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Effects of the use of different educational technologies in conceptual learning of the orofacial myofunctional system

Efeitos do uso de diferentes tecnologias educacionais na aprendizagem conceitual sobre o sistema miofuncional orofacial

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ABSTRACT

Purpose: Compare three learning methods on Anatomy and Physiology of the Orofacial Myofunctional System (OMS): two interactive methods with educational software and one traditional method, regarding the conceptual learning of Speech-Language and Hearing Sciences (SLHS) undergraduate students. **Methods:** Thirty-six students were randomly divided into three groups: Group 1 (G1) - 2D computer game-based method (n=12); Group 2 (G2) - 3D computational model method (n=12); Group 3 (G3) - traditional method (texts and 2D images) (n=12). The learning methods were applied during a complementary study schedule, for seven weeks, after a lecture. Knowledge assessments were conducted prior to the application of the learning methods, immediately after, and six months after completion; the performance of the groups at the three moments was compared. Data were analyzed in SPSS 21 software ($p \leq 0.005$). **Results:** Female individuals were predominant, with mean age of 22.0 (±4.7) years ($F_{2.33}=60.72$; $p=0.260$). The results show that only the pre-test differed from the short-term test in the G1, whereas the pre-test differed from the short- and the long-term tests in the G2 and G3. Regarding correlation between the performance of the groups and the moments of evaluation, it was observed that the results for the G1 were inferior ($F_{2.22}=722.30$; $p<0.001$). **Conclusion:** The 3D computational model was comparable to the traditional method for short- and long-term conceptual learning and knowledge retention, and both were more effective than the 2D computer game.

Keywords: Speech-language and hearing sciences; Anatomy; Physiology; Computer-assisted instruction; Learning

RESUMO

Objetivo: Comparar três métodos de aprendizagem sobre anatomia e fisiologia do sistema miofuncional orofacial, sendo dois interativos (uso de *softwares* educacionais) e um tradicional, quanto à aprendizagem conceitual de estudantes de graduação em Fonoaudiologia. **Métodos:** Participaram 36 estudantes do segundo ano, alocados randomicamente em grupos: Grupo 1 (G1) – método interativo com jogo computacional 2D (n=12); Grupo 2 (G2) – método interativo com modelo computacional 3D (n=12); Grupo 3 (G3) – método tradicional (textos e figuras 2D) (n=12). Os métodos de aprendizagem foram aplicados durante estudo complementar, por sete semanas, após aula expositiva. Foi realizada uma avaliação de conhecimento antes da aplicação dos métodos de aprendizagem, imediatamente após e seis meses depois da conclusão, e o desempenho dos grupos, nos três momentos, foi comparado. Os dados foram analisados no *software* SPSS, versão 21 (nível de significância de 5%). **Resultados:** Predominaram sujeitos do gênero feminino, com média de idade de 22,0 (±4,7) anos ($F_{2,33}=60,72$, p=0,260). Os resultados indicaram que, no G1, apenas o pré-teste diferiu do pós-teste, enquanto no G2 e no G3 o pré-teste diferiu do pós-teste e do pós-teste tardio. Ao verificar a interação entre o desempenho dos grupos e os momentos de avaliação, observou-se que os resultados do GI foram inferiores aos dos demais grupos ($F_{2,22}=722,30$ $p<0,001$). **Conclusão:** O uso de modelo computacional 3D foi comparável ao do método tradicional para a aprendizagem conceitual e retenção de conhecimento, em curto e longo prazo, sendo ambos mais eficazes do que o uso de jogo computacional 2D.

Palavras-chave: Fonoaudiologia; Anatomia; Fisiologia; Instrução por computador; Aprendizagem

Study carried out at Departamento de Fisioterapia, Fonoaudiologia e Terapia Ocupacional, Faculdade de Medicina, Universidade de São Paulo – USP – São Paulo (SP), Brasil

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Conflict of interests: No.

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INTRODUCTION

Researchers in the area of Computer-assisted Instruction (CAI) claim that computer technologies can transform learning through access to information, offering teachers and students the opportunity to collaborate with peers and experts, express and communicate ideas, and explore topics that, otherwise, would be more difficult to introduce and discuss in the classroom[1].

Studies have demonstrated that educational objects and environments that offer alternatives for the development of problem-oriented reasoning, considering the students' prior knowledge and their cognitive architecture, are more appropriate because they can reduce the cognitive demand for operational memory in the formalization of new knowledge and facilitate learning[2,3]. Computer games are an example of this type of learning object; they contain characteristics associated with contextualization and problem solving, offering students different possibilities of strategies to achieve their pre-established objectives[4].

For a computer game to contribute to learning, it has to provide students with feedback about their actions and contain issues whose complexity favors their learning process[5,6]. Cognitive skills such as memory, attention, critical thinking, and hypothesis preparation and confirmation, can be developed through the use of computer games during the learning process[7,8]. In addition, students can construct their knowledge in a more integrative way (knowing and acting) and have greater motivation to learn[4,9].

Currently, there is still no consensus on the effects of computer games on student performance in general; however, positive results have been observed in their application in higher education[4,10]. In Speech-Language and Hearing Sciences (SLHS), a previous study showed that the use of a computer game as a tool complementary to the teaching and learning process was as efficient as the traditional method of teaching regarding the short-term conceptual knowledge retention of students, and that the traditional method was more efficient for long-term knowledge retention[11]. A second study conducted by the same research group identified positive results regarding learning motivation, with better results for the use of a 3D computational model, followed by a 2D computer game, compared with the traditional learning method[12].

Although there is evidence that the use of computer games provides benefits to the training of students in the health area, there is urgent need for further studies addressing pre- and post-game use assessments in order to carefully analyze the results, with regards to learning, considering educational and clinical aspects, as well as the knowledge retention acquired or reinforced by means of this type of educational object[10].

In addition to the results presented in the specific literature on the use of CAI, studies have shown that the integration of computational simulators in teaching and learning contexts can facilitate the understanding of phenomena not observable in science[13] and make abstract concepts visible[14]. The use of visual aids can increase student conceptual knowledge and spatial ability, as well as facilitate the processing of complex data, providing the scientific process with more dynamism[13,14]. Examples of this type of tool include interactive laboratories and animations[1].

Positive effects of the use of educational animations have been observed with respect to development of thinking and reflection skills, understanding of the concepts studied, and student motivation for learning[13,14]. As the results of a recently published systematic review [1] indicate, in most of the studies analyzed, the use of different types of computer simulators, including animations, has been more effective than, or as effective as, the use of traditional teaching and learning methods.

Some recommendations on the use of animation for teaching and learning cited in the literature indicate that animations should (1) be used when complicated spatial structures and dynamic processes are involved; (2) be applied as a complement to other traditional teaching and learning tools or methods; (3) be integrated with verbal explanations; (4) be associated with the curriculum established for the teaching of a particular discipline or area; (5) present a significant contribution to the learning process and encourage collaboration between students[1,14,15].

Animations have been used in higher education in Health Sciences to increase undergraduates' understanding of processes, anatomy, and surgical techniques[16]. In SLHS, a study addressing the efficacy of software containing animations in 3D computer graphics, integrated with audio and video information for learning anatomy and physiology of phonation, reported a significant increase in students' conceptual knowledge[17]. In another survey in this area, the use of a 3D computational model, as a complement to a traditional teaching method in an anatomy discipline, proved to be more efficient for learning than the exclusive use of the traditional method[18].

Results of the few studies on the use of CAI in SLHS are positive, both for conceptual learning and training of clinical skills. However, further studies are still needed to confirm that learning through the use of simulators is comparable to traditional learning[12,18-20]. In this context, the present study aimed to apply and compare three learning methods on Anatomy and Physiology of the Orofacial Myofunctional System (OMS), in terms of conceptual learning and short- and long-term knowledge retention of the topics covered, in SLHS undergraduate students.

Based on the literature data presented, the hypothesis of this study was that conceptual learning and short- and long-term knowledge retention would be greater for students who participate in the interactive method using the 3D computational model and, secondly, for those who participate in the interactive method using the 2D computer game, when compared with each other and with the traditional learning method.

METHODS

This study was conducted with students of the Speech-Language and Hearing Sciences (SLHS) course at the School of Medicine of the University of Sao Paulo (FMUSP), in a formal discipline of the undergraduate course on Anatomy and Physiology of the Orofacial Myofunctional System (OMS), which included weekly teaching sessions and a study schedule developed in the classroom environment. All individuals enrolled in the academic year of the course were included in the study.

Selection and assessment criteria were conducted only after approval of the study project by the Research Ethics Committee of the aforementioned Institution (protocol no. 131/14) and signing of Informed Consent Forms (ICF) by the participants.

Inclusion criteria comprised having completed the basic disciplines of anatomy and human physiology (foreseen in the compulsory curriculum of the undergraduate course in SLHS of FMUSP for the freshman year - 1st and 2nd terms) and being proficient in reading comprehension in English, confirmed by the students' performance on the university entrance exams.

The study sample was composed of 36 students randomly divided into three groups: Group 1 (G1) – 12 students who participated in the interactive method 1, using a 2D computer game; Group 2 (G2) – 12 students who participated in the interactive method 2, using a 3D computational model; Group 3 (G3) – 12 students who participated in the traditional method, using summarized scientific texts associated with 2D images.

Interactive method 1 consisted of the use of a quiz game integrated with the Anatesse 2.0[21] software, which covers topics on anatomy and physiology of the OMS. Figure 1 illustrates a part of this game.

This software was used by the students during a complementary study schedule. To this end, students were allocated in pairs or trios, according to their choice, and used a desktop personal computer (PC) for the supplementary study. On the first day of class, a brief tutorial was presented to instruct students on how to use the software. The topics selected for the supplementary study, each week, were related to themes addressed in each lecture taught in the formal discipline.

The interactive computer game comprises multiple-choice questions illustrated by static images and 2D animations. The students received feedback on the PC screen for each responded question. A picture with a happy green face was shown for the correct responses, whereas a picture with a sad red face was shown for the incorrect answers. The total percentage score was provided at the end of each section of the game.

Each part of the referred game was played twice; however, in the second attempt, after the students' responses were finalized, the correct answer to each question was provided automatically to reinforce performance feedback and broaden content learning possibilities.

Interactive method 2 included the use of the Primal Pictures[22] software, which features topics on Anatomy and Physiology in a 3D computer graphics model. Figure 2 illustrates a part of this computational model.

This software was used by the students during a complementary study schedule. To this end, students were allocated in pairs or trios, according to their choice, and used a desktop PC, with Internet access, for the supplementary study. On the first day of class, students were instructed as in the interactive method 1.

Primal Pictures[22] software is a computational model comprising images associated with brief explanatory texts, 3D animations and graphics videos, slides with summarized integrated texts, and a dynamic 3D human anatomy model. It is divided into areas of domain, including titles according to medical specialties and other areas of health. The following parts of this software were used in the present study:

1. *Speech-Language Pathology*: an area specifically designed for SLHS composed of images associated with brief explanatory texts, 3D graphics videos, and slides with brief integrated texts. Images and 3D animations of Anatomy and Physiology of the OMS were used in this study. Using the resources of this software, students could change the visualization of static images to the side they would like to visualize. They could also resume and forward the animation and video sequences according to the time and number of times they deemed necessary, in addition to including notes and markings for later study. These contents were available in English;
2. *Interactive learning activities for Speech-language Pathology*: this feature of the Primal Pictures tool contains review topics and a quiz game with multiple-choice questions on each of the selected study items. Each week, during the last 15 minutes of the supplementary study time, the students in the G2 reviewed their studies and answered the quiz questions. They received feedback on their performance on the PC screen as follows:

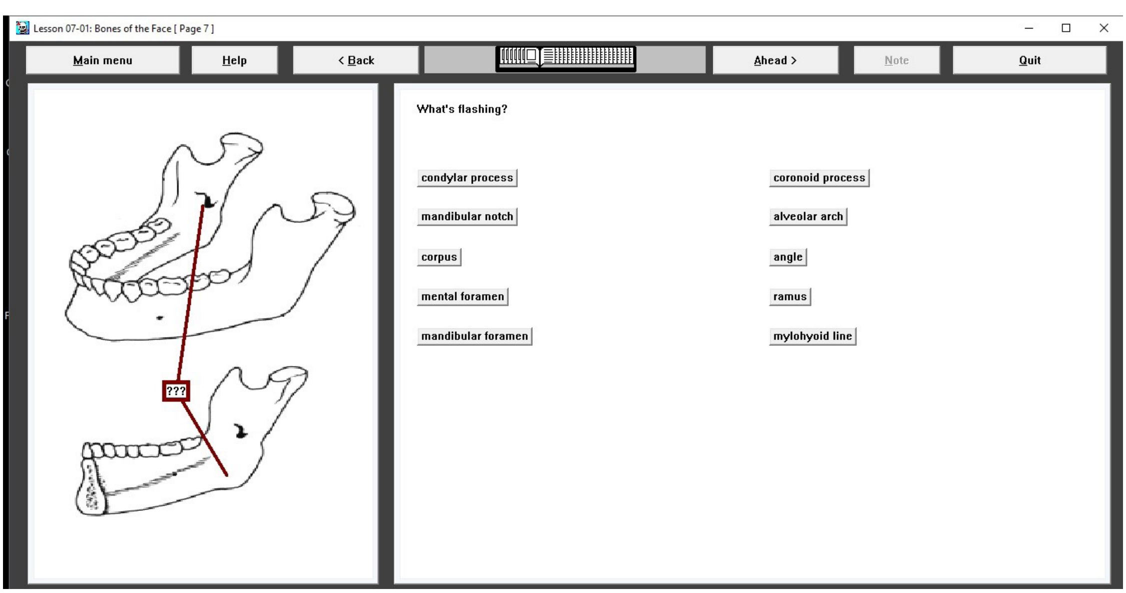

Figure 1. Anatesse 2.0 software – quiz image

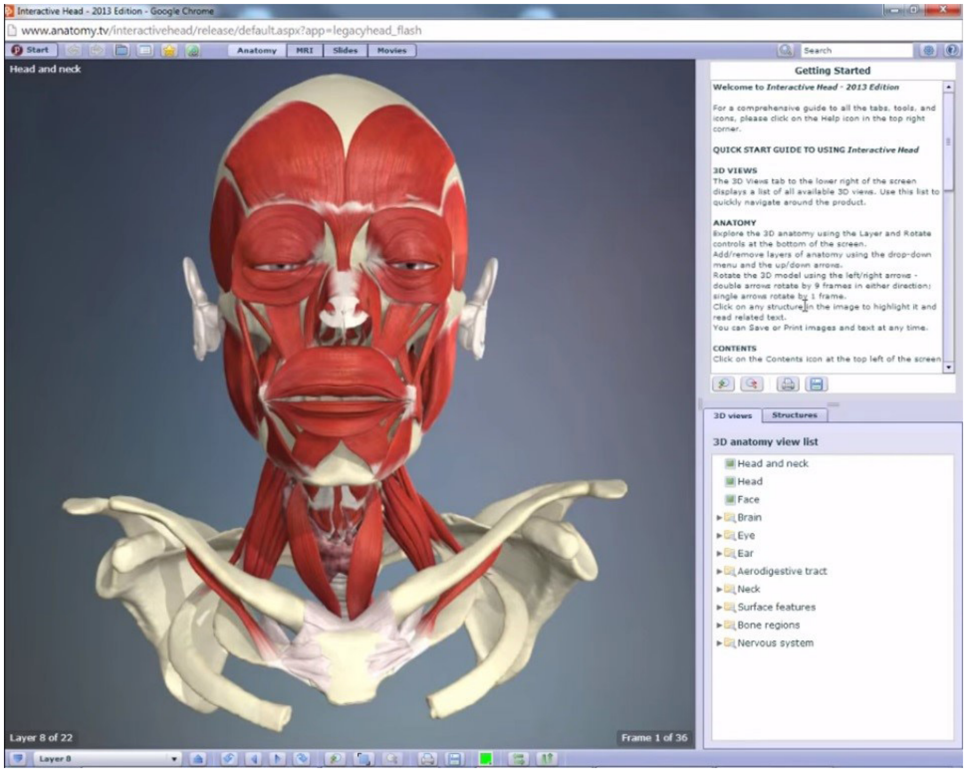

Figure 2. Primal Pictures software – 3D computational model image

First, a text box appeared on-screen informing whether the response provided was correct. Next, the correct response was shown (in both situations) to reinforce performance feedback and broaden content learning possibilities. Finally, at the end of each game stage, the final percentage score was displayed on the screen. The contents of this section were available in English.

The traditional method comprised the use of summarized scientific texts associated with relevant 2D static images of Anatomy and Physiology of the OMS, during the complementary study schedule. The students were told to study the way they usually do - individually, in pairs, or in trios in the classroom. The topics selected for the supplementary study each week were related to themes addressed in each lecture taught in the formal discipline.

The learning methods were applied for seven weeks, which is the total length of the formal discipline. The lectures for both groups lasted three hours, and the supplementary study lasted an hour. The same topics were selected for all groups. Each group was assigned a tutor who accompanied them during their supplementary study schedule.

Aiming to assess the students' knowledge about the topics covered in the formal discipline and reinforced in the interactive and traditional learning methods, as well as to compare the performance between the groups, a knowledge assessment was conducted by means of a specific questionnaire composed of 50 multiple-choice questions (with four alternatives each) specifically designed for use in a previous study[11], considering that there were no standardized and validated evaluations on the themes in the learning methods for SLHS (Annex A).

This questionnaire was applied at three moments: prior to the application of the proposed learning methods (pre-test - previous knowledge assessment), immediately after application (short-term test - evaluation of immediate knowledge retention), and six months after completion of the methods (long-term test - assessment of late knowledge retention). The three groups of students were compared with respect to their performance in the knowledge assessment, at the three moments of the questionnaire application, and the total number of correct responses was considered for data analysis. The students' performance in the knowledge assessment was considered as part of their final grade in the formal discipline.

Collected data were submitted to statistical analysis using the SPSS 21 software. Descriptive analysis was performed according to the mean, standard deviation, minimum, maximum, median, and quartiles for the conceptual test score. One-way Analysis of Variance (One-way ANOVA) was used to compare groups; Repeated measures ANOVA with one factor was applied to compare the moments of conceptual evaluation; Repeated measures ANOVA with two factors was used to verify the correlation between the conceptual evaluation moment and the groups. The Bonferroni *post hoc* test was used for multiple comparisons. A significance level of 5% ($p \leq 0.005$) was adopted for all statistical analyses.

RESULTS

The study sample was composed of 36 students randomly selected and assigned to one of three groups, as shown in Figure 3. Females were predominant in all of the groups, and there was only one male in G1 (Table 1). Mean age of the study participants was 22.0 (±4.7) years, and no statistically significant difference was observed between ages in the groups ($F_{2,33}$=60.72; p=0.260) (Table 2).

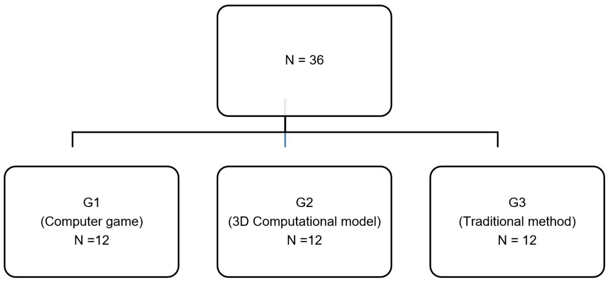

Figure 3. Data distribution of the study participants

Knowledge assessment: descriptive analysis

In all groups, the lowest score occurred in the pre-test, whereas the highest score, per group, was obtained in the long-term test in G1, in the short- and long-term tests in G2, and in the short-term test in G3 (Table 3).

Knowledge assessment: performance comparison of the three groups at each evaluation time

No statistically significant difference was found in the comparison between the groups at each test moment (Figure 4).

Knowledge assessment: performance comparison of each group at the three evaluation moments

In all groups, statistically significant difference was observed between the moments of conceptual evaluation. Results of the Bonferroni *post hoc* test indicated that only the pre-test differed from the short-term test in G1, whereas the pre-test differed from the short- and long-term tests in G2 and G3 (Figure 5).

Table 1. Distribution of gender frequency by group

Group	Gender				Total
	Male		Female		
	n	%	n	%	
G1	0	0.0	12	100.0	12
G2	1	8.3	11	91.7	12
G3	2	16.7	10	83.3	12
General	3	8.3	33	91.7	36

n = number of participants according to gender

Table 2. Descriptive statistics regarding age

Group	Mean	Standard deviation	Minimum	Maximum	Median	1st quartile	3rd quartile
G1	23.2	6.8	18	41	20.5	19.0	26.8
G2	20.2	1.5	18	23	20.0	19.0	21.5
G3	22.6	4.1	18	31	21.5	20.0	24.8
General	22.0	4.7	18	41	20.0	19.0	23.0

Table 3. Descriptive statistics of performance by group in the conceptual knowledge assessment at each assessment moment

Group	Moment	Mean	Standard deviation	Minimum	Maximum	Median	1st quartile	3rd quartile
G1	Pre-test	29.08	4.078	22	38	29.00	26.75	30.00
	Short-term test	33.17	3.786	25	38	34.00	30.25	36.00
	Long-term test	33.67	4.905	26	40	33.50	29.25	38.50
G2	Pre-test	27.67	2.934	23	33	27.00	26.00	29.00
	Short-term test	34.75	3.049	28	39	34.50	33.25	37.75
	Long-term test	32.92	3.147	27	39	32.50	31.25	34.75
G3	Pre-test	29.00	3.438	24	35	28.50	26.25	32.25
	Short-term test	36.17	3.040	32	41	36.00	33.25	39.00
	Long-term test	32.67	4.271	25	40	34.00	29.25	35.75

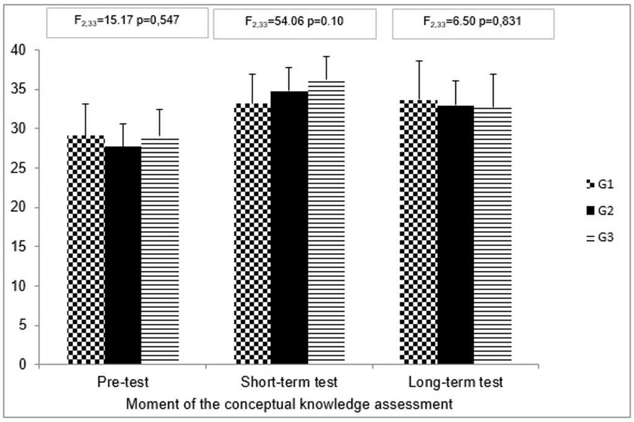

Figure 4. Comparison between the mean score of the groups at each moment of the conceptual knowledge assessment

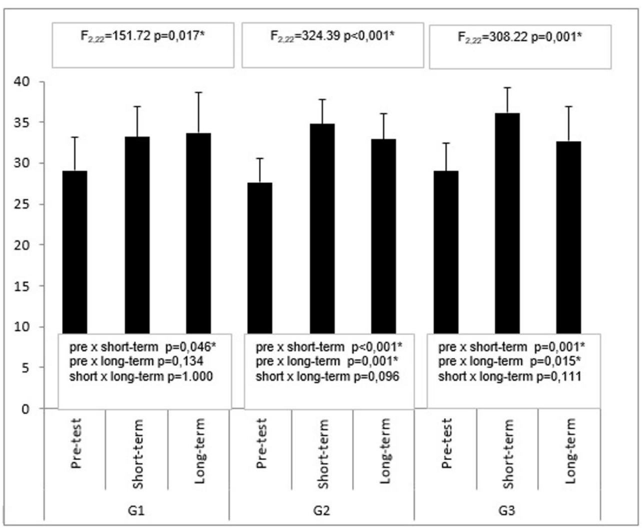

Figure 5. Comparison between the mean score at each moment of the conceptual knowledge assessment by group *= $p<0.05$ – statistically significant

Conceptual knowledge test: correlation between performance of the groups and the three moments of conceptual evaluation

Verification of the correlation between performance of the groups and the moments of conceptual evaluation showed no statistically significant effect of the assessment moment ($F_{2,22}$=13.68 *p*=0.774), but an statistically significant effect was observed for the groups, with the worst performance observed in G1 ($F_{2,22}$=722.30; $p<0.001$); however, no significant correlation was found between the assessment time and the group ($F_{4,44}$=62.04; *p*=0.326).

DISCUSSION

In the present study, three learning methods on Anatomy and Physiology of the Orofacial Myofunctional System (OMS) were applied and compared, namely, an interactive method using a 2D computer game; an interactive method using a 3D computational model; a traditional method using summarized scientific texts associated with 2D static images regarding conceptual learning and knowledge retention of Speech-Language and Hearing Sciences (SLHS) undergraduate students on the theme.

Results of the comparisons between the groups, at each evaluation time, showed that the students' performance in the knowledge assessment was similar, regardless of the learning method applied. Analysis of the students' performance in the knowledge assessment, comparing the three moments of evaluation for each group, revealed that the three learning methods showed positive results for short-term knowledge retention, corroborating the findings of previous studies that identified similar results in knowledge retention immediately after application of both computer games and computational models/simulators, as well as in traditional learning methods[1,11,23,24].

No statistically significant difference between the groups was found in the comparison between the results of the short- and long-term tests. However, when comparing the results of the pre-test with those of the long-term test, it was possible to observe that the application of the 3D computational model produced results similar to those obtained with the use of the traditional method, and that both of them were more effective than the application of the computer game, along the learning process analyzed. Although different studies have demonstrated that the use of computer games can improve motivation for learning and knowledge retention (especially in the short term)[4,11,24], it is necessary to consider that there are situations in which students are still more comfortable using printed texts to study because, during the reading activities, they are able to pause, summarize, and resume the ideas presented, whereas with the use of computer games there may have other distractions[25].

Results of a previous survey showed that the use of a 2D computer game was more effective for the short-term knowledge retention on topics associated with Anatomy of the OMS, but the traditional learning method applied was more effective concerning retention of general knowledge both in the short and long terms[11]. In a recent study conducted in the area of Medicine using a 3D simulator for learning, medical residents reported that the use of this tool was better for understanding the topics related to anatomy, but that they still felt more comfortable using traditional methods for the activities more closely associated with practice and future surgical procedures[26].

As for the use of simulators for learning, including 3D animations, positive effects have been observed regarding the development of thinking and reflective skills, the understanding of the concepts studied, and student motivation for learning[13,14]. A study in the field of Veterinary Medicine demonstrated that students who used 3D animations for learning about functional anatomy were able to detail a certain type of lesion in dogs more completely than those who used materials containing non-animated illustrations on the theme[16]. In the field of SLHS, a study conducted to evaluate the efficacy of software containing 3D animations on Anatomy and Physiology of Phonation observed a significant increase in the students' conceptual knowledge after its application[17]. Most studies in the literature have shown that the use of different types of computer simulators has been more effective than the use of traditional teaching and learning methods (lectures, text-based activities, or practical physical activities), or as effective as the use of these methods[1], corroborating the findings of the present survey.

In the correlation between group and moment of evaluation, it was observed that the computer game proved to be less appropriate for the conceptual learning of students compared with the other methods. A justification for this result may be associated with a possible cognitive overload generated during the interaction of students with the computer game, since in this proposal it was necessary that the students, first, responded to questions of the game about the topics addressed in class, and only then verified the correct answers in order to review the concepts learned and identify their weak points in the learning process. A previous study identified similar results regarding satisfaction after the use of a computer game for learning, and evidenced that the novelty of the subject and used tool generated a high intrinsic cognitive load, requiring great mental effort to solve the presented questions and a learning experience considered superficial(6). It should be considered that, while using an interactive learning tool such as a 2D computer game, most students need to invest additional effort and employ self-control strategies to pay attention to the learning tasks; they must also overcome different types of distractions that may occur, increasing cognitive demand, and reducing gains in terms of learning(27).

Another aspect to be discussed is associated with the possibilities of manipulation of educational objects by students, within the educational methods proposed in the present study. Regarding the 2D computer game, although the feedback to the answers given by the students during its use was provided immediately after the choice of each response to the questions presented, their order was determined by the software, and it was not possible for the students to return and review the contents and their answers in the order they wanted. As for the proposals of the 3D computational model (images, 3D animations, and texts) and the traditional method (texts and 2D images), it was possible for the students to revise the information studied as they deemed necessary, having greater freedom in the organization of their studies, which may have influenced the better results obtained during the learning process by individuals in the G2 and G3. According to the literature, the greater possibility of manipulation of learning tools is related to the greater time students spend studying, the greater ease to pay attention to the learning tasks, and the greater engagement, which would consequently be associated with better results in performance assessments(28).

Teaching and learning methods that contemplate the use of computer games and computational models need to be expanded, better controlled, and improved, especially in relation to the methods of assessing student knowledge retention(9,23) and the transfer of knowledge to clinical practice situations(29). This study brings an initiative to improve knowledge related to conceptual learning, through interactive methods in SLHS teaching, considering that there is still little research in the area addressing this theme(11,12,18,30). Further studies addressing other aspects that interfere with computer-assisted instruction (CAI), such as cognitive effort and time exposure to proposed educational methods, need to be conducted.

CONCLUSION

The use of a 3D computational model was comparable to that of a traditional method for short- and long-term conceptual learning and knowledge retention, and both methods were more effective than the use of a 2D computer game throughout the learning process on the Orofacial Myofunctional System of Speech-Language and Hearing Sciences undergraduate students. The methodology used, as well as the results presented, can contribute to the implementation and assessment of new proposals for application of interactive learning methods during higher education in Speech-Language and Hearing Sciences.

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Annex A. Assessment of knowledge

Individual no.: Date:
Respond to the questions ahead choosing only one alternative for each item.

1. This is a structure of the nervous system extremely important for the coordination of movement, including movement of the muscles involved in the functions of chewing, swallowing, and speaking:
a) hypothalamus
b) thalamus
c) basal ganglia
d) cerebellum

2. Lesions in this structure can cause movement deficits, including changes in speech:
a) hypothalamus
b) thalamus
c) basal ganglia
d) cerebellum

3. Choose the correct sequence of activation of each of the different structures responsible for the neural processing of speech:
a) premotor cortex, motor cortex (supplemental motor area), prefrontal cortex, bulbar and retroambiguous nuclei, basal ganglia, cerebellum, vagus nerve
a)b) prefrontal cortex, motor cortex (supplemental motor area), premotor cortex, bulbar and retroambiguous nuclei, basal ganglia, cerebellum, vagus nerve
c) prefrontal cortex, premotor cortex, motor cortex (supplemental motor area), primary motor cortex, bulbar and retroambiguous nuclei, basal ganglia, cerebellum, vagus nerve
d) premotor cortex, primary motor cortex, motor cortex (supplemental motor area), primary motor cortex, basal ganglia, cerebellum, vagus nerve

4. This is the process through which speech sounds are divided into syllables:
a) vibration of vocal folds in the larynx
b) articulation
c) resonance
d) rhythm

5. These are mobile articulators of the stomatognathic system that participate in speech production:
a) maxilla, mandible, teeth, tongue, and lips
b) mandible, tongue, soft palate, and hard palate
c) tongue, mandible, soft palate, lips, and pharynx
d) tongue, mandible, soft palate, and lips

6. Choose the nerve responsible for the motor innervation of the face:
a) glossopharyngeal IX
b) facial VII
c) trigeminal V
d) vagus X

7. These muscles are innervated by the facial nerve (VII paired cranial):
a) orbicularis oris, mentalis, buccinator, and masseter
b) mentalis, buccinator, risorius, and digastric
c) buccinator, medial pterygoid, lateral pterygoid, and risorius
d) orbicularis of the mouth, mentalis, buccinator, and risorius
8. Which nerve is responsible for innervation of the muscles of mastication and sensations of the face?
a) glossopharyngeal IX
b) trigeminal V
c) facial VII
d) vagus X

9. These muscles are innervated by the trigeminal nerve (V paired cranial):
a) masseter, temporalis, mylohyoid, medial pterygoid, digastric
b) medial pterygoid, lateral pterygoid, milo-hyoid, digastric
c) masseter, temporalis, medial pterygoid, mylohyoid, lateral pterygoid
d) masseter, temporalis, medial pterygoid, lateral pterygoid, mylohyoid, digastric

10. Which nerves are associated with innervation of the following muscles: palatoglossus, palatopharyngeus, levator veli palatini, tensor veli palatini, musculus uvulae?
a) glossopharyngeal, facial, hypoglossal, vagus
b) glossopharyngeal,, vagus, accessory
c) trigeminal, hypoglossal, vagus, accessory
d) glossopharyngeal, hypoglossal, vagus, accessory

11. Which nerve is responsible for motor activation of the tongue muscles?
a) trigeminal V
b) vagus X
c) accessory XI
d) hypoglossal XII

12. Which nerve is responsible for innervation of the intrinsic muscles of the larynx?
a) trigeminal V
b) hypoglossal XII
c) vagus X
d) accessory XI

13. Which of these nerves transmits auditory information?
a) glossopharyngeal IX
b) trigeminal V
c) vestibulocochlear VIII
d) vagus X

14. Which of these nerves transmits information about the position of the head in space?
a) trigeminal V
b) vagus X
c) vestibulocochlear VIII (auditory branch)
d) vestibulocochlear VIII (vestibular branch)

15. Choose the alternative that correctly designates the bones of the skull:
a) temporal, occipital, zygomatic, vomer
b) temporal, frontal, occipital, maxilla
c) temporal, frontal, occipital, parietal
d) occipital, zygomatic, frontal, parietal

16. Choose the alternative that correctly designates the bones of the face:
a) frontal, maxilla, zygomatic, vomer
b) maxilla, mandible, zygomatic, nasal
c) frontal, maxilla, nasal, vomer
d) frontal, maxilla, mandible, nasal

17. Choose the correct alternative about the structures that compose the mandible:
a) The mental symphysis is the fusion point between the two halves of the mandible
b) The mental foramen is the hole through which the mentual branch of the trigeminal nerve (V paired cranial) passes
c) The gonial angle is the structure that articulates with the temporal bone to form the temporomandibular joint
d) The mandibular branch is the flat portion that originates from the gonial angle

18. What is the bone of the face formed by a pair of bones that compose most of the "roof" of the oral cavity - hard palate, nose, and upper arch?
a) maxilla
b) mandible
c) frontal
d) zygomatic

19. What is the main function of the hyoid bone?
a) move the larynx
b) serve as a base for the muscles of the tongue
c) provide support for the laryngeal cartilage
d) anchor the cricoid cartilage

20. Choose the correct alternative regarding the cartilages of the larynx:
a) the epiglottis, thyroid, and arytenoid cartilages are odd, and all other cartilages are even
b) the cricoid cartilage is located in the uppermost portion of the larynx, and constitutes its most stable part c) the epiglottis cartilage plays an extremely important role in the protection of the airways
d) the arytenoid cartilage is odd, its shape resembles that of a pyramid, and has an important participation during the opening and closing of the vocal folds

21. What muscles are responsible for the elevation of the mandible?
a) masseter and temporalis
b) temporal, masseter, and medial pterygoid
c) masseter and lateral pterygoid
d) temporal, masseter, and lateral pterygoid

22. Which of the following are not functions of the suprahyoid muscles?
a) Lowering the larynx, hyoid and floor of the mouth, in addition to fixing the hyoid
b) Lowering and retracting the mandible
c) Elevating the larynx and moving it forward or backward
d) Antagonizing with the chewing muscles, though collaborating in mastication

23. Choose the correct alternative with respect to the muscles of the tongue:
a) the palatoglossus and styloglossus (extrinsic) and longitudinal (intrinsic) muscles are responsible for tongue elevation
b) the superior longitudinal muscle elevates the apex of the tongue, the inferior longitudinal muscle lowers the apex of the tongue, both shorten the tongue
c) the transverse muscle lengthens and narrows the tongue
d) the hyoglossus does not participate in the lowering of the tongue

24. All of the following are palatine muscles, except:
a) tensor veli palatini
b) levator veli palatini
c) hypoglossus
d) palatopharyngeus

25. The soft palate (or palatine veil) is the roof of the:
a) oropharynx
b) nasopharynx
c) laryngopharynx
d) larynx

26. Which of the following corresponds to the posterior cavity of the vocal tract, shaped like tube, that is approximately 12 cm long in adults, and can have its diameter reduced by the constricting muscles?
a) esophagus
b) trachea
c) pharynx
d) larynx

27. Which of these muscles does not participate in the elevation of the mandible?
a) masseter
b) temporalis
c) medial pterygoid
d) lateral pterygoid

28. Choose the incorrect alternative with regards to suction:
a) a vital phenomenon for newborns, influences the growth and adequate development of the craniofacial complex structures
b) is very important in the proper functioning of the other stomatognathic system functions
c) its complete development occurs at the 32nd week of gestation and the coordination between sucking, breathing, and swallowing occurs after the 34th week of gestation
d) it is a reflex of humans that begins in the 4th month of intrauterine life, and is visible as of the 30th week of gestation

29. In order for newborns to feed, coordination between some functions is necessary, except for the function of:
a) respiration
b) phonation
c) deglutition
d) suction

30. Choose the incorrect alternative regarding suction in newborns:
a) position of the larynx is higher compared with that of adults
b) deglutition is performed every 3 to 4 suctions
c) triggered by means of reflexes
d) coordinated with breathing and swallowing during breastfeeding

31. Concerning deglution, it is incorrcet to state that:
a) it is a basic, complex and coordinated biological function
b) it is reflex until the 4th month of life and based on neuromuscular action of the food bolus propelling from the oral cavity to the stomach
c) it begins around the second trimester, 12th week of intrauterine life, and is coordinated with suction as of the 34th week of intrauterine life
d) it remains normal until the beginning of old age

32. Which structure moves downward, covering the larynx, during the Pharyngeal Phase of swallowing?
a) larynx
b) epiglottis
c) tongue
d) soft palate

33. Which structures close (adduction) during the Pharyngeal Phase of swallowing, protecting the lower airways?
a) soft palate and uvula
b) tongue and soft palate
c) vocal folds
d) vestibular folds

34. This structure promotes closure of the esophagus before deglutition, as well as its opening, so that swallowing occurs and food transits through the esophagus to the stomach:
a) upper esophageal sphincter
b) lower esophageal sphincter
c) epiglottis
d) vocal folds

35. This structure does not allow food to return from the stomach into the esophagus:
a) epiglottis
b) vocal folds
c) upper esophageal sphincter
d) lower esophageal sphincter

36. Which of the following statements does not refer to the adult swallowing pattern (which begins between 12 and 15 months of life)?
a) stability of the tongue is propitiated mainly by the mandible, which is stabilized by the action of the masticatory muscles
b) contraction of the facial muscles to stabilize the mandible
c) maturation of the neuromuscular elements and appearance of the upright posture of the head
d) anterosuperior movement of the hyoid bone and larynx

37. Which of the alternatives indicates the correct order of the occurrence of events in the Oral Phase of swallowing?
a) food hold, anteroposterior tongue movement leading the bolus to the pharynx region
b) mastication, centralization of food on the back of the tongue, and anteroposterior movement of the tongue leading the bolus to the region of the pharynx
c) food hold, mastication, centralization of food on the back of the tongue, and anteroposterior movement of the tongue leading the bolus to the region of the pharynx
d) food hold, centralization of food on the back of the tongue, mastication and anteroposterior movement of the tongue leading the bolus to the region of the pharynx

38. Which of the following events does not occur during the Pharyngeal Phase of swallowing?
a) elevation of the hyoid bone, elevation and anteriorization of the larynx, and contraction of the aryepiglottic folds with closure of the vestibular and vocal folds
b) closure of the velopharyngeal sphincter to avoid nasal reflux
c) lowering of the epiglottis by the contraction of the aryepiglottic folds and the weight of the food
d) relaxation of the pharyngoesophageal transition (upper esophageal sphincter)

39. Which of the following events does not occur during the Esophageal Phase of swallowing?
a) onset of contraction movements of the pharynx with propelling of the food bolus towards the esophagus
b) transit of food into the esophagus
c) relaxation of the pharyngoesophageal transition (upper esophageal sphincter)
d) the cricopharyngeal muscle contracts, the larynx and soft palate descend, and breathing is resumed

40. Which of the following structures are involved in the deglutition function?
a) cortex and brain stem
b) cortex and peripheral nerves
c) cortex, brain stem, and peripheral nerves
d) brain stem and peripheral nerves

41. Choose the correct alternative regarding the occurrence of changes in the different phases of swallowing:
a) gastro-esophageal reflux may occur during the pharyngeal phase of swallowing
b) nasal regurgitation occurs in the pharyngeal phase of deglutition
c) tracheal aspiration may occur in the esophageal phase of swallowing
d) masticatory muscle flaccidity is a change that occurs the pharyngeal phase of deglutition

42. Concerning mastication, which alternative is incorrect:
a) it is one of the most important functions of the stomatognathic system
b) it is essential for prevention of myofunctional disorders: it will continue the stimulation of the orofacial muscles initiated by suction
c) it involves neuromuscular and digestive activities
d) it is not a part of the digestive process

43. Choose the alternative that does not correspond to the chewing function:
a) promote adequate strength and function for the development of the maxillary bones
b) fragment the food into smaller particles, which will be mixed and bound through the action of saliva
c) promote strength and function to the laryngeal muscles
d) maintenance of the dental arches and stabilization of occlusion (periodontium, muscles, and articulation)

44. Chewing is based on reflexes conditioned and guided by proprioceptors. Choose the alternative that shows where these proprioceptors are located:
a) oral mucosa, tongue, TMJ, larynx, and epiglottis
b) oral mucosa, periodontal membrane, masticatory muscles, TMJ, and pharynx
c) oral mucosa, periodontal membrane, masticatory muscles, tongue, and TMJ
d) oral mucosa, periodontal membrane, masticatory muscles, tongue, and epiglottis

45. Regarding the phases of mastication, it is incorrect to state that:
a) during incision, there is decreased intensity of muscle contraction elevating the mandible, which will determine oscillatory movements until the food is cut
b) trituration is the phase during which food is transformed into smaller particles; it occurs in the premolars, because their intercuspidal pressure is more intense than that of the molars
c) pulverization occurs mainly in the molars; mandibular movements are varied and of smaller amplitude
d) pulverization involves grinding of the small particles, transforming them into smaller elements

46. In relation to the teeth, which are very important in the chewing function, choose the incorrect alternative:
a) they are precursors of the digestive process and important for speech production
b) their structure involves the crown (visible portion of the enamel-coated tooth), the cervix, the root (located in the alveolar bone and covered by cement), and the pulp
c) deciduous dentition occurs after permanent dentition
d) total contact between the occlusal faces of the upper and lower teeth, in the resting position, occurs during occlusion

47. Choose the incorrect alternative regarding the temporomandibular joint:
a) it connects the mandible to the base of the skull
b) its movements occur through the slide of the condyle
c) is a bilateral synovial joint with synchronized movements
d) it is composed of the mandibular condyle, fossa, and articular disc, not including ligaments

48. Choose the incorrect alternative with respect to respiration:
a) it provides body cells with the necessary oxygen
b) it is the result of a coordinated contraction of a group of muscles
c) it is automatic and voluntary
d) it can be determined by voluntary control

49. Which of the following occurs when the diaphragm contracts:
a) the lungs return to their original volume
b) the thorax remains in its usual dimensions
c) thorax volume increases vertically
d) thorax volume decreases vertically

50. Which of the following is not a change caused by mouth breathing?
a) lesions in the vocal folds
b) facial asymmetry
c) changes in occlusion and masticatory inefficiency
d) postural compensations