to teach the same topic to different students' classes. Since the discipline in question is taught in the second semester of the undergraduate Dentistry course, the study would have to be performed with students who started the course in different years. However, the comparison of different groups of students presents another bias since different teaching experiences between the groups could also influence the parameters analyzed in the present study.

The findings of the present work showed that active strategies combined with formative assessment resulted in improved student performance, due to increased learning and reductions of stress and anxiety. These results suggested that lecturers should be widely encouraged to reappraise their approaches to teaching and assessment.

Disclosures

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2.2 Cardiac Cycle Puzzle: Development and Analysis of Students' Perception of an Online Digital Version for Teaching Cardiac Physiology.

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Lais Tono Cardozo, Victor Travassos Sarinho, Luís Henrique Montrezor, Lucila Ludmila Paula Gutierrez, Érica Maria Granjeiro, Fernanda Klein Marcondes

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Cardiac Cycle Puzzle: Development and Analysis of Students' Perception of an Online Digital Version for Teaching Cardiac Physiology

Lais Tono Cardozo [Universidade Estadual de Campinas | lais_tono@hotmail.com]

Victor Travassos Sarinho [Universidade Estadual de Feira de Santana | vsarinho@uefs.br]

Luís Henrique Montrezor [Universidade de Araraquara | lhmontrezor@uniara.edu.br]

Lucila Ludmila Paula Gutierrez [Universidade Federal de Ciências da Saúde de Porto Alegre | lucilag@ufcspa.edu.br]

Érica Maria Granjeiro [Universidade Estadual de Feira de Santana | ericag@uefs.br]

Fernanda Klein Marcondes [Universidade Estadual de Campinas | ferklein@unicamp.br]

Abstract

Cardiac physiology is a basic subject in the curriculum of health Science undergraduate courses, which allow students to understand the functional mechanisms of cardiovascular organs as well as the physiopathology of cardiovascular diseases. The puzzle of cardiac cycle has been developed to help students to understand and integrate the concepts of morphology and physiology of normal and pathological states of the heart. Considering the good acceptance of the printed puzzle by students and professors, its online version has been developed as a digital educational tool. The aims of this work were to describe the development of the online digital version of this educational game and to evaluate the students' perception of the utility of the digital game for their learning. The digital version was developed using the figures and answers of the original printed cardiac cycle puzzle, including stages 1 and 2, in three languages: Portuguese, English and Spanish. The digital version was tested by professors of Physiology from different university institutions for validation. The final version of game was used in remote teaching in three courses in the health area, during the COVID-19 pandemic. The opinion of students about the usefulness of the game activity for their learning was analyzed by using a survey. In the opinion of participants in this study, the activity with the online digital version of the cardiac cycle puzzle was useful for their learning.

Keywords: Serious game, Active teaching method, Puzzle, Cardiac cycle, Student perception

1 Introduction

Cardiovascular physiology is an important and complex issue in the health courses curriculum. Professionals of health career must know the morpho-functional characteristics of the cardiovascular system, in order to understand the physio-pathological changes of the heart and blood vessels, as well as integrate basic knowledge and clinical application. As a result, the professional will be able to guide, to diagnose and to treat cardiovascular diseases (Abreu *et al*. 2014; Azer, 2014; Malta *et al*. 2014).

First and second-year students of healthcare careers struggle to integrate cardiac morphological and physiological concepts. And it becomes more challenging when the teaching-learning process is fractioned into subjects and based on the transmission and memorization of content in a professor-centered model (Borges *et al*. 2016). For meaningful learning to occur, it is necessary to be student-centered process, using active teaching strategies like educational games (Tarouco *et al*. 2004; Berbel, 2011).

The learning-process "is facilitated when it is done in a fun activity manner" (Campos *et al.* 2003). Students show enthusiasm when their learning is more intuitive and interactive, resulting in meaningful learning. Therefore, digital games are raising as a primary tool for learning, motivating the student and developing different levels of personal experience, in order to help the construction of new discoveries, the personality development, among other positive aspects (Oliveira Neto & Ribeiro, 2012).

Accordingly, to help students learning about heart morphology and physiology; specially the rhythmic control and continuous blood pumping through the heart, the cardiac cycle puzzle was developed (Marcondes & Amaral, 2014). It is a simple and inexpensive game that has been used as an active teaching strategy and was considered useful for learning by students from Dentistry, Medicine, Biology, Nursing and Pharmacy undergraduate courses (Marcondes *et al.* 2015). Besides that, when the puzzle replaced part of the lecture, it increased learning (Cardozo *et al.,* 2016), and reduced test anxiety and stress in dental students (Cardozo *et al.,* 2020a). Considering the good acceptance of the printed puzzle by students and professors, its online version has been developed as a digital educational tool. The aims of this work were to describe the development process of the online digital version of the cardiac cycle puzzle, and to evaluate the student's perception of the utility of the digital game for their learning, during emergency remote teaching due to COVID-19 pandemic.

2 State-of-Art

2.1 Active Teaching Methodologies

In the university, it is difficult for students to maintain attention during traditional lectures because from their childhood, they have access to information and communication technologies, and like to be always connected to a network of contacts, receiving simultaneous stimulus (Abdulmajed *et al*. 2015). Therefore, it is a challenge for them to be focused when old teaching methods are used (Abdulmajed *et al*. 2015; Luchi *et al*. 2019). In addition, although traditional lecture-based class is effective to present information, it did not promote deep and long-lasting learning or development of problem-solving skills (Campos *et al*. 2020).

As possible solutions to these problems, various active teaching methodologies (Berbel, 2011), aiming to produce creative, critical, and collaborative individuals have been proposed in recent years. These include problem-based learning, projects and teamwork, design/visual thinking, education maker, flipped classroom, hybrid teaching, e-learning, personalized teaching, competency-based education, and game-based learning. Such approaches aim to awaken in the student a state of acceptance of the information received (voluntary action), engage them in relation to the knowledge presented (motivation), create an unconditional attraction of the applied methodology (seduction), and provide an ongoing stimulus to continue the proposed activities (reward).

2.2 Digital Games in Education for Health

Digital games provide stimulation that takes the forms of challenge, curiosity, control, fantasy, competition, cooperation, and player recognition (Savi & Ulbricht, 2008). They are tools that can enrich pedagogical practice and have received attention among educational researchers and professors who support their use in learning. Digital games have the potential to provide highly engaging environments, offering high levels of interaction and feedback (Machado, 2104), in addition to allowing free experimentation that can enable learning that is pleasurable, captivating, entertaining, and engaged (Bueno, 2010). They also affect the players in ways that include voluntary action, motivation, seduction, and reward, addressing the challenges and opportunities associated with the needs of young people (Satrio *et al*. 2020). Consequently, classes become more attractive (seduction), awakening the students' curiosity and attention (motivation), improving school productivity, assisting professors to make classes more dynamic (reward), and contributing to the students taking advantage of the school outside the classroom (voluntary action).

Serious games can be used as educational strategy to improve the performance of health care professionals by increasing their learning, skills and attitudes (Nøhr & Aarts, 2010; Akl *et al*. 2013). Serious games are complete and playfully games that are developed not for entertainment, but with specific educational objectives (Sisler & Brom, 2008). This is a new and important technology that has been used in specialized training, including 3D games and motors of games to improve the realistic experience of users (Wattanasoontorn *et al*. 2013). Though the advancement of technology and due to the desire to achieve good health in an interesting and fun way, several serious games for health have been developed in recent years (Wattanasoontorn *et al*. 2013), involving themes related to the transmission of knowledge of first aid and medical information (personal level); to training of competences in health care (professional skills); for recruiting people (research and academy); and to the management of simulations (public health) (Sawyer, 2008).

2.4 Cardiac Cycle Puzzle

In the original printed version (Marcondes *et al*. 2015), the cardiac cycle puzzle presents a figure board in a paper A4 size, as in Figure 1, a table in a paper A3 size accordingly to Figure 2 and chips measuring 5.7 x 2.5 cm, laminated with transparent plastic. Figure 3. In stage 1, the students in groups are requested to use the figure board to organize five images according to the correct sequence of cardiac cycle phases. Figure 1.

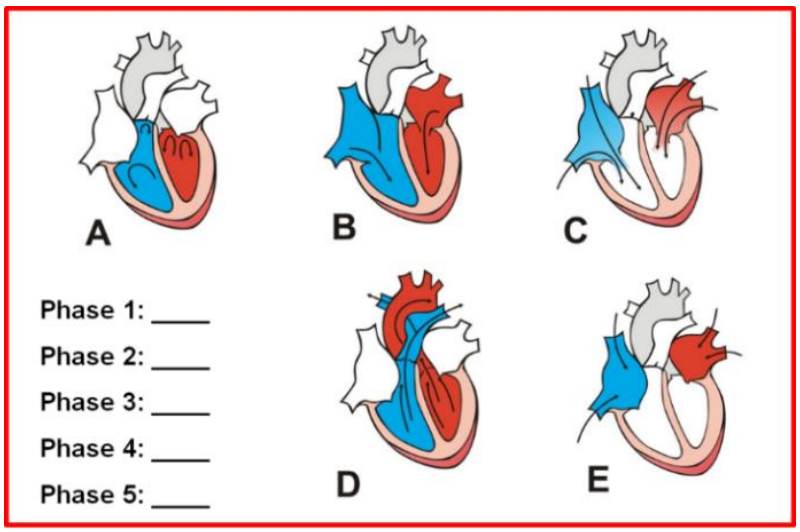

Figure. 1. Stage 1 of printed cardiac cycle puzzle (adapted from Marcondes et al. 2015).

In the stage 2, they should place the chips in a table. Figure 2. The columns of the table indicate: phases of cardiac cycle, atrial and ventricular state, state of atrioventricular and pulmonary valves. Figure 2.

Cardiac cycle phase	Phase	Atrial State	Ventricular state	State of atrioventricular valves	Aortic and pulmonary

Figure 2. Table for placing chips in stage 2 of printed cardiac cycle puzzle (adapted from Marcondes et al. 2015).

The chips indicate the names of the cardiac cycle phases, atrial or ventricular contraction or relaxation, valves opening and closing. Figure 3. (Marcondes & Amaral, 2014; Marcondes *et al*. 2015).

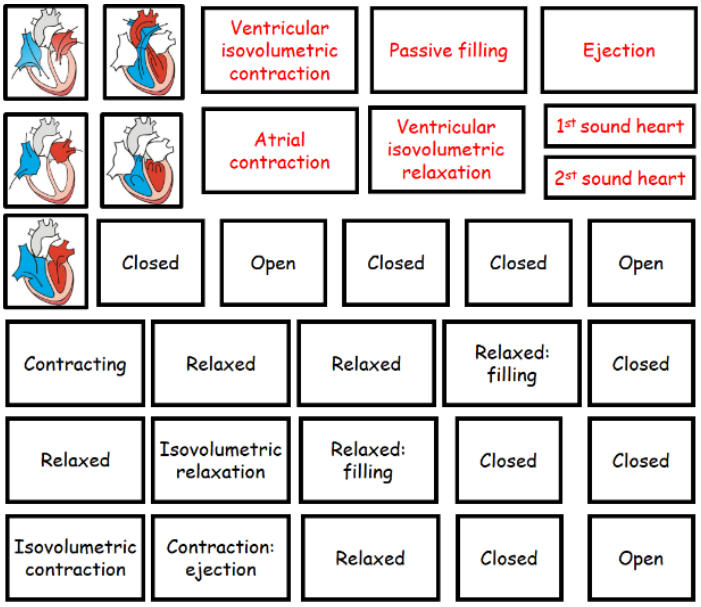

Figure 3. Chips for filling the table in stage 2 of printed cardiac cycle puzzle (adapted from Marcondes et al. 2015).

In the stage 3, the groups receive questions to be discussed and answered. These questions address basic concepts related to the cardiac cycle and its application in clinical situations, and can be adapted for different courses (Marcondes *et al*. 2015; Cardozo *et al*. 2016).

This educational game has basic characteristics of a puzzle: challenge, feedback, entertainment, and eureka factor (Michalewicz *et al*. 2011). The challenge is present because the students have to remember, discuss and integrated their knowledge to place each chip in the correct place and to answer the questions (Marcondes *et al*. 2015; Cardozo *et al*. 2016). The immediate feedback whether or not the pieces have been correctly placed is provided by monitors or professor, who inform if there was an inaccuracy. If so, they ask questions to enable the students to find the mistake and correct it. The same approach is used considering the correction of questions. This way, the teaching-learning process became dynamic and funny. When all the pieces are correctly placed in the table, there is the hit (Eureka!) and the students feel a sense of reward for solving the puzzle (Michalewicz *et al*. 2011; Cardozo *et al*. 2016), as well as when the answers to each question is correct.

This serious game can be used as a complementary strategy (Marcondes *et al*. 2015), after the lecture, or as an active learning method by replacing a lecture (Cardozo *et al*. 2016; 2020a). In both cases, the aim of the cardiac puzzle is to help the students to integrate previous knowledges in order to understand how the morphological and physiological characteristics of the heart contribute to the continuous pumping of blood. The aim of this game is to promote collaborative learning. For this, the movement of the pieces and discussion of the questions would be done according to a consensus of the group of students performing the activity (Marcondes *et al*. 2015; Cardozo *et al*. 2016; 2020).

3 Methods

3.1 Development of the online digital version of the cardiac cycle puzzle

The construction of the digital version of the Cardiac Cycle Puzzle was carried out in two main phases. The first consists of defining a JSON model able to represent a puzzle matrix and possible correct answers according to the arrangement of the fitting pieces. The second, on the other hand, produces a Javascript application from a web game engine capable

of interpreting each modeled JSON, thus creating a generic and reusable solution for different desired educational puzzles.

3.1.1 The JSON model

Five main elements were defined in a JSON model to represent drag'n'drop games in a puzzle-style matrix, which were properly configured for the educational game of the cardiac cycle: *tokens*, *columns*, *rows*, *fixed* and *answers*.

Tokens indicate the pieces that need to be placed in the matrix cells that represent the puzzle. Each token has a unique identifier (*id* property), the image to be displayed in the game (*image* property), a reference value to be assigned to the puzzle piece (*valueRef* property), and the piece size information (*height* and *width* properties. Figure 4.

The matrix itself is composed by the *columns* and *rows* elements, which indicate: an identifier for the respective row and column (*id* property), the label of the respective row or column (*header* property) and the desired column length (*width* property) and line height (*height* property) for the puzzle array. Figure 4.

Fixed informs which pieces will be placed in the puzzle at startup. For this, it is necessary to inform the piece that will be placed in a fixed way (*id* property with the id value of the token), as well as the line (*rowId* property) and the column (*columnId* property) where it will be fixed in the puzzle. Figure 4.

```
export var gameConfig = { id:"ciclo-cardiaco", title:"Ciclo Cardíaco",
  subTitle:"Posicione as fichas em sequência, de acordo com as fases ...",
  timeLimit:120, livesLimit:3,
  timeText:"Tempo:", livesText:"Vidas:", scoreText:"Acertos:",
  attemptsText:"Tentativas:", backgroundImage:"", backgroundSound:"looping.mp
  pressButtonSound:"press.wav", winnerSound:"ta-da.mp3", loserSound:"fail.mp3
  verifyButtonText:"Corrigir Resposta", showAnswerButtonText:"Mostrar Respost
  nextSceneButtonText:"Próximo", wrongAnswerText:"Resposta errada! Tente ..."
  ...,
  tokens:[
    {id:"token1", image:"cardio1.png", valueRef:"1", height:96, width:96},
    {id:"token2", image:"cardio2.png", valueRef:"2", height:96, width:96},
    ...,
  ],
  columns:[{id:"c1", header:"1", width:96},
    {id:"c2", header:"2", width:96}, {id:"c3", header:"3", width:96},
    {id:"c4", header:"4", width:96}, {id:"c5", header:"5", width:96}
  ],
  rows:[{id:"r1", header:"", height:96}],
  fixed:[{id:"token4", columnId:"c1", rowId:"r1"}],
  answers:[
    [ {valueRef:"4", columnId:"c1", rowId:"r1", score:"1"},
      {valueRef:"1", columnId:"c2", rowId:"r1", score:"1"},
      ...,
    ],
    [ {valueRef:"2", columnId:"c1", rowId:"r1", score:"1"},
      {valueRef:"4", columnId:"c2", rowId:"r1", score:"1"},
      ...
    ],
```

Figure. 4. Partial example of a JSON model configuration representing one of the modeled cardiac cycle puzzles.

Regarding the valid *answers* to the proposed puzzle, it is possible to inform different combinations of pieces that can be considered as valid answers for the game. In this sense, answers are represented as a matrix of combinations of pieces in certain positions that represent a valid answer to be accepted by the game. For that, each cell of this matrix will be represented by the *Ref* value of a piece to be placed in a respective row (*rowId*) and column (*columnId*) of the puzzle, followed by a possible score value (*score* property) to be associated with this position in the puzzle. Figure 4.

3.1.2 The Javascript interpreter

To perform the interpretation of the modeled JSON files, a Javascript application based on the Phaser3 web game engine was developed. It performs the initial loading of the images and sounds configured in the JSON model for the configured game, as well as rendering the matrix's representative grid with its respective headers. The inclusion of a Head-Up Display (HUD) according to modeled game dynamics, the rendering of the puzzle pieces deck to be distributed in the matrix, the drag'n'drop control of the pieces according to the matrix cells, and the verification of correct answers and game score according to player attempts, are also executed by the developed application.

The loading of the game media is defined based on the information configured in JSON. For this, some properties referring to sounds such as *backgroundSound*, *pressButtonSound*, *winnerSound* and *loserSound*, together with the properties associated with the images of the tokens, are used to indicate the destination paths of the respective media. A deck for game pieces was also made available for the game, which is filled in at the start of each game with the images and dimensions configured for each token.

The grid rendering is done by including Phaser3 *zone* components, according to the dimensions informed by the columns and rows elements. Each zone controls the drag'n’drop of the game pieces, centralizing pieces partially placed in the respective cells of the configured puzzle matrix. Input and output events for the mouse and parts in the zones are also managed for the purpose of color changes and consequent indication of drag'n’drop status for the respective players.

With respect to the game's HUD, this can display: the time the player still has available to solve the puzzle, the number of lives the player still has in the game, the number of hits the player got with the attempt made, and the number of attempts made by the player. In

this way, there are several possibilities for configuring game dynamics capable of gamifying a simple drag'n'drop of puzzle pieces according to game designer interests.

Two buttons are also placed for the player's use in the HUD, which allow: checking if the player's answer is correct, and showing one of the possible correct answers configured in JSON (if the game has already ended). By pressing the "*Check*" button, the application will check if there is any combination of pieces distributed in the puzzle whose values of the valueRef property are in equivalent positions according to at least one of the position vectors indicated in the JSON matrix answers. It is worth noting that this response verification will only occur when all the pieces of the deck are distributed in the puzzle matrix. The display of the puzzle response, an action performed when the "*Show*" button is pressed, will also only occur when all the player's attempts are exhausted.

A message bar is also available in the game, which allows the display of possible game responses based on player's interactions. Among these, the game can: inform that the player's answer is right or wrong, indicate the number of attempts made, warn that all the pieces need to be distributed in the matrix so that an answer can be evaluated, and explain that some actions only can be done before or after the game is over.

3.1.3 Online digital cardiac cycle puzzle

The digital version was developed using the figures and answers of the original printed cardiac cycle puzzle, including stages 1 and 2. These stages were made available at https://ciclo-cardiaco.herokuapp.com/ in three languages: Portuguese, English and Spanish. Stage 3 was not used in the digital version, because in this stage, the questions for group discussion could be adapted for each course and time schedule. Therefore, the questions could be changed and presented to the students according to the preferences of the professor, as described in item 2.4.

The available stages have no time or attempts limits, allowing the player to make mistakes as many times as necessary to learn the correct combinations suggested as responses to the cardiac cycle. Figure 5.

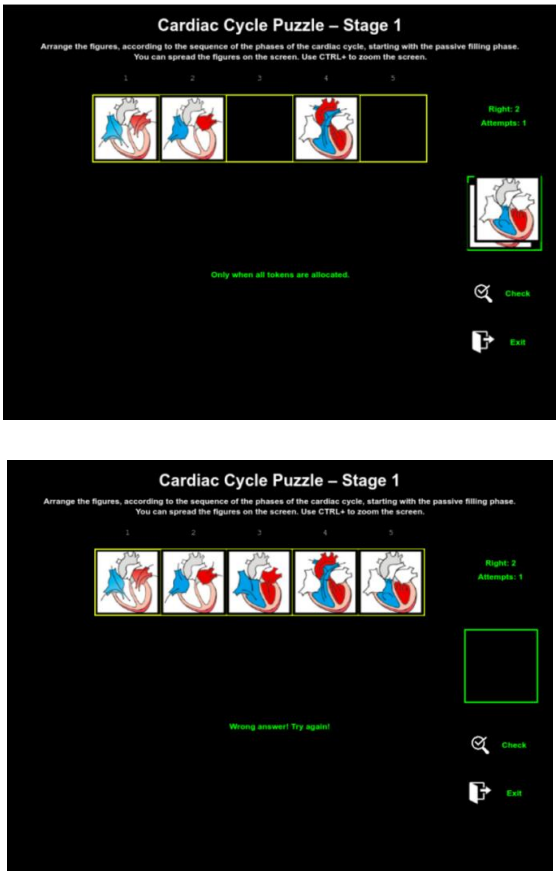

Figure 5. Stage 1 of the online digital cardiac cycle puzzle.

In the first stage, 5 images are illustrated, showing the path of arterial and venous blood in the heart, as well as the contraction and relaxation of the atria and ventricles. It is up to the player to find a possible valid combination between two configurations identified as possible valid responses, by placing the pieces in the cells indicated by the puzzle matrix. Figure 5.

In the second stage, a puzzle with five columns and six rows is presented. The columns indicate the phases of the cardiac cycle, atrial status, ventricular status, atrioventricular valve status and pulmonary and aortic valve status. The pieces to be placed indicate the names of the phases of the cardiac cycle phase, atrial and ventricular contraction or relaxation, opening and closing of valves. It is again up to player to find a possible valid combination according to the two configured as possible right responses, by placing the pieces in the cells indicated by the puzzle matrix. Figure 6.

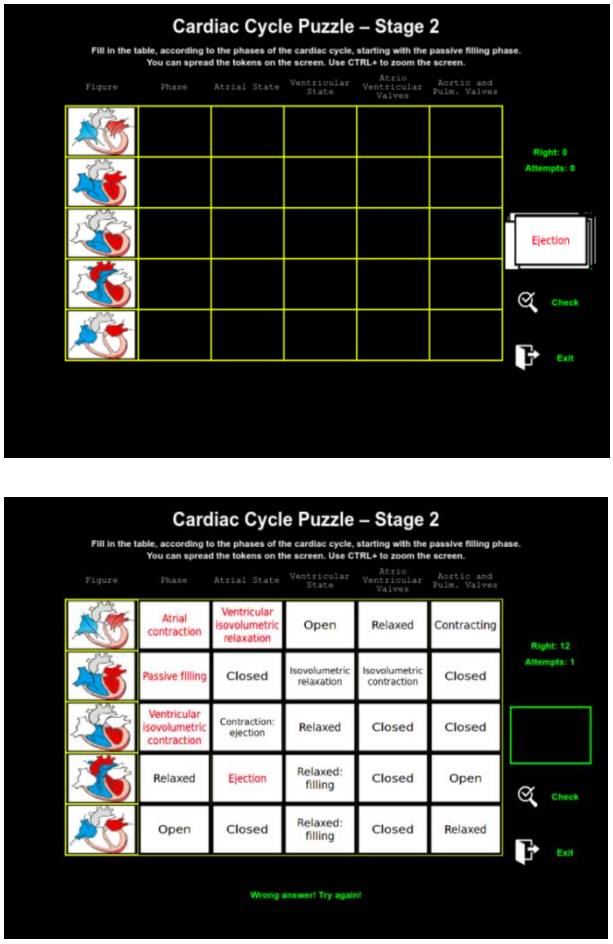

Figure 6. Stage 2 of the online digital cardiac cycle puzzle.

3.2 Students' perception

A prototype of the online digital version of the cardiac cycle puzzle was tested by professors of Physiology at different university institutions. Based on the users' experiences and the feedback received, the online game was validated and improved (Cardozo *et al*. 2020b). The final version of the game, with improvements made during the validation process (Savi *et al*. 2010; Cardozo *et al*. 2020b), was used in remote teaching during the COVID-19 pandemic.

3.2.1 Teaching use of online digital cardiac cycle puzzle

The digital puzzle was used in three courses in the health area, as described below.

Course 1: From 74 students enrolled in the first year of the Dentistry course of Piracicaba Dental School, studying the Biosciences II discipline, 44 agreed to participate in this study. Four students who did not watch pre-class videos before the activity with the educational game were excluded of the study. Therefore, there were 40 participants: 15 men and 25 women. The online digital cardiac cycle puzzle was used as a strategy that replaced the lecture about

this subject, as previously described for the printed version, after a short first class addressing the characteristics of cardiac cells (Cardozo *et al*. 2016). In adapting to emergency remote teaching, part of content of class 1 was presented in 3 pre-class videos of 10, 2 and 9 min, addressing: 1 – introduction to cardiovascular system and pacemaker cells, 2 – cardiac conduction fibers and 3 – contraction of cardiac muscle cells, respectively. These videos were made available for the students, 2 days before the class 1, in the free *Edpuzzle* platform. The videos presented slides and oral explanation of the professor and questions so that the students could check their understanding. *Edpuzzle* generated a report indicating which students had watched each video until the end, and how many questions each student answered.

In class 1, there was a 1h20-synchronous and interactive lecture by *Google Meet*, in which the professor presented the same questions of the pre-class videos. The students answered them by free *Mentimeter app*, anonymously, one at a time. Just after, each question was corrected, and the professor discussed the doubts by using slides in *PowerPoint* software program. In addition, it was also explained how the autonomous nervous system controls the cardiac function. According to the use of printed version (Cardozo *et al*. 2020), the students were then instructed to use a textbook to study the topic addressed in the classroom, as well as the topic of the next class (the cardiac cycle). The lecturer explained that the content taught in the theoretical class, together with reading of the book, would enable the students to understand the topic addressed in the next class. The lecturer also informed that at the beginning of the next class, there would be a new individual test, followed by an educational game activity (Cardozo *et al*. 2020). It has been informed that this test, as well as watching the videos before class1, would not be graded by right answer, but by participation. This strategy has been used in order to stimulate the previous study before the activity with the game. At the end of this class, the lecturer sent an exercise to students by e-mail. It should be made in group to be sent to the lecturer until 4 days after class 1. This way, each group would receive its correction with formative feedback, before class 2, that was done 6 days after class 1.

At the start of the class 2 (synchronous by *Google Meet*), there was a discussion of doubts of the students considering the topics addressed in class 1 and studied in the book. The students were divided into 16 groups (5 - 6 students / group). This class was conducted by one professor and 3 monitors and was repeated 2 times with 8 groups a time. The lecturer then presented a *YouTube-video* showing the movement of blood in the heart during the cardiac cycle. Afterwards, the students answered, individually, a test performed using the *Socrative student app*. After this test, the lecturer presented the instructions for the activity with the

cardiac cycle puzzle. The groups of 5-6 members were divided in *Google Meet* break-out rooms and received the link access to the online digital version of the puzzle. It was instructed that only one student from each group accessed the link, shared the computer screen and manipulated the pieces, during discussion in group. The movement of pieces would be done according to a consensus reached by all the group members, in order to promote collaborative learning (Cardozo *et al.* 2020). In the stages 1 and 2 of digital cardiac cycle puzzle, the groups received feedbacks in the computer screen indicating if the solution was or not right. When the students had doubts, they called the lecturer or monitors by using the cell phone application for exchanging messages *Whatsapp app*. As well as in the activity with the printed version, the role of the lecturer and monitors was not to indicate where errors lay and correct them, but to encourage the students to rethink, discuss among themselves, and solve the problem. If, after discussion, the group was unable to find the errors, and pass stages 1 or 2, the lecturer or monitors asked questions intended to guide the students towards achieving correct positioning of all the pieces (Cardozo *et al.* 2020). For stage 3, the groups received the questions one at a time, to be discussed and answered in the *Socrative student app*. Each group then called the lecturer or monitors by *Whatsapp app* for answers' correction. All the activity lasted 2h.

Course 2: Twenty-one Pharmacy students from the second year of UFCSPA were enrolled in the Physiology discipline in which the online digital game was used, and seventeen students gave informed consent, consisting of 13 women and 4 men. During the period of the COVID-19 pandemic, emergency distance learning was adopted, and lecture classes were made available in asynchronous (as videos) and synchronous classes (as exercises, games, discussions and doubts). In this course the online digital game was used as a reinforcement strategy. In class 1 (asynchronous), the students watched a video class about the cardiac cycle, make notes and were instructed to study the theme. This video was recorded by the professor, using the *PowerPoint* software, and it dealt with the anatomy of the heart, its muscular characteristics, action potential of the pacemaker cells and cardiac muscle contraction, as well as the physiology of the cardiac cycle and the control of cardiac function (Frank-Starling Law and Autonomic Nervous System). The video lasted 1 h and 45 minutes and it could be paused and resumed at any time, in addition to being able to be watched more than once, as the students deemed necessary. It was made available for the students 7 days before the activity with the online digital version of the cardiac cycle puzzle. The students were also instructed to study the topic in the indicated books and their doubts could be forwarded to a group by *Whatsapp app*, in which the discipline professor and the monitors also participated.

At the beginning of the class 2 (synchronous by *Google Meet*), all students said they had watched the video class. The professor explained how the online digital game works, showing on her screen images of it. The students were divided into 5 groups of 4 members in *Google Meet* break-out rooms. One student from each group was instructed to display the game on their screen and then everyone could discuss and solve the two stages of the game. The professor stayed in the main *Google Meet* room as the beginning of the class to answer students' questions. Three monitors participated in the activity, alternately entering in *Google Meet* rooms to monitor the activity and elucidate questions without, however, answer the game. This part of the activity lasted 1 hour. Once the game was over, all students came back to the main *Google Meet* room to discuss the activity, listen to the explanation about the cardiac cycle by projecting textbook images and elucidate their doubts with the professor. Then, the professor started to present the questions that make up the game using free *Mentimeter app*. Each question was presented in professor screen and the students were instructed to talk through *Whatsapp app* to mark the consensus response of the group members. Then, the professor presented the answers of the groups and, together with the students, discussed the answers, indicating what was correct and incorrect. At the end of the activity, there was an opportunity to clarify any doubts that students might still have.

Course 3: Seventy-seven medical students from the first year were enrolled in the Physiology and Biophysic II class in which the online digital game was used. Seventy-two students gave informed consent. Five students were excluded from the study because they did not answer all the questionnaire questions on student perception. Therefore, 67 students participated in this study, consisting of 54 women and 13 men.

During the COVID-19 pandemic period the hybrid teaching system was adopted by the UNIARA medical course. The lectures were in virtual format with synchronous meetings by *Google Meet*. The practical classes were in person in the laboratories, according all the health protocols recommended by the Brazilian health agencies. For the activity using the online digital version of the puzzle of the cardiac cycle, the students participated in one synchronous virtual lecture (class 1, 50 min) and one face-to-face meeting at lab (class 2, 1 h).

The main concepts related to the cardiac cycle was presented by the professor during the virtual lecture. Mainly, the mechanisms of control of the electrical and mechanical activities of the heart, the ventricular volumes, venous return, cardiac output, ejection fraction, cardiac valves functions, and the autonomic and endocrine controls of these mechanisms. In addition, the cardiac cycle phases have been briefly described. For this, slides from the *Power Point*

software were used. The students were encouraged to participate in the discussions, mainly because the professor exemplified the important relationships between cardiac physiology and biophysics with cardiology, highlighting the importance between preclinical and clinical areas. For the lab activity, students were instructed to read the content provided in the textbooks indicated in the medical course syllabus.

Three weeks after the class1, the face-to-face lab activity was carried out with the online digital version of the puzzle. Participants (n = 67) were divided into 22 groups (3 - 4 students / group). The activities were conducted by two professors (11 groups / professor), and it was repeated 3 times by each one, following the health recommendations. Although the students were instructed to read the content in the textbooks before the activity, it was not possible to know in fact if they had studied. Students were informed about the link access to the online digital version of the puzzle, and they were instructed about the activity dynamics. It was suggested that only one student from each group accessed the link and manipulated the app during discussions with other members of the group. Smartphones (16 groups), tablets (4 groups), and laptops (2 groups) were used. Throughout the activity, professors were available to guide student discussions. Whenever a group requested for the professors help, they guided the discussion in order to assist students in the cardiac cycle reasoning. Professors never showed students how the table should be completed. The goal has always been to stimulate students' thinking about the heart functions and discussion among group members. At the end of the activity, as soon as the groups correctly completed the two stages of the virtual game, some questions related to heart functions were presented to the groups using *Power Point* slides. Each question was individually presented, and students were instructed to discuss it; first, within each group and then between groups. This dynamic facilitated the groups interactions, stimulating discussions within the group and between groups. Professors were present encouraging the participation of all members of each group during discussions and raising questions that could be added to discussion complement about heart physiology.

3.2.2 Analysis of students' perception

In this study, analysis was made of the students' perception concerning the usefulness of the game activity for their learning. The work received approval from the Research Ethics Committees of the participating institutions: CAAE 10859119.0.0000.5418, Piracicaba Dental School (FOP-UNICAMP); CAAE 42980515.0.3002.5345, Federal University of Health Sciences of Porto Alegre (UFCSPA); and CAAE 40019820.9.0000.5383, University of Araraquara (UNIARA).

Analysis of the students' perceptions of the online digital version of the cardiac cycle puzzle was performed in activities undertaken in the Physiology classes of three courses in the health area: Dentistry (n = 40) at FOP-UNICAMP, Pharmacy (n = 17) at UFCSPA, and Medicine (n = 67) at UNIARA, totaling 124 students.

The activity employing the online digital version of the cardiac cycle puzzle and questions regarding the students' perception of it were part of mandatory disciplines in the three courses, where all the students participated in all the activities, irrespective of the research. To reduce vulnerability and ensure the students' autonomy in deciding to participate in the research (Tengan *et al*., 2005), the request to use the data for the purpose of the research was made at the end of the course. The students only participated in the study after giving free and informed consent (FIC) in digital forms, authorizing the use of their answers concerning the activity with the online digital game.

This study was undertaken while presential teaching activities at the three institutions were suspended due to the COVID-19 pandemic (OPAS, 2020), being replaced by emergency remote teaching delivered in synchronous and asynchronous classes, according to the demands and characteristics of each institution. The resources available and the strategies used by the professors and institutions participating in this study differed in terms of the classes prior to the activity with the online digital cardiac cycle puzzle. This was in accordance with the envisaged use of this educational game, in both printed and digital versions, which depended on the number of hours of teaching, the chronograms of the disciplines, and the learning objectives of the professors in each course. It should be stressed that it was not the objective of this study to make comparisons among the courses, but rather to obtain the students' opinions regarding the activity made with the digital game, without discussing differences related to the characteristics of the courses and the participating institutions.

For analysis of the students' perceptions, after the activity performed with the online digital game, the students from the three courses were requested to answer two questions: 1) "Was the cardiac cycle puzzle activity useful for your learning? Indicate your answer on a scale from 1 to 5, where 1 = *it was not useful for learning* and 5 = *it was necessary for my learning*. Justify your answer". 2) "Did you study for the activity with the cardiac cycle puzzle? Indicate your answer on a scale from 1 to 5, where 1 = *I did not study and did not feel prepared for the activity* and 5 = *I studied sufficiently and felt prepared for the activity*. If you did not indicate 5, explain why you think that you did not study sufficiently or did not feel prepared for the activity".

The Likert-type scale responses were used to calculate the means and standard deviations. Analysis of variance (ANOVA) and Tukey's test were used to identify significant differences ($p < 0.05$). The justifications for the responses were analyzed and grouped. Similar justifications were presented according to the number of students who indicated them. Percentage frequencies were not calculated, because several students provided more than one justification, while others did not justify their answers. Consequently, the total number of justifications did not correspond to the number of students who participated in the work.

Results

In the opinion of the students of the three courses participating in this study, the activity with the online digital version of the cardiac cycle puzzle was useful for learning (Table 1), and the reasons for this evaluation were similar among the courses. For most students, the activity with the online digital game made it easier to understand the addressed topics, allowing to identify what had been understood and the remaining doubts. The students' positive perception was also due to the fact that the educational game presents figures, the activity is dynamic and provides interaction with colleagues.

Table 1. Students' perception of the usefulness of the activity with the online digital version of the cardiac cycle puzzle for their learning.

Question	Course 1 (n=40)	Course 2 (n=17)	Course 3 (n=67)
Was the activity with the cardiac cycle puzzle useful for your learning? On a scale of 1 to 5, indicate your answer, considering 1 = it was not useful for learning and 5 = it was necessary for my learning.	4.70 ±0.61[a]	4.94 ±0.24[a]	4.79 ±0.48[a]
Justifications	n[b]	n[b]	n[b]
It made content easier to understand (58)	12	10	36
It showed what I knew and allowed me to identify my doubts (29)	13	2	14
It was more visual, having figures (26)	3	2	21

It made content easier to be remembered (26)	5	1	16
It was more dynamic way to learn (24)	6	2	16
Sharing knowledge with colleagues in the group made me understand better (17)	10	4	3
It sintetized the content (12)	3	0	9
It forces reasoning (11)	2	0	9
It was playful, fun, funny (7)	3	0	4
It was very useful at time of remote teaching (3)	0	0	3
It didn´t help much because I missed a class before (1)	1	0	0

[a]mean ± standard deviation of answers in the Likert– type scale ($p > 0.05$, ANOVA). [b]number of students who presented this justification in each course. Obs.: some students presented more than one justification.

As the use of the cardiac cycle puzzle requires the students to have previous knowledge about the heart, the perception of the students about their previous preparation for the activity was evaluated. The results considering the pre-class study (Table 2) show that the study prior to the activity with the online digital educational game differed among the participating students, and the difficulty of organizing time was the main reason for those who evaluated not having studied enough.

Table 2. Students' evaluation considering their pre-activity study.

Question	Course 1 (n=40)	Course 2 (n=17)	Course 3 (n=67)
Did you study for the activity with the cardiac cycle puzzle? On a scale of 1 to 5, indicate your answer, considering 1 = I did not study and I did not feel	4.08 ±0.83 [a]	2.24 ±1.15 [a]*	3.85 ±0.91 [a]

prepared for the activity and 5 = I studied enough and felt prepared for the activity.

Justifications	n[b]	n[b]	n [b]
I studied the content and some doubts I had were resolved in the activity (30)	9	3	18
I couldn't organize myself to study all the material (24)	7	7	10
I could have studied more, because I saw that I confused some things (20)	8	2	10
I didn't feel prepared just by reading the content, I miss an explanation in class (5)	3	0	2
I was not feeling well (5)	1	0	4

[a]mean ± standard deviation of answers in the Likert – type scale *significant difference in comparison to course 1 and 3 ($p < 0.05$, ANOVA + Tukey test). [b]number of students who presented this justification in each course. Obs.: some students presented more than one justification.

Discussion

The application of a teaching strategy in different courses and institutions enables evaluation of its broader effectiveness. If the strategy is effective, it should work in different contexts, even if not in exactly the same way or to the same degree, with the possibility of adaptations. The results obtained in this study indicated that the students believed that the activity with the online digital version of the cardiac cycle puzzle assisted their learning. These results were similar to those obtained for the printed version of this educational game (Marcondes *et al*. 2015; Cardozo *et* al. 2016).

The opinions of the students regarding the activity evidenced that the teaching strategy was viable in situations of remote teaching or distance learning. In the present case, the fact that the students considered the educational game activity useful was important, but it was not possible to confirm that the teaching strategy increased learning. Often, the student may show a positive reaction because the activity is different to a traditional class, and for this reason, he/she believes that the learning was greater than achieved by only watching a theoretical explanation (Prince, 2004; Cardozo *et al.*, 2016). Although we did not evaluate the

students' learning, studies show that the use of active teaching strategies can alter levels of motivation and interest, leading to changes in behavior and making the student feel more inclined to study at home, paying more attention to the topic being studied (Downing *et al*., 2020).

The cardiac cycle puzzle can be used in different ways, according to the objective of the lecturer, the curriculum structure, and the time available. However, it should be clarified that the purpose of the activity with this educational game, using both the printed and online digital versions, was not to make the teaching process more entertaining. Instead, it aimed to facilitate understanding of a complex subject important for all courses in the health area, which requires of the student considerable study, attention, and ability to integrate the content. The solution of the cardiac cycle puzzle requires basic knowledge of heart morphology and physiology, with the success of the activity in assisting learning being dependent on previous preparation by the student. Therefore, it is crucial that the student should prepare for the activity, follow the instructions given by the lecturer, attend the class prior to the activity, and study the indicated content. In the absence of prior preparation for the activity, the student may like the game, finding it entertaining and dynamic, but without attaining any significant learning. In contrast, much better performance can be achieved when the students have prepared for the activity, when interactions with other group members are positive, and when they are able to have fun, while focusing on the content studied (Montrezor, 2021; Savage *et al*. 2017).

For the three courses evaluated, the justifications for the answers to the question concerning the students' opinion regarding the usefulness of the game were similar. The justification provided by the greatest number of students was that the activity assisted understanding. As observed for the printed version of the same game, applied in a presential class, the results indicated that the students believed that the objective of the educational game had been achieved. The justifications presented by the students contributed to understanding what they most valued in an active teaching methodology. The fact that the answers indicated that the activity with the educational game made it easier to understand the topic suggested that the entire context of the strategy (previous study and the activity with the game, including discussion with colleagues, the monitors, and the lecturer) was useful for learning. Nonetheless, it did not enable elucidation of why understanding the topic became easier.

However, the other justifications allowed the reasons for this positive effect to be identified. The second most frequent justification was that the activity with the educational game enabled the students to identify what they had understood and what their doubts were.

This was coherent with one of the precepts of active methodologies, which is to enable the student to accompany the progress made during the teaching-learning process (Kulasegaram and Rangachari, 2018). In the group discussion to define the correct sequence of the figures and the positioning of the cards in the table, indicating the sequence of events of the cardiac cycle, the students were able to explain what they had understood to colleagues, argue in defense of their understanding of the topic, and reconsider what they believed they had understood. These processes would be unlikely to occur in an exclusively theoretical class, where the student hears, sees, and receives information, without sufficient time to process it during the class (Kulasegaram & Rangachari, 2018; Raes *et al*. 2019).

The use of games allows the student to acquire knowledge in an active and dynamic way, with the individuals involved generally being more open to mutual assistance, with analysis of errors and successes, provoking a deeper reflection on the concepts under discussion (Teixeira and Apresentação, 2014). In the present case, some of the spontaneous justifications are worth highlighting, because they evidence the importance given by the students to the feedback process allowed by the activity with the online digital cardiac cycle puzzle: "*The cardiac cycle puzzle activity enabled me to identify a doubt I had about the cycle, which I didn't even know I had (I hadn't properly understood isovolumetric relaxation and passive filling), leading me to study these specific topics. Hence, this exercise was essential for my learning*"; "*It was very useful, because in the classes employing images and diagrams, I had thought that I understood the cardiac cycle. However, when I performed the game with my colleagues, I perceived that I still had some doubts, which were clarified in the interactions with the other group members and the monitors*"; "*It was necessary, because I could test my knowledge of the cardiac cycle and identify where there were difficulties, in order to be able to subsequently review the subject and resolve my doubts*". These perceptions of the students were coherent with another premise of active methodologies, namely their association with formative assessments (Hoffmann, 2019). A formative assessment is not necessarily an exam or a test. It may be an informal activity that allows the student to perceive what he/she already knows, so that the study can be reorganized to enable learning of what has not yet been understood. The goal of such an assessment is to evaluate the teaching-learning process, rather than its outcome (Malta *et al*. 2014; Hoffmann, 2019; Cardozo *et al*. 2020; Marcondes *et al*. 2020).

Another reason indicated by the students for the activity with the educational game being useful for learning was that it was "more visual", since it used images. The activity required attentive analysis of the images to identify the route of blood through the heart, the

moments of opening and closing of the heart valves, and the contraction and relaxation of the atria and ventricles. Consequently, the students' perception was probably related to the integration of information needed to complete the task. Attentive analysis of the images was also necessary to identify the cards that completed each row and column of the table. Learning is achieved by the use of different sensory organs (Hernández-Torrano *et al*. 2017), with vision being one of the main senses activated during teaching-learning activities (Relvas, 2012). Hence, images assist in the formation of memories and later activation of previously acquired knowledge Sosa *et* al. 2018). In the present case, the perception of the students showed that they identified the contribution of this process to enhancement of their learning.

The justification indicating that the activity with the online digital game was useful for "it made content easer to be remembered" was the 4th most indicated justification, but it was not clear what the students meant. They could have believed that the activity helped in remembering the content worked on, which could have been related to the context and the interactions that occurred during the activity (Hernández-Torrano *et al*. 2017). The fact that it involved visual analysis, together with interaction among colleagues and feedback from colleagues, monitors, and professors, would make it easier to remember what was discussed, explained, and corrected, compared to what would be understood and remembered following a non-interactive taught class.

The dynamic nature of the activity was also indicated as a factor that assisted learning, which was related to the fact that the activity involved different actions and skills, rather than only listening, as would be the case in a traditional theoretical class. This perception was as expected for the use of active teaching methodologies in which the student is no longer a passive listener, instead acquiring an active role that can include speaking, arguing, moving around, and arranging didactic (Hernández-Torrano *et al*. 2017). In this way, the class does not become boring and the students do not lose attention and concentration (Marcondes *et al*. 2021).

The interaction with colleagues was also identified by the students as a factor favoring their learning. Collaborative activities assist in the social construction of knowledge during the interactions between group members, while also increasing the interest and motivation of the students (Montrezor, 2021; Vuopala *et al*., 2016). Cooperation is effective when the students discover that they share similar objectives, with success depending on the actions of the group. This stimulates and improves interaction among the group, with the members assisting and encouraging others in attaining the learning objectives (Herrmann, 2013). As an example, one of the students provided the following justification of the importance

of working as a group: "*I found it very interesting! I had never participated in an activity such as this before, so it was a novelty. I thought it was really useful, because as a group, we discussed and "racked our brains", in order to understand all the steps and relate them to the heart phases, the atrial and ventricular states, and the opening and closing of the valves, so it was a great experience!*".

Other justifications provided by the students were less frequent, but nonetheless deserve attention. For some of the students, the activity with the online digital game was useful for learning because it "synthesized the content" and "forced reasoning". This indicated that the students perceived that in the activity with the online digital game, fundamental concepts were approached in such a way as to enable understanding of them, with this process involving the effort and concentration of the participants. This perception was important for stimulating the students to prepare for the activity and become responsible for their learning, developing self-regulation ability (Polydoro *et al*., 2015). Consequently, the professor becomes a mediator guiding the teaching-learning process, no longer being a transmitter of information, which is also in accordance with the purpose of active methodologies (Marcondes *et al*. 2021).

Another justification of the students concerned the perception that the activity was "game-based/entertaining", referring to the fact that it was a more pleasant and relaxed way of learning. As reported by Savage *et al*. (2017), the use of an active teaching strategy provides a more relaxed environment, so that the student feels more at ease in asking questions and making mistakes, resulting in greater interest and motivation. A less formal and more relaxed environment makes the participants feel more comfortable in trying and making mistakes, in addition to reducing the fear of being judged when expressing their doubts, favoring collaborative learning (Lizzio *et al*. 2002; Tyng *et al*. 2017). However, it should be stressed that although a teaching activity may often be entertaining, providing a relaxed atmosphere appreciated by the students, this may not necessarily be reflected in the occurrence of learning (or improved learning). It is essential for the professor to define the intended learning objectives, so that learning actually occurs, avoiding the risk that the active methodology becomes merely a transient distraction (Marcondes et al., 2021).

Three students suggested that the activity with the online digital version of the cardiac cycle puzzle was useful in the context of virtual education, indicating that they valued the online strategy. Although this might seem obvious, it should be noted that this opinion of the students showed that they valued the efforts made to improve the pedagogical practice, confirming that the strategy adopted was effective, in the opinion of the students. This feedback

to the professor is very important, since it encourages continuing efforts to improve teaching strategies (Hoffmann, 2012; Marcondes, 2020).

Only one student did not consider the activity with the online digital game useful for learning, because he felt that "*a previous class was lacking*". The student indicated that he expected the activity to function as a reinforcement of learning. However, in this course, the purpose of the game activity was to replace the theoretical class on the cardiac cycle, not to reinforce what might have been taught in a theoretical class. The opinion of the student could indicate that he was not accustomed to active methodologies that require student participation, reasoning, and interaction. This could have been due to previous experiences in basic education that mainly involved the transmission of information by the professor, resulting in difficulty in adapting to the active teaching strategy (Downing *et al*. 2020). Another possibility is that the student may not have prepared individually before the activity. He may have watched the pre-class videos, but not performed reading of the textbooks, or he may not have understood all or part of what he read. This possibility was related to the second question, as discussed below.

The success of an active teaching methodology depends on the engagement of the student (Downing *et al*. 2020), including periods of individual study. The results of the activity, in terms of student learning, may be poor if the student does not follow the instructions given by the professor. For example, in the present case, the student should watch the pre-class videos (course 1) or the video class (course 2), perform the group exercise before the online digital game activity (course 1), and complete the required textbook readings (courses 1, 2, and 3). It is also essential that clear instructions are given to the students. In the present study, in addition to providing instructions, the professors explained that previous study would be necessary to enable the students to learn, with mutual assistance, during the group activity performed in the subsequent class. If these prerequisites are not observed, then the results obtained from assessment of the learning achieved, or analysis of the students' perceptions, may indicate that the teaching strategy was unsuccessful. This would not necessarily mean that the approach was ineffective, since its failure would be related to insufficient prior knowledge of the students. In the case of the activity with the online digital game analyzed here, the professors requested the students to undertake previous study using a textbook. In addition to the above considerations, in the present work, analysis of the students' previous preparation was necessary, because the activity with the online digital game was carried out during emergency remote teaching implemented due to the COVID-19 pandemic. Therefore, difficulties related to the pandemic, including access to digital resources, could influence the results of the study, so they should be

taken into account. For this reason, the students were also asked if they had undertaken previous study and felt prepared for the activity with the digital version of the cardiac cycle puzzle.

The results showed that the course students participating in the study had not all studied to the same degree, and did not feel equally prepared for the activity. The possible Likert- type scale score varied from 1 to 5, with 5 indicating that the student felt that he/she had studied sufficiently and felt adequately prepared. In two of the courses, the average scores were near 4 (Table 2), indicating that the students were of the opinion that they had prepared themselves. However, in one of the courses, the average score was near 2, indicating that the students did not feel prepared for the online digital game activity. Understanding this perception of the students required analysis of their justifications.

In courses 1 and 3, where the students felt prepared for the activity, the most frequent justifications indicated that a score of 5 was not given because they felt that although they had studied, they had remaining doubts, which were resolved in the online digital game activity. This perception of the students was in line with the intended purpose of the active teaching strategy adopted, since it was expected that the activity would be an opportunity for learning. It was expected that the students would have doubts and would not have mastered all the content. Therefore, this justification did not reflect insufficient preparation by the students.

In these courses, as well as in course 2 (where the students believed that they had not prepared sufficiently), the most frequent justification for not feeling prepared was the difficulty of organizing to study, due to inability to efficiently allocate time for their various activities. The second most frequent justification, "*I could have studied more*", did not enable elucidation of whether this was due to difficulty in organizing their time, or, if the student considered that he/she had studied sufficiently, he/she "*confused some things*" during the activity, perceiving that he/she knew less than had been imagined. However, these justifications were not mutually exclusive and showed the difficulty that the students found in organizing their study, which could be related to the development of self-regulation of learning. Many of the skills expected of students entering university, such as autonomy, critical reasoning, motivation to learn, and knowing how to organize their time for the various activities of the disciplines, are not learned in previous years, during basic education (Polydoro *et al*., 2015; Cardozo *et al*., 2020). Furthermore, the inability to organize their time was likely to become more acute during emergency remote education. A small number of students indicated that they did not feel prepared because there was insufficient explanation provided during the class. In other words, they had expected that the online digital game activity would be used as

reinforcement, after a theoretical explanation. This justification suggested that the students had not become familiarized with active teaching strategies (Downing *et al*. 2020), which was understandable, given that taught classes still predominate in basic education in Brazil. Therefore, it is essential for the professor to plan teaching activities in such a way as to assist the students in developing the skills described above.

A justification provided by some students from two courses was "*I was not feeling well*". This did not make it clear whether the students were not well during the activity, or during the previous study. Nonetheless, it deserved attention, because it is important that the professor should be sensitive and open to understanding that these situations may arise, preventing the student from benefiting from the active strategy, due to an external factor unrelated to the study or the strategy. During the emergency remote education caused by the COVID-19 pandemic, this understanding was essential to allow the establishment of closer relationships between the professors and the students, including the possibility of repeating the activity or planning other complementary activities for these students. In the context of the pandemic, it is vital that professors understand their role in this new educational process, not only in the use of technologies, but also in ensuring that such resources can be used with all the students, meeting the specific educational needs of each individual (Granjeiro *et al*. 2020).

The use of educational games gives the professor an opportunity to analyze and understand the development of reasoning in the students, making the teaching-learning process more dynamic (Teixeira and Apresentação, 2014). The separate consideration of the results for the three participating courses enabled elucidation of whether the students positively evaluated the online digital game for the same reason or for different reasons. The identification of these reasons supported understanding of how the students' learning occurred, in addition to enabling improvement of the teaching strategy and the development of other similar strategies. For example, if the professor knows that the students greatly appreciate strategies or teaching materials that are visual in nature, it may then be appropriate to use other such tools to reach a greater number of students. If the students place value on group activities and perceive that they learn better with them, it is then necessary to pay special attention to this type of activity, since it can contribute to them developing collaborative learning strategies outside the classroom, improving their abilities to study, solve problems, and work effectively with colleagues.

In previous work (Marcondes *et al*., 2015; Cardozo *et al*., 2016), agreement was observed between the students' perception and the positive effects of the printed cardiac cycle puzzle activity on learning, stress, and anxiety prior to a test (Cardozo *et al*., 2016, 2020). A

limitation of the present study was that it was not possible to perform this assessment, because although the perceptions of the students were evaluated, their learning was not assessed. Since this study was undertaken in the context of adapting didactic activities for emergency remote teaching, it was not possible to use learning assessment tools equivalent to the methods that had been used by the researchers in the presential activities and were available at the participating institutions. However, a future study is being elaborated that will allow such analyses.

Conclusion

This article describes the development of a digital version of the cardiac cycle puzzle, together with the students' perceptions of the effectiveness of its use in higher education. Descriptions are provided of the following aspects: the adaptations made in the digital version, compared to the physical game; details of the implementation of a JSON model representative of the game; the online prototype developed and made available; and the process of analysis of the students' perceptions of the use of the digital version by professors of three undergraduate courses in the health area.

According to the reported perceptions of the students, the digital version of the cardiac cycle puzzle contributed to their learning. Therefore, the digital version seems to be as effective as the original printed version, considering these students' perception.

The online digital game could also be used as an additional resource for individual study and the fixation of learning, subsequent to the group activities, since it may be accessed by the students anywhere and at any time. The digital version of the cardiac cycle puzzle is an active learning resource that could be used by any undergraduate student interested in learning about cardiac physiology.

Finally, it should be highlighted that although the cardiac cycle puzzle was developed to substitute a theoretical class on this topic, it can be adapted according to the learning objectives of the professor, the chronogram of the discipline, and the physical and staffing infrastructure of the institution in which it will be used. Therefore, the development of the digital version of the puzzle expands the possibilities for adoption of this teaching resource.

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2.3 University pedagogy for emergency remote teaching of cardiac physiology during the covid-19 pandemic.

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Lais Tono Cardozo, Maria Antonia Ramos de Azevedo, Rafaela Costa, Pamella Telles Pessoa, Karina Reche Casale, Fernanda Klein Marcondes

Autorização para inclusão do artigo publicados na tese disponível no Anexo 2.

University pedagogy for emergency remote teaching of cardiac physiology during the covid-19 pandemic

Lais Tono Cardozo[1]*, Maria Antonia Ramos de Azevedo [2]*, Rafaela Costa[1], Pamella Telles Pessoa[1], Karina Reche Casale[1], Fernanda Klein Marcondes[1*]

[1] Piracicaba Dental School, Department of Biosciences, University of Campinas - UNICAMP, Piracicaba, Brazil

[2] Institute of Biosciences, Department of Education, São Paulo State University - UNESP, Rio Claro Brazil

* These authors have contributed equally to this work and share first authorship

Correspondence:
Fernanda Klein Marcondes
ferklein@unicamp.br

Footnote: This study is part of LTC PhD thesis in development at Dentistry Graduate Program of Piracicaba Dental School.

Abstract

During the COVID-19 pandemic, higher education institutions adopted emergency remote teaching. Consequently, university lecturers had to search for digital teaching tools. However, the use of such systems must be based on sound educational concepts, in order to ensure success of the teaching-learning process. The purpose of this work is to share the procedures used for remote teaching of cardiac physiology in a course in the health area, presenting the didactic and pedagogical justifications for their use. In addition, evaluation was made of learning and of students' perceptions of the teaching and assessment strategies used. There was no difference between test grades obtained by students in emergency remote teaching and those from students in presential teaching, the year before. The positive opinions of the participating students showed that the strategies led to better organization of their study outside

of classes, providing a sense of security about what had been learned. The teaching and assessment strategies enabled the intended objectives to be achieved, with assimilation of the theoretical concepts and procedures enabling the students to be protagonists in their education, in an educational process where responsibility was shared among the teachers and the students.

Keywords: methodology, assessment, serious game, flipped classroom, quiz

Palabras clave: metodología, evaluación, juego serio, aula invertida, cuestionario

Introduction

The COVID-19 pandemic led many countries to introduce a range of measures to limit transmission of the virus, including social distancing, hand hygiene, use of face masks, and suspension of presential teaching [1]. Classes had to shift to the mode denoted emergency remote education, a term used to differentiate it from planned distance learning for online environments [2, 3]. The challenges faced by teachers were the lack of experience in incorporating digital technologies in their teaching practice, the need to rapidly learn how to safely use such them in their classes, and the promotion of student learning, motivation, and engagement [4].

These challenges emerged at a time when there was already an increasing search for teaching methods that could replace the predominant use of taught classes and memorization of concepts. For meaningful learning, it is necessary to relate new information to relevant aspects of the student's daily life and previous knowledge [5, 6], in addition to stimulating the active participation of the student in the learning process [7]. The use of active methodologies in university education can make a significant contribution, provided they are accompanied by periodic assessments that ensure better understanding of the evaluation criteria and procedures adopted during the proposed activities [8]. For this purpose, and to promote student engagement [9], in the presential classes concerning cardiovascular system physiology, the use of educational games and formative assessments was considered useful by the students, since it increased learning and reduced anxiety and stress before tests [10].

During remote teaching, teachers sought update and train in teaching practices. The university pedagogy is essential in order to avoid the search for teaching techniques being restricted to procedures. For this purpose, the epistemological field of university pedagogy can make a significant contribution, offering ways to organize pedagogical activities that are based on clear foundations of the courses taught, taking account of the teaching concept, objectives, and methodology, with evaluation of the links between the course pedagogical activities and the training initiatives of the teachers [11].

The aim of the present work is to share the strategies used in remote emergency teaching of cardiac physiology, in a course in the health area, justifying the use of the strategies employed in light of the concepts of university pedagogy, with evaluation of the students' learning and opinions.

Characterization of the emergency remote teaching

This study was approved by the institutional Research Ethics (CAAE 10859119.0.00005418)[1]. Presentation will be made of part of the sequence of classes, teaching strategies, and learning assessments used in the emergency remote teaching of cardiac physiology in the basic discipline of the 2nd semester of FOP-UNICAMP, taught in 2020, as indicated in the Figure 1. The strategies presented in this paper emerged from conceptual theoretical studies developed during the professional activities of the participating professors and monitors, together with their students.

All the activities and procedures constituted part of the discipline, regardless of the present research. To evaluate if remote teaching influenced the level of learning, the scores obtained in a test, by 44 and 73 students (presential teaching), who gave their free and informed consent respectively in 2020 and 2019. The activities developed for teaching the topics of basic cardiac physiology and the cardiac cycle will be described, indicating in underlined text the didactic and pedagogical reasons for use of the teaching and assessment strategies described.

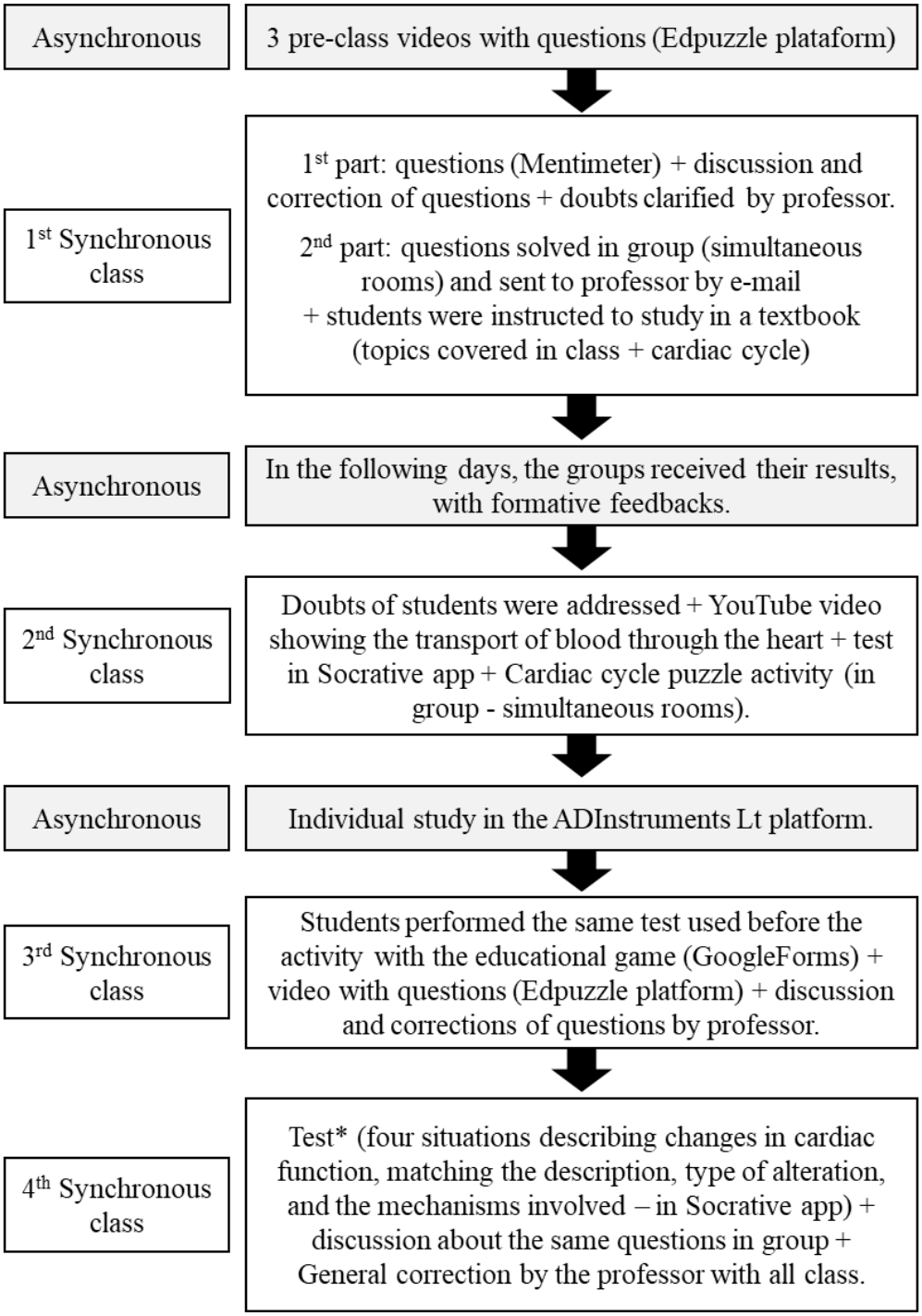

Figure 1. Synchronous and asynchronous teaching strategies and learning assessment used in the emergency remote teaching of cardiac physiology in Dentistry course of Piracicaba Dental School, University of Campinas. *Test applied in face-to-face teaching, before pandemic, that was also used in this study, in order to compare emergency remote and face-to-face learning.

Basic cardiac physiology – adapted flipped classroom, diagnostic and formative assessments

In order to actively stimulate understanding of information received in oral explanations, promote involvement of the students in their own learning, and reduce their difficulty in maintaining attention during lengthy online classes, pre-class videos were recorded using GoogleMeet, where the professor presented the content using PowerPoint slides. The first video (10 min), introducing the topic, presented questions about stress in dentistry and hypertensive crisis situations in the dental consulting room. This contextualization was necessary to awaken the students' interest in the topic to be studied, since neuroscience recognizes that the student learns from perception of the significance and potential application of the new knowledge during professional or personal life [12]. Also presented were the learning objectives, which should be defined considering what the student should be capable of explaining or doing, applying the knowledge acquired. However, this is often so evident to the professor that it may be forgotten, or it may be considered unnecessary to indicate its importance to the students. It is also possible that the professor may not understand the questioning of the student about the reason for learning a topic, which may be interpreted as a lack of interest, when in fact the student is searching for the rationale of what is intended to be taught and learned.

In the first video, the automaticity of heart pacemaker cells was also described. The second video (2 min) concerned the transmission of electrical stimuli by the cardiac conduction fibers. The third video (9 min) described the plateau action potential and cardiac muscle contraction.

Included in the pre-class videos were questions to enable the students to determine whether they had understood the information provided, with the videos not being continued until the questions were answered. Before providing an answer, the student was able to review the video. These videos were made available on the free Edpuzzle platform, for access up to one day before the class. A participation grade was awarded to the students who watched the videos in full and answered the questions, regardless of whether the answers were correct, using the report provided by the digital platform. The use of questions during the videos enabled the students to check their understanding, such that they did not just passively receive information [13]. This process of checking learning, known as formative or procedural assessment, allows both the student and the teacher to adjust their actions [14]. In this way, content that has not been learned can be identified, revisited, and actually learned, according to a teaching strategy

that avoids discovering what has not been learned only after the application of a test at the end of the discipline [15]. In this way, the professor analyzed the students' answers, identifying the points of greatest difficulty, which could then be addressed in the synchronous class.

In the first part of this class, the questions in the pre-class videos were answered individually by the students, using the free Mentimeter application. The answers were discussed and corrected, one by one, with any doubts being resolved using the same slides presented in the pre-class videos, or new slides, enabling the professor to clarify the errors and points of greatest difficulty that had been identified in analysis of the report concerning the videos. In the next step, explanation was provided concerning the topic of autonomic control of cardiac activity, which had not been addressed in the pre-class videos. Therefore, the above strategies were an adaptation of the flipped classroom. This methodology considered that the previous contents needed to have been assimilated, so that the students understood how the autonomic nervous system controls the cardiac function. Hence, the pre-class video questions answered and discussed in the first part of the synchronous class represented a diagnostic assessment, before presentation of new content. This assessment consisted of checking whether the student had previously assimilated the knowledge necessary to understand the new information, with the teaching-learning process proceeding according to the notions of proximal development zone in the education process [16]. The use of the questions during the discussion made the class more dynamic and engaged the students.

In the second part of the class, groups of students were allocated to simultaneous rooms, where they performed an exercise in which they were asked to analyze records of action potentials, identify those that corresponded to skeletal, smooth, and cardiac muscles, and explain why summation of contractions occurs in skeletal muscle, but not in cardiac muscle. The students also answered questions about the intrinsic heart rate and autonomic control of cardiac chronotropism. This and next group activities involved 16 groups of 5-6 students, with mixing of students with different performances, as indicated by the grades achieved in a previous discipline. The groups were instructed to provide consensual answers and solutions in the proposed activities, such that they could mutually assist each other. Explanations were provided concerning the nature of collaborative learning and how scientific studies have demonstrated the positive results obtained by team learning, with students alternating in the roles of providing and receiving assistance [17].

The completed exercise was sent to the professor by e-mail. In the following days, the groups received their results, with formative feedbacks. The formative feedbacks consisted

of comments identifying what had been understood by the group, together with indication of additions or corrections that should be made by the group. The interactions among the students, monitors, and professor occurred by e-mail and by written and audio WhatsApp messages. Also, monitors forwarded the most frequent doubts to the professor, allowing interventions to be made with all the students. The group exercises and corrections with formative feedback, constituted formative assessments necessary for accompanying the evolution of the teaching-learning process.

For the next class, the students were instructed to study the topics covered so far, as well as the cardiac cycle, using a textbook. It was explained that this individual study was needed so that all the members could contribute to the group activity to be performed in the next class. In order to encourage this study, it was informed that there would be a test, with grades awarded, at the beginning of the subsequent class.

Cardiac cycle – serious game, interactive study, and formative assessments

At the start of the second synchronous class, doubts of students were addressed. This was followed by presentation of a YouTube video showing the transport of blood through the heart. The students then completed a test, using the free Socrative application, consisting of five multiple choice questions about the content (cardiac cycle) studied using the textbook. Before the start of the test, the students were informed that marks would not be awarded for correct answers, but instead for completion of the test. The aim of the home study and the test applied before the game activity was to assist the first-year-students in developing academic self-regulation [18]. In the case of the cardiac cycle topic, no oral explanation of the content was provided, since the objective was to develop the topic using the game, as an active teaching methodology. This approach was based on the presupposition that when the student discovers and actively tries to understand information, it is better understood and remembered [7], compared to an oral explanation about the same topic.

In the next stage, the groups received a link to access the digital version of the cardiac cycle puzzle [19, 20]. One of the students projected the game onto the screen and the positions of the tokens in the tables were determined following discussion. Afterwards, they answered open questions, using the Socrative application. When a group had doubts, the professor or monitors were called to the room, using a WhatsApp message, and assisted the students by means of questions. No direct answers were provided, in order to provide a

challenge and encourage reasoning and the integration of information and concepts [10]. The use of educational games is an example of the active methodology known as gamification, where serious games are developed for educational purposes, or game elements are used in teaching [21].

After correction of the answers for each group, the students were instructed to study the topics used for the evaluation performed in the next class. For individual study, an interactive lesson was provided on the ADInstruments Lt platform [4], which included text explanations, videos, and exercises with checking of the answers, so that the students could study and assess their learning, prior to the next class. The interactive lesson enabled the students to complement their textbook study, also providing a type of formative assessment.

Analysis of the learning process

In the next synchronous class, the test used before the activity with the educational game was applied again, so that the students could identify what they had learned from individual study and the group activity. The Google Forms platform was used, with the questions and alternatives of the same question being randomized. The students then individually watched a video with questions, on the Edpuzzle platform, involving the understanding of cardiac fibrillation and cardiac arrest. The tests were then marked, with discussion of the incorrect answers, so that the mistakes could be used to assist learning. In this activity, there was time for individual analysis, followed by another collective activity that permitted the exchange of experiences and knowledge concerning the topic.

In other synchronous class, by using the Socrative platform, the students were individually asked to analyze four situations describing changes in cardiac function, matching the description, type of alteration, and the mechanisms involved (bradycardia, tachycardia, myocardial infarction, and cardiac fibrillation). In order to compare the students´ learning in face-to-face with online teaching, the grade obtained in this individual test that was compared to the grades obtained by other students who had face-to-face teaching, in the year before. The situations and questions were the same. There was no significant difference in the scores obtained in this same individual test, by the students who had emergency remote (8.96 ± 0.30) and presential teaching (9.25 ± 0.21; $p > 0.05$) in the year before.

Just after, this individual test, students discussed the same situations and answer the same in their groups. The situations and the information to be matched were sent in a PowerPoint file, one student /virtual room opened the file and the group discussed the correct matches for completing the task. General correction was provided by the professor with all class.

These activities constituted summative assessments that enabled determination of the students' understanding of cardiac physiology, applying knowledge in practical situations presented in videos or in descriptions of clinical situations. These strategies avoided evaluation of the memorization of concepts or processes, instead enabling assessment of the students' understanding of them and their use. The assessments were short and were applied on different days and in different formats, in order to reduce the stress of the tests and avoid situations where a mistake in a test might compromise the performance of the student.

Students' perceptions

For analysis of the students' perceptions of the strategy, they were requested to answer the question: Did the use of different formative assessments alter, in any way, your mode of studying, the organization of your time, your interest in the topics studied, or any other aspect of your study routine? Out of the 44 students participating in the study, 42 answered "yes", and 2 answered "no". The last two students reported that they had maintained the same mode of studying. The main points mentioned by the students who answered "yes" were that they organized their study routine better, felt positive about the ability to identify what they knew or did not understand, and felt responsibility when preparing to help the group in the activities, as shown by the justifications transcribed below:

"Definitely! Performing the tests in the class, working as a team, generated discipline and encouraged responsibility, motivating me to always be informed about the content, so that I could contribute to my group and perform the tests."

"Yes, because as a result I didn't allow material to accumulate and I managed to accompany the classes without delay in study of the material. It changed my way of organizing time, and although I sometimes became tired, I believe that it is a good teaching technique."

In order to evaluate the opinions of the students regarding the influence of the teaching and assessment strategies on their preparation for the assessments this question was

answered: Did performing different activities and tests make you feel more prepared to for the assessments? All the participating students replied that they felt better prepared for the evaluations, indicating that the activities enabled them to identify what they knew or did not understand, and that reviewing the topics in different ways helped them to remember the content at the time of the assessments, as shown by the following answers:

"Yes, because with the different activities, I unconsciously studied a little every day, so I felt more secure in the final assessment, because the content had already been assimilated in various ways. For me, it worked very well."

"Yes, all these constant activities helped me at the time of the assessment, because their diversity made the content seem fresh and consolidated."

Concluding remarks

During emergency remote education implemented due to the COVID-19 pandemic, university professors faced new challenges, including low attendance and lack of attention of students during classes [22]. If the student is not induced to think critically about the material presented, with no perception of its relationship with future or daily professional activity, interest will be lost in the class, in studying, or in the proposed teaching activity [23]. In addition, it is essential that students should be able to perceive what they understand and what remains to be understood [14]. They should be encouraged to review their study routine, feeling secure in presenting their doubts, as well as be able to make mistakes without fear of judgment. In emergency remote education, new difficulties are related to the effort required to maintain attention on the screen of a device, often without interaction with colleagues or the professor, as well as common issues related to internet connections, equipment, suitable places for study, and family circumstances.

The present work describes adaptations in teaching practices, defined based on university pedagogy. The opinions of the students showed their belief that the teaching and assessment strategies used had positive effects on the organization of their study and in preparation for the learning assessments, indicating that engagement and learning had been achieved. The procedures used here assisted the students in assimilating theoretical conceptual knowledge, enabling them to become protagonists in their training by means of a shared process of educational co-responsibility involving professors and students.

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3 DISCUSSÃO

No ensino superior, para que os objetivos educacionais sejam alcançados, é necessário que os estudantes da área da saúde desenvolvam pensamento clínico e crítico, e habilidades para resolução de problemas, mais do que memorizem uma grande quantidade de informações (Prober e Norden, 2021; Nasre-Nasser et al., 2022). Neste sentido, vale destacar que muitas vezes o foco do professor está em "cobrir" o conteúdo da disciplina, fornecendo muitos detalhes que parecem relevantes, sem que haja tempo suficiente para que os alunos reflitam sobre os temas e organizem seu conhecimento e novas informações (Marcondes et al., 2021; Nasre-Nasser et al., 2022). Destaca-se, então, a importância da implementação de estratégias ativas de ensino, que promovam maior engajamento, participação, atenção e aprendizado.

Para que as estratégias ativas de ensino tenham efeitos positivos sobre o aprendizado, como comprovado nos estudos apresentados nos três capítulos (Cardozo et al., 2020a, 2021b), é necessário que os estudantes estejam engajados e que assumam a responsabilidade na construção do seu conhecimento, seja no ensino presencial ou remoto.

Neste contexto, as avaliações formativas devem fazer parte do processo ensino-aprendizagem, pois estas permitem ao aluno identificar o que está aprendendo, suas dúvidas e erros, e reorganizar sua forma de estudar. E, para o professor, as avaliações formativas permitem a análise do progresso dos estudantes ao longo do processo, e a revisão do planejamento e da condução das aulas e atividades (Kulasegaram e Rangachari, 2018; Kibble, 2019).

Para avaliar a eficácia da atividade com o jogo educacional, combinada com avaliações formativas, verificamos o aprendizado dos alunos, analisando o seu desempenho em testes após a atividade, comparado ao desempenho após aulas expositivas sobre o mesmo tema (Cardozo et al., 2016) e também temas diferentes (Cardozo et al., 2020a). O objetivo do primeiro artigo apresentado nesta tese não foi somente avaliar o aprendizado, do ponto de vista de desempenho, mas também avaliar o estresse e ansiedade antes de uma prova, sobre o assunto trabalhado com a estratégia ativa combinada com avaliações formativas, comparado à prova após aulas expositivas de outro tema, pois estes fatores podem comprometer o desempenho acadêmico do aluno (Cardozo et al., 2020a), bem como sua vida profissional futura (Downing et al., 2020).

Segundo Cooper et al. (2018) e Downing et al. (2020), a aprendizagem ativa afeta a ansiedade do aluno em sala de aula. Se o aluno se adapta às atividades e entende que elas podem melhorar seu aprendizado, ele pode ficar menos ansioso. Por outro lado, se o aluno não compreende os desafios propostos e o seu papel durante atividades com metodologias ativas ou não se sente preparado para as avaliações formativas, sua ansiedade pode aumentar, influenciando negativamente o seu aprendizado. Os resultados obtidos nesta tese, evidenciando o menor nível de ansiedade e estresse antes da prova, sugerem que, ao utilizar estratégias ativas combinadas com avaliações formativas, o aluno se sente mais seguro para a prova, sentindo-se mais calmo e confiante sobre o seu aprendizado (Cardozo et al., 2020a).

Um aspecto essencial da aprendizagem ativa é a oportunidade de colaboração e interação entre os estudantes, uma vez que atividades em pequenos grupos, possibilitam o desenvolvimento de habilidades para a resolução de problemas, comunicação, argumentação, colaboração trabalho em equipe. Além disso, a interação entre os membros do grupo e a discussão promovem integração, conexão social e o sentimento de pertencimento (Metz e Metz, 2021). Estas habilidades são melhor desenvolvidas quando os alunos percebem que compartilham objetivos semelhantes e quando sabem que os objetivos individuais dependem das ações do grupo (Herrmann, 2013).

Estas vantagens das atividades colaborativas podem ser evidenciadas com o uso do quebra-cabeça do ciclo cardíaco, utilizado nesta tese. Este jogo não é simplesmente uma gamificação, e não tem como objetivo a competição, mas apresenta regras muito bem delimitadas e o objetivo é o aprendizado. A atividade envolve atenção, análise visual, argumentação e criatividade, de modo que os alunos construam juntos o seu conhecimento, favorecendo a aprendizagem significativa (Cardozo et al., 2016). Por meio das interações interpessoais, os jogos educacionais também possibilitam o desenvolvimento de técnicas interpessoais, e desenvolvimento de senso de comunidade entre os estudantes (Kane et al., 2022).

Com a mudança abrupta do curso presencial para o ensino remoto, por conta da pandemia do COVID-19, os estudantes perderam a oportunidade de interagir presencialmente com os professores e colegas de turma. E os professores enfrentaram novos desafios, incluindo a baixa frequência e falta de atenção dos estudantes, a própria falta de experiência com tecnologias digitais na prática docente, e a necessidade de aprendê-las rapidamente. A partir destes obstáculos, houve a busca por estratégias ativas de ensino, que possibilitassem maior engajamento e participação dos alunos aumentou.

Neste ponto, é importante destacar que, apesar dos desafios apresentados no início da pandemia por COVID-19, para nós a adaptação para o ensino remoto foi relativamente rápida, pois já vínhamos trabalhando com ensino ativo, e a nossa preocupação na busca por estratégias digitais foi de continuar utilizando ferramentas que fossem úteis para o aprendizado dos alunos, e não apenas usar instrumentos sem objetivos definidos a priori.

Adaptar o quebra-cabeça do ciclo cardíaco para o formato digital foi uma das estratégias que usamos, buscando manter, no ensino remoto, a efetividade da dinâmica e do aprendizado que havíamos observado no ensino presencial (Cardozo et al., 2016, 2020a). E, para esta verificação, avaliamos a percepção discente, ou seja, perguntamos a opinião do aluno a respeito da estratégia utilizada, já que este tipo de avaliação também fornece indícios da eficácia no processo ensino-aprendizagem.

Neste contexto, a versão digital do quebra-cabeça do ciclo cardíaco foi usada em três cursos da área da saúde, de três universidades diferentes, e como apresentado no segundo artigo desta tese, na percepção dos alunos, o jogo foi útil para o aprendizado (Cardozo et al., 2021b). Além disso, no terceiro artigo aqui apresentado, descrevemos as adaptações para o ensino remoto, realizadas em uma sequência de atividades e avaliações formativas planejadas e desenvolvidas, com base em conceitos de pedagogia universitária. Neste estudo as opiniões dos alunos demonstraram que as estratégias de ensino e avaliações formativas tiveram um efeito positivo sobre o seu aprendizado, engajamento e organização do estudo (Cardozo et al., 2021a).

Avaliar a opinião dos alunos é uma importante ferramenta para identificar e compreender as estratégias de ensino que “estão funcionando” e aquelas que requerem ajustes. Solicitar e considerar a opinião dos alunos não significa aceitar todas as suas solicitações, mas entender o que funciona ou não em sala de aula, além de mostrar aos estudantes a importância de se utilizar e variar as estratégias ao longo da disciplina, bem como permitir que eles de fato participem do processo ensino-aprendizagem, incluindo o planejamento deste. Avaliar a percepção discente foi fundamental no ensino remoto, pois assim, conseguimos adaptar as diferentes estratégias ao longo do semestre.

Nos três estudos, que compuseram esta tese, a maioria dos participantes eram ingressantes, que passavam por um período de muitas mudanças e adaptações à vida acadêmica. Em sua percepção, eles indicaram que as metodologias ativas criaram um ambiente de aprendizado mais descontraído, possibilitaram que aprendessem com os colegas, nas atividades em grupo, e se organizassem melhor para estudar. Para melhor compreendermos os efeitos do

uso de metodologias ativas associadas a avaliações formativas, pretendemos, em estudos futuros, investigar “se” e “como” estes fatores de fato mudam a forma de estudar, o interesse e compromisso discentes, e poderiam favorecer melhor preparo, menor estresse e ansiedade antes de provas, bem como a adaptação à rotina universitária.

4 CONCLUSÃO

Os resultados obtidos nesta tese sugerem que a metodologia ativa, associando o uso de um jogo educacional com avaliações formativas, melhorou o aprendizado e promoveu mudanças positivas no comportamento dos alunos, no ensino presencial e remoto. Evidenciam também que, além da análise quantitativa do aprendizado, é importante que o professor utilize estratégias de ensino que façam o aluno se sentir mais motivado, engajado e perceba a necessidade de aprender sempre. E mostram que, para o professor, é crucial entender seus estudantes, avaliar a sobrecarga acadêmica, e disponibilizar diferentes estratégias de ensino e de avaliação, com o objetivo de otimizar o ambiente educacional e melhorar o aprendizado.

Como perspectiva futura, pretendemos investigar como os fatores relacionados ao uso das metodologias ativas de ensino aqui pontuados, de fato contribuem para o melhor aprendizado e redução de estresse e ansiedade antes de provas.

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ANEXOS

ANEXO 1 - Certificação dos Comitês de Ética

ANEXO 1A – Parecer do CEP FOP UNICAMP

Como o parecer tem 23 páginas, apresentamos aqui a 1ª, com identificação do projeto, e as últimas com a aprovação da última emenda pelo CEP - FOP. O título deste projeto aprovado pelo CEP e o mesmo título do auxílio pesquisa FAPESP, que compreende as análises realizadas no curso de Odontologia da FOP – UNICAMP.

UNICAMP - FACULDADE DE ODONTOLOGIA DE PIRACICABA DA UNIVERSIDADE DE CAMPINAS - FOP/UNICAMP

PARECER CONSUBSTANCIADO DO CEP

DADOS DA EMENDA

Título da Pesquisa: EFEITO DE JOGOS EDUCACIONAIS, USADOS COMO ESTRATÉGIAS ATIVAS DE ENSINO, SOBRE O APRENDIZADO, NÍVEL DE ESTRESSE E ANSIEDADE DE ALUNOS UNIVERSITÁRIOS

Pesquisador: Fernanda Klein Marcondes

Área Temática:

Versão: 4

CAAE: 10859119.0.0000.5418

Instituição Proponente: Faculdade de Odontologia de Piracicaba - Unicamp

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 4.119.365

Apresentação do Projeto:

Transcrição editada do conteúdo do registro do protocolo e dos arquivos anexados à Plataforma Brasil

Trata-se de SOLICITAÇÃO DE EMENDA (E1) ao protocolo originalmente aprovado em 25/04/2019 para ajustes na metodologia e, por conseqüência, ajustes no número de participantes, na FR, no cronograma e nos modelos de TCLE e TALE. A solicitação detalhada está descrita ao final do parecer.

A EQUIPE DE PESQUISADORES citada na capa do projeto de pesquisa inclui FERNANDA KLEIN MARCONDES (Bióloga, Docente do Departamento de Ciências Fisiológicas da FOP - UNICAMP, Pesquisadora responsável), LAÍS TONO CARDOZO (Bióloga, Doutoranda no PPG de Odontologia da FOP/UNICAMP, Pesquisadora participante), PATRÍCIA OLIVEIRA DE LIMA (Cirurgiã Dentista, Docente na Universidade Paulista (UNIP) e da Faculdade Anhanguera, Pesquisadora colaboradora no Departamento de Ciências Fisiológicas da FOP/UNICAMP, Pesquisadora participante) e MAELINE SANTOS MORAIS CARVALHO (Enfermeira, Doutoranda no PPG em Odontologia da FOP/UNICAMP, Pesquisadora participante), o que é confirmado na declaração dos pesquisadores e na PB.

Delineamento da pesquisa: Trata-se de estudo educacional com intervenção, longitudinal, que

e Biorrepositórios e para a necessidade de aplicação de novo TCLE quando da realização de novas pesquisas com o material estocado. RECOMENDAÇÃO 5- Pesquisas com dentes doados por profissionais de saúde ainda são toleradas em hipótese pelo CEP-FOP, mas os pesquisadores devem estar cientes de que esta solução dista do ideal ético de consulta direta ao participante por meio de TCLE específico da pesquisa ou da obtenção dos dentes a partir de um Biobanco de dentes e que estas últimas situações deveriam ser escolhidas em substituição à primeira. RECOMENDAÇÃO 6- Os pesquisadores devem manter os arquivos de fichas, termos, dados e amostras sob sua guarda por pelo menos 5 anos após o término da pesquisa.RECOMENDAÇÃO 7- Destaca-se que o parecer consubstanciado é o documento oficial de aprovação do sistema CEP/CONEP e os certificados emitidos pela secretaria do CEP-FOP, a pedido, após a aprovação final do protocolo, só têm valor simbólico e devem ser evitados. RECOMENDAÇÃO 8- Intercorrências eeventos adversosdevem ser relatados ao CEP-FOP por meio da PB. RECOMENDAÇÃO 9- Os pesquisadores devem encaminhar os resultados da pesquisa para publicação e divulgação, com devido crédito a todos que tenham colaborado com a realização da pesquisa. RECOMENDAÇÃO 10- O parecer do CEP-FOP é fortemente baseado nos textos do protocolo encaminhado pelos pesquisadores e pode conter inclusive trechos transcritos literalmente do projeto ou de outras partes do protocolo. Trata-se, ainda assim, de uma interpretação do protocolo. Caso algum trecho do parecer não corresponda ao que efetivamente foi proposto no protocolo,os pesquisadores devem se manifestar sobre esta discrepância. A não manifestação dos pesquisadores será interpretada como concordância com a fidedignidade do texto do parecer no tocante à proposta do protocolo.

Conclusões ou Pendências e Lista de Inadequações:

Não há mais pendências por resolver (vide texto acima) em relação à solicitação de emenda (E1) e em relação ao relatório parcial de atividades da pesquisa.

Considerações Finais a critério do CEP:

Parecer de aprovação de Emenda a protocolo emitido "ad referendum" conforme autorização do Colegiado na reunião de 19/02/2020. O parecer será submetido para homologação na reunião de 19/08/2020.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

UNICAMP - FACULDADE DE ODONTOLOGIA DE PIRACICABA DA UNIVERSIDADE DE CAMPINAS - FOP/UNICAMP

Continuação do Parecer: 4.119.365

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_1583454_E1.pdf	27/06/2020 03:16:38		Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE2corr.pdf	27/06/2020 03:16:13	Fernanda Klein Marcondes	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLEalunosPGcorr.pdf	27/06/2020 03:15:34	Fernanda Klein Marcondes	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLEprofessorescorr.pdf	27/06/2020 03:15:27	Fernanda Klein Marcondes	Aceito
Outros	2020relatorioparcialcorr.pdf	27/06/2020 03:15:10	Fernanda Klein Marcondes	Aceito
Outros	respostapendenciasE1.pdf	27/06/2020 03:14:39	Fernanda Klein Marcondes	Aceito
Projeto Detalhado / Brochura Investigador	projeto2.pdf	25/06/2020 18:06:04	Fernanda Klein Marcondes	Aceito
Folha de Rosto	folhaDeRosto2.pdf	25/06/2020 15:33:49	Fernanda Klein Marcondes	Aceito
Declaração de Instituição e Infraestrutura	declinstitcorrigida.pdf	24/04/2019 14:15:44	Fernanda Klein Marcondes	Aceito
Declaração de Pesquisadores	declpesquisadoras.pdf	02/04/2019 10:49:00	Fernanda Klein Marcondes	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

PIRACICABA, 28 de Junho de 2020

Assinado por:
jacks jorge junior
(Coordenador(a))

As análises realizadas nos cursos de Farmácia e Medicina da Universidade Federal de Ciências da Saúde de Porto Alegre (UFCSPA) e Universidade de Araraquara, respectivamente, fazem parte do projeto intitulado "Avaliação discente sobre o uso de metodologias ativas no ensino de fisiologia", com colaboração interinstitucional, que compreende as estratégias utilizadas em outros temas de fisiologia, além do sistema cardiovascular. Por isso, são apresentadas aqui a 1ª e últimas folhas dos respectivos pareceres de aprovação pelos CEPs institucionais.

ANEXO 1B – Parecer do CEP UFCSPA

UNIVERSIDADE FEDERAL DE CIÊNCIAS DA SAÚDE DE PORTO ALEGRE

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

Elaborado pela Instituição Coparticipante

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: AVALIAÇÃO DISCENTE SOBRE O USO DE METODOLOGIAS ATIVAS NO ENSINO DE FISIOLOGIA

Pesquisador: Fernanda Klein Marcondes

Área Temática:

Versão: 3

CAAE: 42980515.0.3002.5345

Instituição Proponente: Universidade Federal de Ciências da Saúde de Porto Alegre

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 4.640.011

Apresentação do Projeto:

Trata-se de análise de resposta ao parecer pendente n.4.593.543, emitido pelo CEP em 16/03/2021, conforme descrição a seguir.

1) Incluir Termo de anuência da PROGRAD da UFCSPA, necessária pela inclusão dos cursos de Toxicologia Analítica, Química Medicinal e Física Médica, na emenda do projeto. O documento, ao contrário do que foi informado na carta-resposta, não foi localizado na PB. Na resposta a esse parecer, informar claramente o nome do arquivo a ser analisado, que deve estar relacionado com o teor do documento, citando-o na carta-resposta, atendendo à pendência;

2) O relatório parcial, encaminhado corretamente no formulário da UFCSPA, deverá ser enviado para análise, via NOTIFICAÇÃO. Aproveitamos a oportunidade para que seja feito o correto preenchimento do formulário,pois no campo "RELACIONAR ABAIXO AS ATIVIDADES DESENVOLVIDAS ATÉ O MOMENTO", devem contar a descrição das atividades, conforme cronograma aprovado,ou, em caso de suspensão, devido a pandemia do COVID-19, deverá ser assim justificado, minimamente.

alunos para a participação no estudo.

Benefícios:Não haverá nenhum benefício direto aos alunos decorrente de sua participação na pesquisa, pois independentemente de participar ou não na pesquisa, a metodologia de ensino de que trata o presente estudo foi disponibilizada a todos os alunos que cursaram as disciplinas Biociências I e II.Indiretamente o benefício será o aprimoramento das metodologias de ensino utilizadas.

Comentários e Considerações sobre a Pesquisa:

Projeto em execução.foi anexada carta-resposta, através da qual foram encaminhados:

1)Termo de anuência da PROGRAD da UFCSPA;
2) O relatório parcial corrigido.

Demais considerações vide campo "Conclusões ou Pendências e Lista de Inadequações"

Considerações sobre os Termos de apresentação obrigatória:

Todos documentos apresentados.

Vide campo "Conclusões ou Pendências e Lista de Inadequações".

Recomendações:

Vide campo "Conclusões ou Pendências e Lista de Inadequações".

Conclusões ou Pendências e Lista de Inadequações:

Relatório parcial preenchido de forma completa. Entretando, a pesquisadora responsável deverá encaminhá-lo, conforme orientado no parecer anterior Nº 4.593.543, como NOTIFICAÇÃO, via Plataforma Brasil e não dentro dessa emenda.

Considerações Finais a critério do CEP:

De acordo com o parecer do Relator.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1681216.pdf	18/03/2021 14:17:59		Aceito
Outros	FORMULARIORELATORIOPARCIAL2021.pdf	18/03/2021 14:17:18	Fernanda Klein Marcondes	Aceito

Outros	AutorizacaoPROGRADUFCSPA.pdf	18/03/2021 14:16:55	Fernanda Klein Marcondes	Aceito
Outros	resppendenciasUFCSPA_18_03_2021.pdf	18/03/2021 14:16:27	Fernanda Klein Marcondes	Aceito
Outros	PARECERPB_FOP_CEP_E6_UFCSPA.pdf	15/01/2021 21:46:10	Fernanda Klein Marcondes	Aceito
Outros	Relatparcial_E6.pdf	11/12/2020 03:01:35	Fernanda Klein Marcondes	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	2020TCLE_E6.pdf	11/12/2020 03:01:10	Fernanda Klein Marcondes	Aceito
Projeto Detalhado / Brochura Investigador	2020PROJETOmetodologiasativasE6.pdf	11/12/2020 03:00:56	Fernanda Klein Marcondes	Aceito
Outros	2020EMENDA6.pdf	11/12/2020 03:00:41	Fernanda Klein Marcondes	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLEprofessores.pdf	07/07/2020 03:17:46	Fernanda Klein Marcondes	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLEmodeloUFCSPA.pdf	02/05/2019 11:40:45	Fernanda Klein Marcondes	Aceito
Outros	14_autorizcolegiadoUFCSPA.pdf	02/04/2019 09:17:39	Fernanda Klein Marcondes	Aceito
Outros	12_aceiteLuciliaUFCSPA.pdf	02/04/2019 09:16:51	Fernanda Klein Marcondes	Aceito
Outros	11_cartaconviteLucilaUFCSPA.pdf	02/04/2019 09:16:38	Fernanda Klein Marcondes	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	10_UEFS_TCLE.pdf	02/04/2019 09:14:50	Fernanda Klein Marcondes	Aceito
Outros	9_UEFS_autoriz_Colegiado.pdf	02/04/2019 09:14:39	Fernanda Klein Marcondes	Aceito
Outros	7_aceiteEricaUEFS.pdf	02/04/2019 09:14:13	Fernanda Klein Marcondes	Aceito
Outros	6_cartaconviteEricaUEFS.pdf	02/04/2019 09:13:43	Fernanda Klein Marcondes	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:

Não

PORTO ALEGRE, 09 de Abril de 2021

Assinado por:
Fernanda Bordignon Nunes
(Coordenador(a))

ANEXO 1C – Parecer do CEP UNIARA

UNIVERSIDADE DE ARARAQUARA - UNIARA

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Avaliação discente sobre o uso de metodologias ativas no ensino de fisiologia no curso de medicina

Pesquisador: Luis Henrique Montrezor

Área Temática:

Versão: 5

CAAE: 40019820.9.0000.5383

Instituição Proponente: ASSOCIACAO SAO BENTO DE ENSINO

Patrocinador Principal: Financiamento Próprio

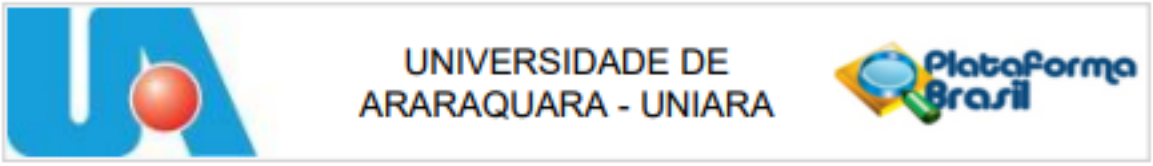
DADOS DO PARECER

Número do Parecer: 4.742.417

Apresentação do Projeto:

O pesquisador apresenta as seguintes informações sobre a pesquisa: Com o objetivo de verificar se há relação entre a opinião do aluno e seu desempenho acadêmico, será realizada análise de correlação entre as notas obtidas pelos alunos em testes realizados após as atividades com os jogos educacionais sobre contração muscular, sinapse e sistema nervoso autônomo, fisiologia renal, potencial de ação e ciclo cardíaco, debates, vídeos e portfólio sobre fisiologia dos sistemas endócrino e digestório, e a resposta indicada na questão sobre percepção discente. Esta questão consiste em solicitar aos alunos que indique, numa escala de 1 a 5, se a estratégia foi útil para o seu aprendizado, sendo 1 = não foi útil, e 5 = foi necessária para o meu aprendizado. Também é solicitado que o aluno justifique sua resposta.
A amostra total do estudo será de 1.000.

Com relação ao portfólio sobre Fisiologia do Sistema Endócrino e o jogo instrucional sobre contração muscular, sinapse e sistema nervoso autônomo, utilizados pela primeira vez em 2016, objetiva-se avaliar se houve alteração na proporção de erros e acertos nas questões de prova antes (2015) e após o uso destes recursos didáticos (2016 - 2018). Para esta análise, será solicitada autorização dos alunos para análise de suas respostas às questões de prova sobre os temas acima.



Considerações Finais a critério do CEP:

O Projeto de pesquisa encontra-se adequado e aprovado, de acordo com colegiado e com a normativas vigentes. Qualquer alteração que venha ocorrer, em especial Eventos Adversos, pedimos a gentileza de informar este CEP por meio de Emenda e/ou Notificação, junto a Plataforma Brasil e, no decorrer do desenvolvimento da pesquisa solicitamos o encaminhamento do Relatório Parcial, e após a conclusão do mesmo o envio do Relatório Final, procedimentos esses de cunho obrigatório.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

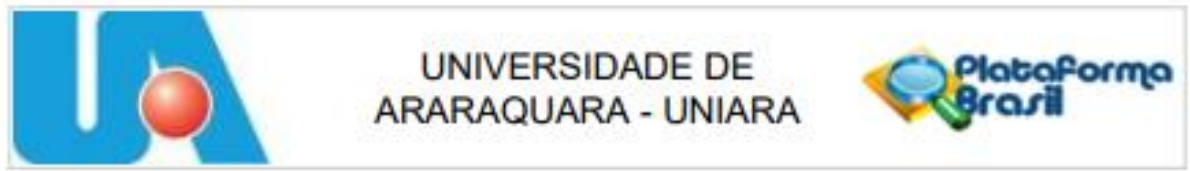
Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1658153.pdf	27/04/2021 18:12:49		Aceito
Projeto Detalhado / Brochura Investigador	Projeto.pdf	27/04/2021 18:11:56	Luis Henrique Montrezor	Aceito
Outros	RespostaParecerista4.docx	27/04/2021 18:09:49	Luis Henrique Montrezor	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE.docx	27/04/2021 18:09:12	Luis Henrique Montrezor	Aceito
Declaração de concordância	ConsentimentoInstitucional.pdf	06/11/2020 14:49:01	Luis Henrique Montrezor	Aceito
Folha de Rosto	Folhaderosto.pdf	06/11/2020 14:37:18	Luis Henrique Montrezor	Aceito
Declaração de Pesquisadores	TermoConcentimentoPesquisador.pdf	05/11/2020 13:53:05	Luis Henrique Montrezor	Aceito

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não



ARARAQUARA, 28 de Maio de 2021

Assinado por:

Adilson César Abreu Bernardi
(Coordenador(a))

ANEXO 2 - Autorizações para inclusão dos artigos publicados na tese

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ANEXO 3 - Verificação de originalidade e prevenção de plágio

Este relatório foi gerado na plataforma *Turnitin*, excluindo-se o texto dos 3 artigos já publicados e referências bibliográficas, trechos que são idênticos a arquivos publicados e disponíveis na internet.

CONTRIBUIÇÃO DE JOGO EDUCACIONAL ASSOCIADO A AVALIAÇÕES FORMATIVAS PARA O APRENDIZADO DE FISIOLOGIA CARDÍACA, NO ENSINO PRESENCIAL E REMOTO

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