Way Back Home - An Auxiliary Teaching Tools in Biology Education in Colleges

Dongran Yu*

Department of Marine Life, Ocean University of China, Qingdao, China

* Corresponding Author Email: 19050031059@stu.ouc.edu.cn

Abstract. In undergraduate biology education, especially in cell biology, it has been a challenge for students to integrate images well to memorize the complex and scattered expertise. In traditional biology teaching, the teacher's way of explaining with images is not good enough to show the connection between cell structure and function directly. Biology students need to spend long extra time to memorize these very essential points, which not only reduces students' interest in learning, but also is a very painful process for students with poor spatial imagination. However, the newly emerged VR game technology, which is visual, playful, and interactive, can be a good solution to the problem of students' interest in learning and their lack of spatial imagination. According to this situation, this paper designs a VR game as a supplementary teaching tool for cell biology and examines it from seven aspects: game mechanics, visual aesthetics, narrative, motivation, music score, learning objectives, and relevant. With using this VR game, biological related specialized student can directly see the changes in structure and remember them with pleasure, and teachers with similar teaching needs could also use them to improve learning effects. Finally, the advantages and limitations of this teaching aid are evaluated, aiming at broadening the current means of teaching undergraduate biology and providing new ideas for future higher education teaching of cell biology.

Keywords: Active learning, Biology education, higher education, VR teaching.

1. Introduction

The traditional way of teaching biology theory mainly relies on the lecture of the teacher with pictures and videos to make students understand the whole process of biological structures and how they perform their functions. These can be effective for relatively simple biological structures and processes. However, university biology expertise often involves a variety of cellular structures and multiple substances in complex biological processes, for which the traditional pictures and video materials alone are not vivid enough, and it is difficult to understand such abstract and messy life structures by memory alone, especially cell biology. As a required course for biology majors, cell biology is devoted to the study of various structures and life processes at the cellular level and to the investigation of their impact on ultimate function. This course involves a large number of different kinds of cell structures and their various types of knowledge points appropriate to their functions, which cannot be understood by memorization of functions alone and must be related to specific cell structures. But unlike clear and simple high school knowledge, cell biology often involves multiple levels of structure, with each level of matter involved in different traits and functions. Traditional forms of picture and video aids do not meet the teaching requirements of students, and the whole process of memorization becomes boring. Many students are unable to relate complex structures and functions because of their insufficient abstraction ability, and passive and boring learning makes teaching and learning unsatisfactory.

As a result, the traditional lecture method is no longer appropriate for today's educational needs, and more teachers are exploring other active learning strategies and developing more intuitive and efficient biology teaching aids. Some researchers have used the Internet to introduce student response systems that embed questions into the classroom so that students can answer instructional questions in class and use the results to provide teachers with immediate feedback in the classroom to determine knowledge and progress [1]. Others have begun to use group-based collaborative learning, in which all students are divided into groups to work together on higher-level tasks such as modeling biological concepts or interpreting papers, thus stimulating independent inquiry to guide students in the

acceptance and application of new concepts [2]. However, research has mainly focused on the exploration and improvement of teaching formats without designing specific teaching aids. In terms of the form of course types, the current research on new teaching aids is more focused on biochemistry, which is also a basic course and has a broader range of students, with little research on cell biology and no intersection with virtual reality technology. Moreover, the above is more often presented in the form of ideas and outlooks, and no specific tool design has been done.

The use of games for learning and development purposes in the context of the current educational development is definitely not a new phenomenon. And several features of games even make them a relatively desirable medium for learning. The first is that research has found no significant gender differences in motivational outcomes in learning or educational games, despite gender differences in the time and type of digital games played by boys and girls [3]. Games also possess a unique motivational function. Games are able to motivate learners to stay engaged over time through a range of motivational structures such as stars, points, leaderboards, badges, and trophies. There is also a frequently cited argument that games allow for graceful failure. Failure is a very important, even necessary, step-in learning. Failure is presented as a lower consequence in games, which reduces the likelihood of dampening learners' self-confidence and motivation and instead encourages them to explore new solutions [6]. And the games are highly compatible and can cover a wide range of fields such as humanities, science, and engineering. Based on the above characteristics of games, if we can make full use of them in the teaching process and apply them to biology teaching, it will be a very effective learning method that can stimulate learners' interest in learning.

VR has been incorporated as a new tool for teaching and learning, although it is still difficult to implement on a large scale, it still has many advantages, such as immersion and interactive sense. 3D technology is very suitable for presenting complex cell structures and procedures in a more intuitive way, and it can be interactive to a certain extent according to the instructions, which can better allow students to observe the differences between different cells and every step of the biological change process. The combination of VR and games is a good option for students who are not motivated by the low level of knowledge about cell biology. The affordances of game are playful, motivating, engaging and emotional design. It can be a good way to stimulate students' interest and guide them to learn cell biology more efficiently.

The application of VR game technology in biology teaching has great advantages due to the characteristics of VR games and the maturity of related technologies. So far, the application of VR games as an auxiliary teaching tool has achieved excellent results at the high school level, but there is no systematic application and related deep research at the university level. Based on the above facts, this paper will provide a virtual reality game based on cell biology knowledge to explore new ideas of teaching aids for biology students in colleges and universities.

2. Methods

Based on these foundational ideas, a VR game called 'Way back home' was designed. The game was divided into the following components: game mechanics, visual aesthetics, narrative, motivation, music score, learning objectives, and relevant content and skills covered by the game. [7]

2.1. Game Mechanics

The game is based on the concept of imagining all the elements and structures of the cell as 'lost children', where the learner, wearing a VR receptive device, will become an emissary and use knowledge of cell biology to navigate through the delicate structure of the cell by dragging or clicking on elements and structures that are not in their original position in the game interface to the correct location. Elements and structures that are not in their original position in the game interface are dragged or clicked with the controller to the correct location to help them find their 'home' - i.e., where they are supposed to be. If the learner's command is correct, the elements and structures will display smiling expressions and correct beeps to show feedback, unlock the next level, and give

additional instructions on the interface about the knowledge. If the command is incorrect, a sad expression and a prompt tone will guide the student to review the knowledge and encourage the learner to repeat the experiment.

In the normal mode of the game, all cell biology related knowledge will be divided into different levels according to the difficulty and learning progress. Each level will be set in different contexts, such as small intestine epithelium, heart muscle, kidney, etc., to help learners determine the differences in cell structure in different contexts. Through this game, students can correctly identify the three-dimensional structure and vivid processes of biological facts.

For teachers who teach this subject, through the game's self-design model, teachers can choose their own unit types, scenarios and fill in the content to design game levels as a supplemental task after class according to their teaching purposes and teaching schedule. Even students can design tasks for each other through this mode for peer assessment.

2.2. Visual Aesthetics

The panoramic view of the game will present the accurate and realistic cell structure inside the living organism in 3D, and at the same time, in order to achieve a visual effect with the aesthetic tendency of college students, it will use soft and bright colors to distinguish different areas and structures on this basis, in order to weaken the intimidation of the real cell structure to the learners, so that the learners can learn in a more relaxed and happy mood. At the same time, each cell and structure will show different expressions according to the different operations of the learner, making the overall effect more vivid.

2.3. Narrative

Before the learner enters all the levels, the system will show the game concept by means of short video and voice. At the beginning of each level, a guided voice narrates the basic scenario of the level (e.g., Welcome to the human small intestine epithelium, there are two bridge grains lost, please help them to choose the correct position) and gives a brief narration of the knowledge. If the learner performs the correct action, the system automatically releases an explanatory voice and video; if the instruction is incorrect, there is a prompting voice.

2.4. Motivation

Motivation is generated mainly through the following.

1) Expressions: The shame of incorrect instructions is weakened by praise expressions and pity expressions displayed by cells and structures, motivating learners to make multiple attempts.

2) Stars: The number of stars earned at the end of each level is determined by the number of errors and the time spent. A full score of three stars results in appreciative effects and speech, while accumulating high-quality stars unlocks badges and improves ranking.

(3) Ranking: Rankings are set up in different areas (class, school, province, etc.), and the top students will get the relevant titles, motivating learners to improve their proficiency and judgment of relevant knowledge through the way of ranking.

(4) Badges and trophies: According to the evaluation of learners' learning effect in different directions (such as time spent, accuracy, etc.), learners will unlock different badges and trophies to motivate learners.

2.5. Music Score

As learners make different selections, different tones will indicate the result of the selection. Additional explanations after a correct choice and guidance sounds after a wrong choice are used to help learners reduce their anxiety and absorb the knowledge carefully. The background music throughout the process uses soft, ethereal drones to help learners stay immersed and focused.

2.6. Learning Objectives

The learning objectives set by this game are intended for undergraduate biology majors to be able to memorize cell models in different contexts by playing with them and to master the model structure of cell biology and the functions that go with it. It helps students with poor spatial ability to establish the structure and operation of the cell model in 3D perspective, and helps students with poor learning interest to stimulate learning interest and memorize and understand cell biology points in a more relaxed way.

2.7. Relevant content and skills covered by the game

"Way back home" covers all the relevant models and reaction mechanisms that students must learn in undergraduate cell biology, and distinguishes between different scenarios in which the underlying models change. The above game only takes cell connection as an example to explain the game mechanics, the specific knowledge points and learning content to be covered by each country's major universities according to the specific circumstances of the syllabus for the selection and sorting of levels.

3. Discussion

3.1 Theory of change

Need statement: The expertise of cell biology is scattered and complex. It is difficult for students majoring in biology to remember and understand, while this is essential knowledge for biological research. Based on this fact, a game can be designed so that students can directly see the changes in structure and remember them with pleasure.

Target population: Biological related specialized student, and teachers with similar teaching needs, and other undergraduate cell biology enthusiasts.

Core program components: Based on more sophisticated expertise, not simple cell models, and learner can click or drag elements in the game interface to finish the structure and process, making it more fun and interactive

Outcomes: Through this process, users can easily remember the knowledge related to cell biology, such as cell connections and cell communication in a fun way.

Hypothesis: If the user's command is correct: smiling face & correct prompt sound & the supplementary explanation of relevant knowledge. If command is incorrect: sad expression & hint & leading sound. The large data prediction model for the user's electricity consumption is implemented in the Clementine software.

3.2 Media affordances

Playful: In contrast to the traditional teaching model, learners can enjoy playing the game through images, videos, and guide sounds in the VR receiver, and can continuously earn positive feedback such as stars and trophies through the controls.

Interactive: Interactivity is reflected in the fact that learners can use controllers to participate in the game and get feedback by clicking or dragging. In the self-design mode, learners or teachers can create levels that suit their learning needs by changing the scene and cell structure, and share them with other players for mutual evaluation.

Specialized: The design is specifically designed for students studying cell biology, and the knowledge points involved are all about deeper expertise in cell biology rather than simple popular biological models, so it requires the user to have at least a basic general knowledge of high school cell biology.

Spatial: With the support of VR equipment, immersive 3D images of cell structures can be created, enabling learners with weak spatial imagination to visualize the real situation of cell structures.

3.3 Evaluation

On the one hand, by using this VR game, learners can have a better and more comprehensive understanding of the material structure at the biological cellular level and form a three-dimensional framework of real scenes in their minds. It can help students with poor spatial ability or poor interest in learning to build and consolidate their understanding of relevant models, remember relevant knowledge points in combination with images, and understand each structure and corresponding functions at different levels in different contexts. At the same time, "The Way Home" can be used as a supplementary learning tool for teachers to develop application scenarios according to their teaching progress and needs. It can be used for supplementary homework after class, pre-testing before class, or even as a time-limited chapter test in class to test students' learning effects.

On the other hand, this VR game teaching is only at the stage of concept, not yet practically applied in the university classroom, and the real feedback of its effect on students' learning is not known yet. There are still many issues to be considered in the application, such as the objective equipping of VR equipment in the school, the applicable scenarios, the time of use, and the acceptance level of the lecturers and students. The specific research on the knowledge points of game integration needs to be further studied and evaluated.

Another point that needs to be clarified is that according to the current evaluation criteria, games can only be used as a teaching aid. Because the efficiency of games as a learning tool is relatively lower than that of traditional teaching modes, it cannot completely replace the traditional cell biology classroom and professional teachers. However, it is a feasible attempt to help students with low interest in learning and spatial imagination as an aid for pre-reading, reviewing and class quizzes.

In conclusion, although traditional education still dominates the teaching of biology in colleges and universities, the introduction of this virtual reality aid can be tried in the teaching of basic professional courses at the undergraduate level to enable students to combine images with theoretical knowledge better. Through the relevant analysis based on the above theory, we can know that this kind of game can be carried out in theory. However, there may be many other things to consider when this concept is actually applied to reality. Also, it has certain limitations such as the restricted places of use. However, it is undeniable that it may be an idea to increase the interest and learning effect of teaching and learning among college students.

4. Conclusions

VR games have the advantages of being playful, visual, and interactive, which is one of the well-technical tools for teaching biology. However, the current research on VR games in biology teaching is only at the high school level, and there is no relevant research in university biology teaching. Based on this fact, this paper combines university biology teaching with VR game technology and proposes a VR game for learning cell biology knowledge-"Way Back Home" as an auxiliary teaching tool, taking cell biology subject as an example. And according to the components of the learning game, it is described in detail in seven parts: game mechanics, visual aesthetics, narrative, motivation, music score, learning objectives, and relevant contents and skills covered by the game. It is ensured that it has a complete game structure and can accomplish the set learning objectives well.

The game is divided into levels based on the knowledge points or basic models of cell biology. In the game the learner takes on the role of an emissary and uses the controller to help elements and structures in the cell that are not in their original position to return to their correct location. If the learner's commands are correct, a smiling expression and crisp sound effects appear, and additional knowledge is given. If the learner's command is incorrect, the system displays a sad expression and sound effect, followed by a text prompt that encourages the learner to repeat the attempt. Explanatory audio and video are also released during the process. The game uses 3D to present accurate and realistic cell structures throughout, and uses soft, bright colors for aesthetic treatment. After completing levels learners earn stars. By accumulating stars, learners can unlock badges and improve their ranking in the leaderboard, thus continuously motivating learners to improve their proficiency

and judgment in related knowledge. At the same time, the game also sets up a self-designed mode, so that teachers can make reasonable use of the tasks according to their own teaching purposes and the teaching progress of the class, to achieve more accurate teaching effects. With the aid of the game, "Way Back Home" VR game can stimulate students' learning interest and independent learning ability to a certain extent and help students with weak spatial imagination to build 3D biological models, thus improving students' interest and knowledge absorption efficiency.

After subsequent analysis, it is undeniable that the game has certain limitations: 1) At present, the game is only in the conceptual stage and has not been applied in practice. In the future, students' real feedback on the learning effect of this game should be accepted and the game should be iterated. 2) Some problems still need to be solved for the game to be applied on a large scale. 3) The game can only be used as a teaching aid at present and cannot completely replace the traditional classroom and lecturer.

In conclusion, the conceptual model of VR game based on cell biology undergraduate teaching proposed in this paper needs further research and feedback iteration. However, the use of VR games for biology teaching is promising. It can be extended beyond the cell biology subject to other similar basic disciplines based on structural and functional adaptation. Depending on the means of use by instructors and students, it could be extended to a wider and more practical application. Although traditional biology teaching still occupies a non-negligible position at present, with the continuous improvement of technology and related theories, VR games, as an emerging teaching tool, are believed to have more theoretical research and practical applications in the future.

References

[1] Trisha V, Kaitlyn R, Reihaneh R, Matthew P, Marilyne S. Research-based implementation of peer instruction: a literature review [J]. CBE life sciences education,2015,14(1).

[2] Deborah A, Kimberly T. Approaches to Cell Biology Teaching: Learning Content in Context—Problem-Based Learning [J]. Cell biology education,2003,2(2).

[3] Annetta L, Mangrum J, Holmes S, Collazo K, Cheng Meng-Tzu. Bridging Realty to Virtual Reality: Investigating gender effect and student engagement on learning through video game play in an elementary school classroom [J]. International Journal of Science Education,2009,31(8).

[4] Papastergiou M. Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation [J]. Computers & Education,2008,52(1).

[5] Lenhart A, Madden M, Smith A, et al. Teens, Kindness and Cruelty on Social Network Sites: How American Teens Navigate the New World of" Digital Citizenship"[J]. Pew Internet & American Life Project, 2011.

[6] Hoffman B, Nadelson L. Motivational engagement and video gaming: A mixed methods study [J]. Educational Technology Research and Development, 2010, 58(3): 245-270.

[7] Plass J.L, Homer B, Kinzer C. Foundations of Game-Based Learning [J]. Educational Psychologist,2016,50(4).

[8] MacCallum K, Day S, Skelton D, et al. Mobile affordances and learning theories in supporting and enhancing learning [J]. International Journal of Mobile and Blended Learning (IJMBL), 2017, 9(2): 61-73.

[9] Aikens M.L. Meeting the Needs of a Changing Landscape: Advances and Challenges in Undergraduate Biology Education [J]. Bulletin of mathematical biology,2020,82(5).

[10] Plass J.L, Salisbury M.W. A Living-Systems Design Model for Web-Based Knowledge Management Systems [J]. Educational Technology Research and Development,2002,50(1).

[11] Driessen E.P, Knight J.K, Smith M.K, Ballen C.J. Demystifying the meaning of active learning in postsecondary biology education [J]. CBE Life Sciences Education,2020,19(4).

[12] Dalgarno B, Lee M.J.W. What are the learning affordances of 3-D virtual environments? [J]. British Journal of Educational Technology,2010,41(1).