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Human Embryology teaching mediated through a virtual environment room

Ensino de Embriologia Humana mediado por sala ambiente virtual

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***Palavras-Chave*—Fetal development, Education, Ludicity, Virtual reality.**

***Abstract*—** *Difficulties linked to the way of how we understand and present Human Embryology contents are aggravated by traditionalist characteristics still identified in the educational field. The way this science is taught must be based on interactive didactic resources, enhancing the best visualization of its phenomena. In this context, guided by the David Ausubel's Meaningful Learning Theory, the Human Embryology Virtual Environment Room was developed strengthening this content's teaching-learning process through a virtual game resource that dynamically represents Human Embryonic Development main phases. This resource was submitted to appreciation by Basic Education expert teachers, validating it as an educational product, assessing didactic, methodological and other issue related aspects through an electronic validation form. The quantitative results analysis and interpretation was carried out using Likert's Scale Median Ranking calculation; qualitative data was analyzed under Lefèvre & Lefèvre's Discourse of Collective Subject precepts. The results demonstrate that the educational product has been validated by expert teachers and it is possible to infer that it does constitute a potentially significant product for Human Embryology teaching.*

***Resumo*—** *Dificuldades atreladas a forma de compreensão e apresentação do conteúdo de embriologia humana, são agravadas por características tradicionalistas que ainda se identifica na educação. O ensino desta ciência deve ser pautado em recursos didáticos interativos, que potencialize melhor visualização de seus fenômenos. Neste contexto, norteado pelos pressupostos da aprendizagem significativa de David Ausubel, foi desenvolvido a Sala Ambiente Virtual de Embriologia Humana, com objetivo de fortalecer o processo de ensino-aprendizagem deste conteúdo por meio de recurso lúdico virtual que represente, dinamicamente, as principais fases do desenvolvimento embrionário humano. Este recurso foi submetido à apreciação de docentes*

especialistas em ensino, com trajetória consubstanciada na Educação Básica, para validá-lo como um produto educacional, avaliando aspectos didático metodológicos e de representação do tema através de um formulário eletrônico de validação de produto educacional. A análise e interpretação dos resultados quantitativos foram efetuadas por meio do cálculo do Ranking Médio, a partir da escala Likert; os dados qualitativos, foram analisados sob preceitos do discurso do sujeito coletivo de Lefèvre e Lefèvre. Os resultados demonstram que o produto educacional foi validado pelos docentes especialistas. Infere-se que o mesmo se constitui como um produto potencialmente significativo no ensino de embriologia humana.

I. INTRODUCTION

Certain traditional teaching characteristics can still be identified in the educational field, such as a strong technicist tendency, where knowledge possession and task execution remain as the sole teacher responsibility, whilst students exercise a passive memorizer role. Another sign of this is found in the disjointed pedagogical activities limited to the use of conventional didactic resources avoiding incorporation of alternative methods that could motivate and assist the students in grasping new contents [1, 2, 3].

Historical paradigms shifts usually don't happen out of a sudden, becoming therefore a process in itself where some excelling professionals face certain difficulties. But teachers are the main responsibles for changing this scenario. Taking care of the students' learning process is one of their main tasks, acting as the teaching-learning process Manager taking care of its individual preparation, creatively elaborating the class and providing the right conditions motivating the students to have an active role in this process. Well-planned and well-managed classes, with a dynamic and innovative profile, have better chances of success [4, 5].

Human Embryology studies is a part of Developmental Biology that integrates Morphological Sciences. Their studies develop all knowledge related to the beginning of human life – cells, tissues, organs and systems' origins. Therefore, these studies elucidate several biological mechanisms that determine the shifts occurring from fertilization, antenatal development until birth. It also clarifies the anatomy and explains how normal and abnormal relationships are developed in human structures. Embryonic development is a part of the human species perpetuation process; maintaining its genome and variability [6, 7, 8].

Human development and embryology are some of the most important subjects in all of Natural History [9]. Teaching this science cannot be limited to ineffective didactic models such as theoretical classes centralized in textbooks as its main resources. This traditionalist model establishes a deficient teaching-learning process, failing to provide the proper visualization of embryonic processes that can possibly be too abstract for the students' mental representation [10, 11].

Innovations in information and communication technologies have triggered structural and functional changes in society, offering these very elements in the educational area, contributing to content mediation and enriching its learning. [12]. Souza; Oliveira [13] also affirm that information and communication technologies are related with the student's reality, with teenagers increasingly involved in virtual environments and becoming their main potential users.

The Brazilian National Curriculum Parameters for High Schools instructs that with the information technologies dissemination in products and services, these elements also need to find their own space in regular school learning and they should be seen as part of its teaching process. Natural Sciences need to identify the technological elements that are essential for their development with live contents, targeted as educational means [14].

Based on these premises, the availability of alternative tools for mediating Human Embryology contents is essential for teachers (that eventually have no access to different materials for teaching this subject); as well as for students (that demand adequate resources according to their cognitive structure, enhancing their interest for complex subjects). This cognitive emphasis can be established by a non-arbitrary and substantive interaction between previous subjects and new contents, following David Ausubel's Meaningful Learning key elements. According to Moreira [15], this kind of interaction provides new meanings for previous subjects, turning them into a more elaborate and richer knowledge, bestowing them with new meanings.

Considering this context, anchored on David Ausubel's Meaningful Learning premises, the "Human Embryology

Virtual Environment Room" educational product was developed in order to contribute to this subject's teaching-learning process reinforcement through a virtual ludic resource dynamically representing Embryonic Development main phases.

II. METHODOLOGY

This study is an Action Research that, according to Picheth et al. [16], can be understood as a knowledge strategy and an investigation methodology associated with an action and / or problem solving.

The educational product was initially developed focusing on High School students as its target audience. However, before their access, it's paramount to obtain an assessment from the teachers encharged with the students' routine education, validating the ludic resource. Therefore, experienced Biology Sciences teachers (hereby denominated as Expert Judges) also constitute this study's target audience. Consent was obtained through the Free and Informed Consent Form. The study was approved by the "Centro Universitário de Volta Redonda Ethics Committee for Research with Human Beings", following the protocol of the "Brazilian Certificado de Apresentação de Apreciação Ética" number 37107220.0.0000.5237.

The study's structure is organized in four main stages, ranging from initial content preparation to educational product validation (*Fig. 1*).

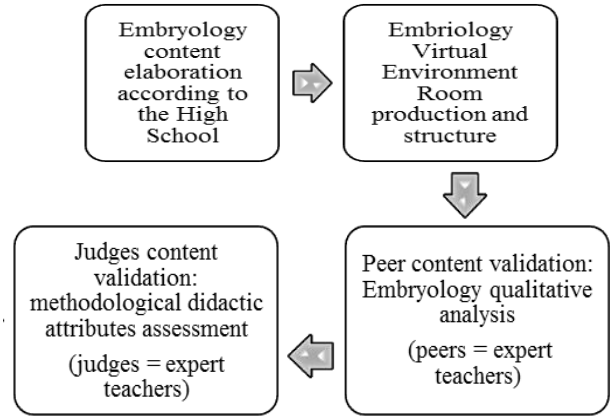


Fig. 1. Study stages synthesis. Source: Elaborated by the authors (2020).

2.1 Data collection and analysis techniques

Teachers were electronically invited receiving an email containing the instructions, a download link for the Human Embryology Virtual Environment Room and an access link to the Educational Product Validation Form. This electronic instrument was used to collect data, using Google Forms with the following structure: the educational product title and the study objective are presented on the first page. The second page contains the Free and Informed Consent Form assuring the process safety by a signature, enabling the option to proceed to the next stage, comprised of 11 questions concerning the Expert Teacher profile. And in the last section, the educational product validation form is presented with its analytical dimensions, comprised of 15 questions, 11 of those with optative answers and 4 of those with discursive answers.

These dimensions were based and adapted following the "Coordination for Higher Education Personnel Improvement - Educational Product Working Group" guidelines, proposing a series of concepts (denominated as "dimensions") subsidizing the analysis of educational products coming from several stricto sensu graduation programs [17].

The form's optative questions follow a Likert-type scale of five possible answers increasing in their order of value. According to Bonici; Junior [18] for each Likert scale numerical element, a qualitative meaning is attributed reflecting the participant's attitude towards the assessed dimensions.

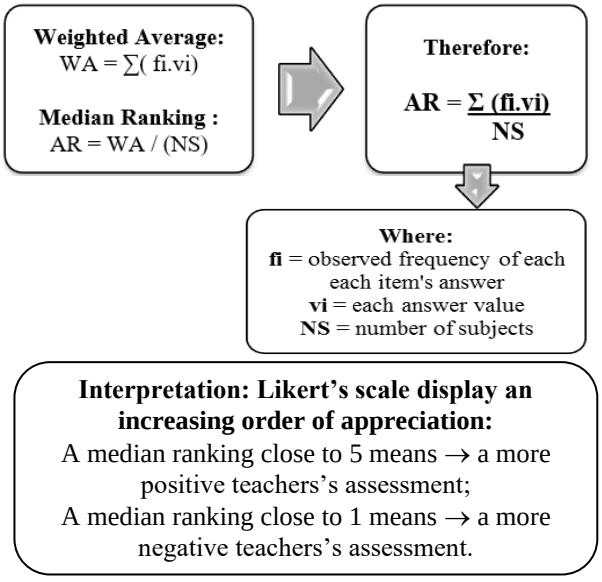


Fig. 2. Strategy to estimate the Median Ranking for each dimension and interpretation. Source: Organized by the authors (2020) based on Bonici; Junior [18] and Almeida Júnior [19].

The quantitative results analysis and interpretation (*Fig. 2*) was performed according to Almeida Júnior's Median Ranking calculation [19, p. 209], that being "an attributed value between 1 to 5 assigned to each answer allowing the weighted artihmetic mean calculation, based on the answers frenquency".

Analysis and interpretation of qualitative results were carried out based on Lefèvre & Lefèvre's [20] Discourse of Collective Subject, meaning that for each question, the content of similar opinions presented by different teacher's statements are aggregated between themselves. This association is described by the synthesis and assimilations that tend to reconstruct the social representation of each teacher involved in the study.

2.2 The Making of Human Embryology Virtual Environment Room

This educational product has a simple technological structure and it is fairly easy to handle. Microsoft PowerPoint 2016 was adopted to structure the virtual environment and also to create all the animations, including dynamic graphical presentations interconnected by links that organize the stages of embryonic development in chronological order.

The virtual environment room initial presentation occurs through an animation culminating in the screen displayed at *Fig. 3*. This educational product comes in two languages, both in English and in Portuguese. The initial screen contains a button displaying the word “Portuguese” allowing the players to access the same game with all translated contents.

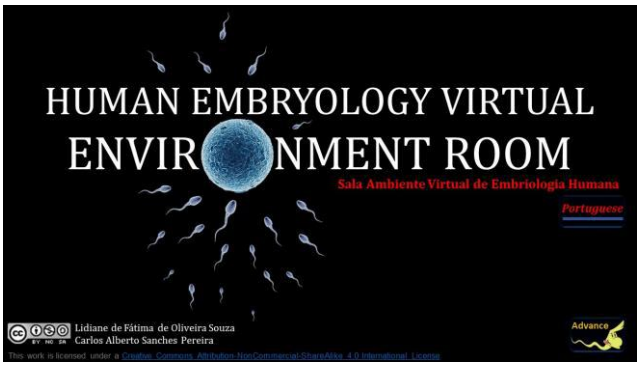


Fig. 3. Educational product initial screen. Source: Authors' file collection (2020).

In next screen, the character “Silas” (exclusively designed for this game by a professional designer) is presented to the players, placed in a setting that simulates the school environment (*Fig. 4*). In this screen's the upper corner, it's possible to find a button with direct recommendations for teachers regarding the educational product application.

Fig. 4. Virtual Environment Room front door representation. Source: Authors' file collection (2020).

By clicking on the door, the student can access the virtual environment room designed as a floor plan detailing the Human Embryology stages, working as a summary with active links that redirect the player to each stage (*Fig. 5*).

Fig. 5. Virtual room route designed as a floor plan. Source: Authors' file collection (2020).

After this, "Silas" provides some explanation about the standard layout structure of each stage’s main screen (i.e. those that display the studied stage functioning as the proposed teaching tools command centre) as seen on *Fig. 6*. The game is comprised of 15 main screens chronologically organizing the Human Embryology study.

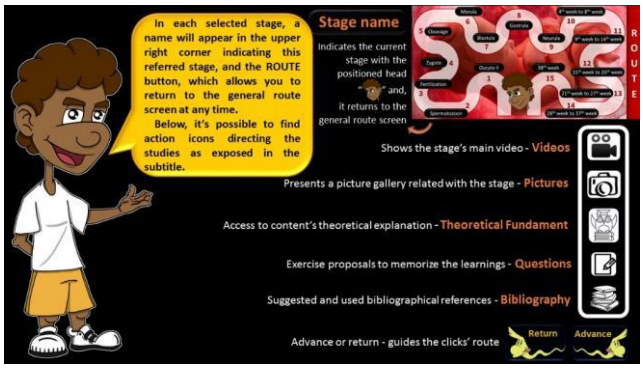


Fig. 6. "Silas" explains the standard layout of each stage's main screen. Source: Authors' file collection (2020).

After the layout explanation, the player will be instructed to click on the animated pulsating button marked as “Next”, starting the journey through the Embryonic Development stages. And after passing through all the 15 phases, Silas sends the following final message to the players, saying: “Thanks for your company! Our life is a gift, our most precious good! Enjoy it with love!”. At last, moving to the final credits.

2.3 Product contributions to the teaching area: educational implications

This study’s relevance, considering its main contributions and educational implications, is comprised of three essential dimensions:

a) for teachers, it allows the incorporation of ludic subsidized ideas in a potentially significative material with a pedagogical and didactic methodology that aggregates value in its formative process. This educational strand suggests that using a resource such as the Human Embryology Virtual Environment Room during the classes can be performed in different ways according to the teachers' choice, reality and creativity. The next session brings some suggestions on how to implement it;

b) for the educational and scientific community, this study provides an addition to scientific production and experimentation of innovative ludic resources used for Sciences and Biology teaching;

c) for students, the interaction and contextualization established by the product tries to contribute with the integral shaping of cognitive aspects (i.e. improving the assimilation of new meanings about Embryology, processing information and critical thinking considering contemporary Embryology issues); of socioemotional aspects (i.e. providing critical reflection to improve attitudes towards life, incentivizing positive social relationships, responsible decision making and shaping the student's behaviour as a transformation agent facing Embryology related concepts); and of physical aspects (i.e. encouraging good habits by addressing issues such as self-medication, illegal drugs consumption, teratogens, smoking habits, et al.) therefore, helping to build up promising future life prospects for the students.

Considering these points, the product complies with the established guidelines of the Brazilian Law 9394/96, Article 35-A, § 7º affirming that: "High school curriculum should consider the students' broad formation, adopting a working routine targeting their life prospects improvement and their physical, cognitive and socioemotional formation.” [4].

III. RESULTS AND DISCUSSION

3.1 Content validation: qualitative analysis of Embryology subjects represented in the educational product

In this first content validation stage, it was noticed that even with the vast content and structure, few specific observations were made regarding the theme's representation and the teachers' appraisals were abundant. Based on these appraisals, it is possible to assume that the educational product follows adequate purposes for Basic Education Embryology teaching, since this analysis was carried out by teachers working with this subject, confirming Oliveira's [21] statement that a teachers' vision is a crucial part of the study, enriching it in all dimensions, since they are the agents of paramount importance in the teaching-learning process.

As for the Human Embryology subjects' suitability and representation in the educational product, Costa Segundo et al. [7], states that Embryology teaching mediated by virtual didactic resources is an efficient strategy, allowing students to interact through a dynamic and easily accessible tool.

And according to Pereira [22], ludic elements, when used for teaching, make theorization better elucidated fitting into the individual's daily practice. This happens mostly because the student can interact in this new knowledge construction, enhancing curiosity and critical spirit.

3.2 Educational product validation by judges: methodological didactic attributes assessment

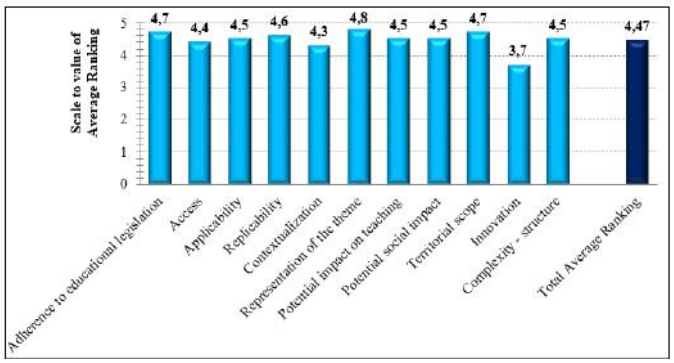
When crossing the academic credentials data with time and teaching segment activity, the target audience prevalence was obtained, constituted mostly by PhDs (60%) with extensive teaching experience for more than 20 years (50%) and 90% of the teachers have professional experience in the “High School general education modality” segment, converging with the period intentionally chosen for this educational product in its initial development stages.

The multiple-choice questions included in the educational product validation form present the analytical dimensions assessed by the teachers (Graphic 1).

The educational product compliance to the Brazilian Law 9394/96 and to the National Common Curricular Basis regards the way on how the educational product meets contributive premises and purposes on the foundations of national education legislation. From the median ranking of 4.7, it can be inferred that from the teachers' perspective, the educational product contains enough attributes to consider the students’ comprehensive

education in physical, cognitive and socio-emotional aspects according to Article 35-A § 7, contributing to the final High School stages attributing the students with "I – command over scientific and technological principles presiding over modern production and II - knowledge of contemporary forms of communication", as described in items I and II of Article 35, § 8 of the Brazilian Law 9394/96. As well as working on various skills related to the specific competences contained in the fields 2 and 3 in he Brazilian Common National Curricular Basis [4, 23].

Graphic 1. Educational product validation ranking.



Source: Elaborated by the authors (2020).

The access dimension obtained a 4.4 median ranking, configuring the educational product as an easily accessible one. Costa Segundo et al. [7] found in his study that virtual didactic contents presented by easily accessible tools represented an efficient strategy allowing better student interaction levels.

Applicability and replicability requirements obtained 4.5 and 4.6 grades, respectively. In view of this positive appreciation, it's possible to infer that the Human Embryology Virtual Environment Room is an easily adaptable resource both for partial and integral use. This content corroborates with Rizzatti et al. [17] stating that teachers are free to partially or fully use and reuse products deriving from professional Master's degrees, even combining them with other materials. In other terms, it's possible to adapt these products in accordance to their didactic needs, to the reality applied upon them and in different social groups.

It's possible to infer from the median 4.3 ranking regarding the contextualization dimension that the educational product succeeds in contextualizing with the students' reality upon presenting the content in a technological format that is currently becoming increasingly present young people's lives [13].

In the Embryology issue representation dimension, a median ranking of 4.8 was obtained. It is possible to understand that the Human Embryology knowledge is properly incorporated into the educational product in a logical and dynamically represented sequence. According to the Brazilian Common National Curricular Basis, this is necessary to develop and explore different software resources that represent the contents, enabling phenomena and process simulation and the consequent knowledge grasping by the students [23].

Both the average ranking in the teaching potential impact dimension and the potential social impact resulted in a 4.5 score. It shows that the Human Embryology Virtual Environment Room has the potential to generate promising results for the teaching-learning process, a fact that corroborates a similar study developed by Pereira; Lima [5] when teachers change and update their way of teaching, a new opportunity arises for students to take on a new role inside and outside their classrooms, deconstructing standards of social and cultural stigmas and reconstructing them, having the very students as active subjects in this process.

In terms of territorial coverage, a median ranking of 4.7 was observed. Therefore, it can be considered that the educational product has the potential for regional, national and international outreach since it is structured in the vernacular Portuguese language, a fact that expands the possibility of reaching Portuguese-speaking countries, as well as widespreading it internationally with its English translated version.

The innovation dimension obtained the lowest median ranking, scoring 4.3. But even with this mark, 50% of the teachers indicated that the educational product has a highly innovative content. It's possible to believe that the low median ranking value may be due to the usage of a broadly known program (i.e. Microsoft PowerPoint) but the intention was to revisit it with an innovative proposal. According to Rizzatti et al. [17, p. 11], "innovation doesn't only derive from the educational product itself, but from its methodology development, from the usage of techniques and resources, making it more accessible and from using it in a social context".

The last analyzed dimension considered the complexity – structure aspect, with a median ranking of 4.5. Most teachers (60%) rated this item as "without complexity" allowing us to infer that, in the structural sense, the educational product content format and organization is appropriate both for the teachers' professional practice and for its use by students, based on different linguistic resources, i.e., verbal, visual, audio, digital, as well as in the fields of artistic and scientific languages, "expressing and sharing information, experiences, ideas and feelings in different contexts and producing meanings that lead to mutual understanding", following the recommendations

established by the fourth general competence of Basic Education described in the Brazilians Common National Curricular Basis [23].

When analyzing the total median ranking, it is possible to highlight that ten out of eleven analyzed dimensions obtained a median ranking value above 4.3. There is an oscillation in the dimensions median ranking varying between 3.7 (lowest median ranking obtained in the innovation dimension) and 4.8 (highest median ranking obtained in the issue representation dimension). And the end result was a total median ranking of 4.47.

Based on these dimensions median ranking results and the total median ranking score, those teachers' analysis can be considered as extremely positive, substantiating the Human Embriology Virtual Environment Room validation as a potentially significant ludic resource for the Biology teaching learning process in High Schools. Corroborating with authors such as Wong; Subramaniam [24] and Bain; Meagher; Barker [25], in examining the literature on the technology usage and infusion in the scienctific college teaching learning process, it is clear that they are effective because they enrich this process by innovating Life Sciences studies.

It's also worthy to notice that all assessed dimensions provide a detailed discussion about the educational product. This fact, according to the Coordination for Higher Education Personnel Improvement working group report, can lead to a higher qualification of the product in question. And it creates an opportunity for other professional Master's research products to have direct impacts in Basic Education improvements [17].

3.3 Educational Product teachers' recommendations

The last validation form questions were formulated in a discursive design where expert teachers were able to freely include their contributions, later associated between themselves observing similar opinions. Based on these, some inferences were established according to Lefèvre's principles; Lefèvre [20].

90% of the teachers demonstrated some interest in using the educational product as a didactic resource in their pedagogical practice. And all of them (100%) stated that they would recommend it to other professional colleagues. In their justifications, key similar concepts stood out:

The product's quality was considered clear, objective, with a dynamic approach and easy to be used and adapted;

The product presented a new narrative enhancing the player's interest;

The product has a potential to make the teaching learning process become easier;

It improves content understanding in a non-literal and arbitrary way (i.e. through explanation and visualization);

Spreading this product can represent a good access opportunity for several students and teachers.

Rizzatti et al. [17] reports that educational products propagation can contribute to a higher visibility of these very resources potentializing the inclusion of differentiated methodologies that, according to Vlnieska [26], guarantees a more meaningful, participatory, dynamic and attractive learning. The author also points out that caring for constant search of meaningful and effective learning must be at the heart of teachers' motivation and inspiration and that “pedagogical action” is based on trusting that education is a transformation source.

Both feedbacks referring to these appraisals and the limitations are constructive criticisms that make it possible to recognize the teachers' vision, since they are the ones in the teaching front line. And according to Ruiz et al. [27], it is crucial that they share what they think, their expectations and knowledge adding some value to the proposed material. This author, working as researcher at University of Buenos Aires, mentions that the material validation process, which occurs whenever a teaching resource is completed, needs to be done in a participatory manner by a representative group carrying out a final assessment with specialized and impartial views.

IV. CONCLUSION

Based on the concept that meaningful learning principles can enhance Human Embryology teaching-learning, the perceived results are promising considering the achieved median ranking grades and the teachers' feedback contents, justifying the Human Embryology Virtual Environment Room validation as a potentially significant ludic educational product, contributing to this content's teaching innovation presenting the main Embryonic Development phases in a dynamic and pleasant way, also involving the students in experiencing this phenomenon.

On that account, the proposed educational product displays enough potential characteristics to reduce difficulties associated to the way of how Embryology contents are presented and understood, enhancing and strengthening this science's teaching-learning process.

Considering this, it's expected that the Human Embryology Virtual Environment Room will be used as a subsidy for Biology teachers and as an additional resource to the students in assimilating and building up new meanings about Embryology in their cognitive structure,

developing critical thinking regarding these issues in their social contexts and also acting as a transformation agents.

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