

# Aprendizagem através de Role-Playing Games: uma Abordagem para a Educação Ativa.

## Learning Through Role-Playing Games: an Approach for Active Learning and Teaching.

Marco Antonio Ferreira Randi<sup>1</sup>  
Hernandes Faustino de Carvalho<sup>II</sup>

### KEYWORDS:

- Undergraduate Education;
- Role-Playing Game;
- ATP Synthesis;
- Cell Cycle;
- Endocytosis And Cellular Digestion;
- Medical Education;
- Active Learning.

### PALAVRAS-CHAVE:

- Graduação;
- Role-Playing Game;
- Síntese de ATP;
- Ciclo Celular;
- Endocitose e Digestão Celular;
- Aprendizagem Ativa.

### ABSTRACT

*This study evaluates the use of role-playing games (RPGs) as a methodological approach for teaching cellular biology, assessing student satisfaction, learning outcomes, and retention of acquired knowledge. First-year undergraduate medical students at two Brazilian public universities attended either an RPG-based class (RPG group) or a lecture (lecture-based group) on topics related to cellular biology. Pre- and post-RPG-based class questionnaires were compared to scores in regular exams and in an unannounced test one year later to assess students' attitudes and learning. From the 230 students that attended the RPG classes, 78.4% responded that the RPG-based classes were an effective tool for learning; 55.4% thought that such classes were better than lectures but did not replace them; and 81% responded that they would use this method. The lecture-based group achieved a higher grade in 1 of 14 regular exam questions. In the medium-term evaluation (one year later), the RPG group scored higher in 2 of 12 questions. RPG classes are thus quantitatively as effective as formal lectures, are well accepted by students, and may serve as educational tools, giving students the chance to learn actively and potentially retain the acquired knowledge more efficiently.*

### RESUMO

*Avaliamos o uso dos role-playing games (RPGs) como uma metodologia de ensino e aprendizagem em Biologia Celular. Alunos do primeiro ano de Medicina participaram de aula expositiva tradicional (grupo referência) ou de aula com RPG (grupo RPG). Comparações foram feitas pela análise de questionários pré- e pós-aula com RPG, das notas nas provas regulares, e das notas obtidas em um teste aplicado um ano após a conclusão da disciplina. Dos 230 alunos que participaram das aulas com RPG, 78,4% responderam que o RPG é uma ferramenta eficaz na aprendizagem; 55,4% acharam que essas aulas são melhores que as aulas tradicionais, mas não as substituem; e 81% responderam que usariam essa metodologia. Os alunos do grupo referência tiveram nota maior em uma de 14 questões das provas regulares; os alunos do grupo RPG tiveram notas maiores em duas de 12 questões aplicadas um ano depois. Portanto, aulas com RPG foram tão eficientes quanto as aulas tradicionais (quantitativamente), são bem aceitas pelos estudantes, e podem ser uma metodologia que lhes dá a chance de aprender ativamente e, potencialmente, levar a uma melhor retenção do conhecimento aprendido.*

Recebido em: 03/09/2012

Aprovado em: 26/02/2013

<sup>1</sup> Universidade Federal do Paraná, Curitiba, PR, Brasil.

<sup>II</sup> Universidade Estadual de Campinas, Campinas, SP, Brasil..

## INTRODUCTION

Most introductory undergraduate courses use a lecture-based class style in which the teacher speaks and the students listen. This type of "transmission of knowledge" may be useful for situations such as remembering facts and concepts at a low level and rote memorization. Despite the fact that some teachers are capable of delivering highly motivational lectures, this style is somewhat ineffective at constructing high-level content associations and at providing students with the necessary professional skills<sup>1,2</sup>. Groups focussing on higher education are challenged with developing tools that engage students and increase active participation and critical thinking rather than emphasizing rote memorisation of scientific concepts and facts<sup>2,5</sup>. The process of developing these tools conforms to the National Research Council's standards for scientific teaching<sup>6</sup>. These standards postulate that "student understanding is actively constructed through individual and social processes". Encouraging group work and peer discussions, along with other cooperative strategies, may lead to better student learning outcomes. Experts thus suggest that these approaches should be used in conjunction with, or even instead of, lectures<sup>7-12</sup>. Such teaching strategies are consistent with the Vygotskian perspective that learning is built socially through participants' interaction with each other throughout the process of assimilating new knowledge<sup>13</sup>. These strategies are also consistent with Ausubel's theory of meaningful learning<sup>14</sup>, in which the student learns by meaningfully adding new knowledge to the network of concepts that he or she already knows, leading to better learning and facilitating progress.

There are several strategies for encouraging student involvement in the learning process<sup>15</sup> that are designed to enhance student comprehension through team learning, leading to the development of cooperative skills. Examples of these strategies include problem-based learning<sup>16</sup>, small group discussions<sup>17</sup>, the use of theater or role-playing<sup>18-22</sup>, and the use of concept maps<sup>23,24</sup>. Each strategy has its benefits and drawbacks. Games are also used to promote student involvement in active learning<sup>25</sup>, and role-playing games (RPGs) are one type of group-based game used across all levels of education<sup>26-30</sup>. Like most games, RPGs typically feature fantasy, mystery and clear rules and goals, allowing the player to exert a degree of control over the process. All of these components are related to creating an immersive environment that facilitates learning<sup>31</sup>.

In short, an RPG is a game in which a person (in this case, the teacher) tells a story that is enacted by the players who are given roles as the various pieces of background information. Challenges related to the story are then presented and must be

addressed by all participants. Each player represents a character in the story and is attributed (quantitatively-defined) skills. These skills are tested during the game to decide if the character succeeds in his or her attempt to perform a task that solves the problem or overcomes the challenge. The skill is usually tested against some kind of quantifiable decision-making system, such as rolling dice. The dice introduce randomness into the game, create suspense and provoke playfulness among the players. This is the main difference between role-play, which refers to the playing of roles in a theatrical play, and RPG, that introduces clear rules according to which the players must decide how to act.

One of the most interesting and significant aspects of the RPG is that the whole team must win together: there are no losers in this kind of cooperative game, ensuring that nobody is excluded or feels excluded.

One example of an RPG that has been created for teaching cell biology may be found in Appendix B: Example history – ATP synthesis and C: Character sheets – ATP synthesis.

Healthcare professionals often work in teams, so in addition to learning specific concepts on a course, practicing cooperation is also an important part of their education. RPGs are intrinsically cooperative games because there is no way for a player to win alone.

In Brazil, medical school begins as an undergraduate program, and cell biology is one of the first courses taken by students. Teaching cell biology to freshman students is not a simple task, especially because cell biology features a lot of abstract knowledge. Cell biology encompasses microscopic and submicroscopic aspects of life, such as molecules and energy. These concepts may be difficult for a freshman to grasp. Thus, even with the use of lectures and plenty of multimedia material, such as slides, videos and animations, it may be difficult for students to understand and learn the course material<sup>19,21,32</sup>. Simply presenting the information to the student is often not enough. The student must be engaged and interested in the subject in order to learn the material effectively. In fact, this is true for most lecture-based courses<sup>33</sup>.

In this study, we addressed the following questions: Will students feel more satisfied with this alternative methodology? Will they approve of the new methodology for learning cell biology? Will they learn and retain the acquired knowledge better than students who listen to lectures?

In this report, we present a novel way of teaching and learning cell biology that involves an immersive RPG-based class. This RPG introduces a playful aspect that may lead to a more pleasant and active way of learning, while aiding the development of cooperative and sociability skills.

**METHODOLOGY**

The study was undertaken on two public universities in Brazil from 2008 to 2010. One is a federal university in the state of Paraná, and the other is a state university in the state of São Paulo. All of the students were in the first semester of an undergraduate medical course, which is when the cellular biology course is taken. The average student age was 18, and all the students had begun the medical program after a very competitive admission process (known as the “vestibular system”). At the federal university, the applicant to opening ratio was 30:1, and at the state university, it was 79:1. These students were thus expected to be knowledgeable and possess a variety of specific skills upon admission to the programs.

The students’ participation was voluntary. Of 405 eligible participants, 18.3% declined to participate in the study. All of the participants were given information on the research, and those who decided to participate (n = 331) freely provided written informed consent. The study was approved by the National Committee for Research Ethics (Comissão Nacional de Ética em Pesquisa – CONEP; <http://portal2.saude.gov.br/sisnep/pesquisador/>) under the code CAAE-0520.1.146.000-07.

For each course, the students were initially divided into two groups according to the alphabetical order of their names, dividing the class in two halves: one group (the lecture-based group) attended a two-hour lecture, and the other (the RPG group) took a two-hour RPG-based class on the same topic. The groups were then switched to the other type of class to learn another topic, meaning each student had the chance to participate alternately in the lecture-based group and in the RPG group. The diagram in Figure 1 shows a (hypothetical) example of how the students participated in the classes in each period. Three topics were developed for the RPG-based classes (two for each course term), focusing on ATP synthesis, the cell cycle, endocytosis and cellular digestion. From these three topics, two were selected for the RPG-based classes in each course term. As the RPG-based classes were optional, some students did not participate in either RPG group and only attended the lecture-based classes (Figure 1). These students were only included in the lecture-based group for the analyses. An average of 33.1% of students attended the RPG-based classes, and 66.9% attended the lectures. The number of participants in each group for each course in each term is provided in Table 1.

**TABLE 1.**

Scores on cell biology exams after lecture- or role-playing game- (RPG) based cell biology classes. Data reported as mean score ± SEM (n = number of participants).

	Year	Question Topic	Lecture	RPG	P Value
Federal University	2008	ATP synthesis	6.9 ± 0.20 (62)	7.3 ± 0.30 (24)	.21
		Cell cycle	4.5 ± 0.43 (53)	4.9 ± 3.34 (30)	.59
			4.3 ± 0.28 (53)	4.7 ± 0.30 (30)	.29
	2009	ATP synthesis	7.0 ± 1.52 (63)	7.0 ± 1.56 (25)	.94
			Cell cycle	3.3 ± 0.21 (58)	2.8 ± 0.28 (35)
				<b>1.9 ± 0.18 (58)</b>	<b>1.3 ± 0.19 (35)</b>
State University	2008	Endocytosis	5.4 ± 0.41 (76)	5.3 ± 0.56 (33)	.92
		Cell cycle	7.1 ± 0.29 (76)	7.1 ± 0.47 (33)	.93
			3.8 ± 0.31 (84)	3.6 ± 0.51 (25)	.78
	2009	Endocytosis	6.7 ± 0.29 (68)	6.2 ± 0.35 (40)	.31
			7.0 ± 0.27 (68)	7.1 ± 0.43 (40)	.75
		ATP synthesis	5.2 ± 0.45 (60)	4.1 ± 0.48 (48)	.10
		7.6 ± 0.25 (60)	7.3 ± 0.33 (48)	.40	

A narrator trained specifically to lead the class (a lecturer, graduate student, or undergraduate student who had already attended the cell biology course) guided each team. Their training involved several meetings to discuss and deepen their understanding of the information on cell biology to be taught (that was consistent with the material covered in the lectures) as well as the story they would narrate (see appendix). The teacher’s role in such a class was also discussed. Two teachers, 7 graduate cell biology students and 7 undergraduate students took part as narrators. For the RPG-based classes, the students were subdivided into teams with a minimum of 5 and a maximum of 10 students per team, according to the number of narrators in each course. For example, if there were 45 students and 5 available narrators, each team would be composed of 9 students. The stories for each class were created by groups that were involved in a university teacher training program. A simple guide explaining how to conduct an RPG-based class is presented in Appendix A: How to play the game.

Between one week to a month before the “test” class, we gave all of the students a 20-minute explanation of the study.

The students were briefly told to study the information in cell biology textbooks. Those who had agreed to participate in the RPG-based classes were instructed to organize themselves into teams and were told that they would have to respond a questionnaire. Character sheets for the game (see Appendix C) and additional information on the project were made available to all of the students at the federal university by email, and to all of the students at the state university by means of a distance-learning tool (<http://teleduc.nied.unicamp.br/>). Students had received no preliminary information on the stories to be used in the RPG.

The lectures and RPG-based classes were held at the same time and lasted two hours. The lecturer was the teacher regularly assigned to the class, and the previously trained personnel gave the RPG-based classes.

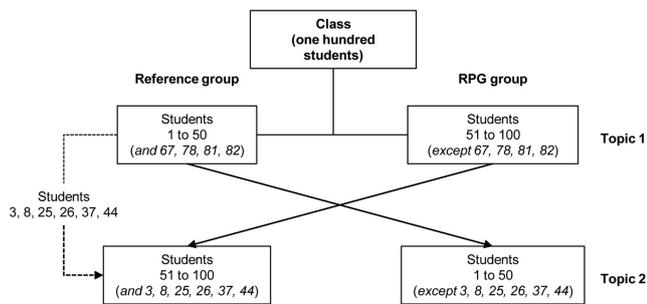


Fig. 1 - An example on how students attended the two different groups in two different topics of the classes. In this example, students 3, 8, 25, 26, 37, 44, 67, 78, 81 and 82 did not participate in any RPG-based class.

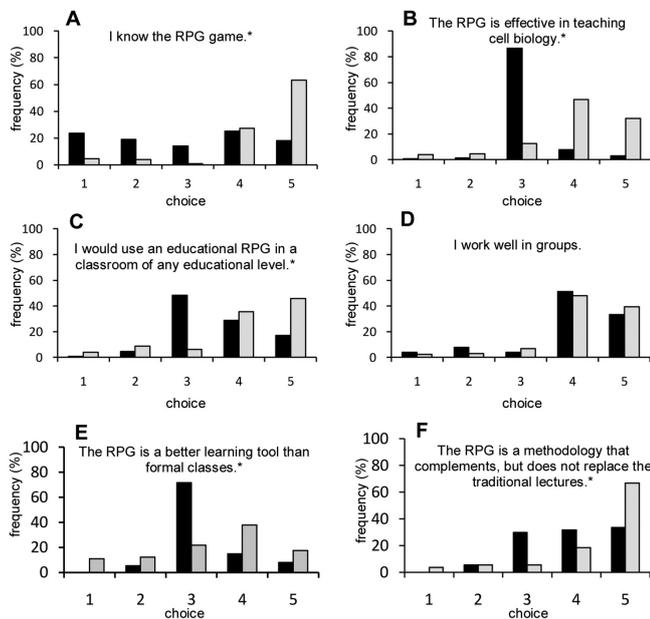


Figure 2. Frequency distribution (%) of responses to the questionnaire administered to first year medical students regarding their feelings about the use of a role-playing game- (RPG)-based strategy in class. Graphs were constructed using data from a questionnaire administered both before (black bars) and after (grey bars) the RPG-based class. The Likert scale choices were as follows: 1 = completely disagree; 2 = partially disagree; 3 = neutral/no opinion; 4 = partially agree; 5 = completely agree. \*Indicates that the distribution of the responses from before and after the class were not independent ( $P < 0.05$ ).

## Evaluation

### Pre/post comparisons within the RPG-based class participants

We administered pre-tests (two days to one week before the class) and post-tests (just after the class) to all of the students that attended the ATP synthesis and cell cycle RPG-based classes. The tests consisted of statements (Figure 2), and respondents were to agree or disagree with the statements using a five-point Likert-type scale. The statements were to evaluate student satisfaction with the RPG-based class. We compared the distributions of the responses for each assertion using the contingency Chi-square test with Yates' correction (as some of the response frequencies were under 5). The null hypothesis was that the pre- and post-test answers were independent.

### Short-term evaluation by exam

We also used the scores students obtained in exam questions normally used for these courses to compare what the students had learned in the two types of classes. The questions were different for each course and each year, depending on the course coordinator. The questions were posed in an open-ended format, pertaining to different levels of Bloom's taxonomy for the cognitive domain 34. The questions were scored by the course coordinator who did not know which group the student was in, and the results were compared using the unpaired student's t test.

### Comparison of medium-term retention of content

We measured the medium-term retention and comprehension of the class content through an unannounced four-question evaluation tool (two questions for each topic, presented in Table 2) that was administered one year after the students had completed the cell biology course. The tests were applied in a 40-minute period during another course that the students were taking. The class composition was almost identical to the previous year, since the students follow the same courses during their degree course. Three different teachers scored the tests independently, and the identities of the respondents were not made available to them. A Pearson correlation was used to test the scores awarded by each teacher. The average score given by the three teachers was used to compare the two groups (reference versus RPG) using the unpaired student's t test.

For all statistical analyses, differences were considered significant when the P values were  $< 0.05$ .

TABLE 2.

Questions for medium-term evaluation. The tests were applied unannounced to the students one year after they had completed the course.

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### Endocytosis and cellular digestion

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Briefly describe one of the endocytosis and cellular digestion pathways; use the main organelles and proteins involved in the process in your description.

Comment on the importance of the cell membrane receptors (plasma membrane and organelles membranes) in the cellular vesicular traffic.

### Cell cycle

Check points during the cell cycle guaranteeing that the mitosis will generate two daughter cells identical in genetic content. Two of these check points are essential: the transition  $G_1 \rightarrow S$  phase, and the transition metaphase  $\rightarrow$  anaphase. Which factors are checked in these check points, and what is their importance to the success of the process?

Several drugs used in cancer therapy alter microtubules' dynamics and play an important role in the cell division mechanism. How may these modifications affect the cell division process? How may this be useful to the treatment of cancer?

### ATP synthesis

Describe how ATP is produced in the mitochondria, citing the energy conversion processes (chemical, redox potential, membrane gradients).

What should happen during the ATP synthesis process (citric acid cycle and electron transport chain) if the mitochondria is treated with oligomycin (a drug that inhibits the ATPsynthase)? Provide a detailed explanation.

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## RESULTS

### Student perception of the RPG method

To shorten our report of the results of the Likert-scale questionnaires, we considered partial or complete disagreement (Options 1 and 2) to be disagreement, and partial or complete agreement (Options 4 and 5) to be agreement. Option 3 remained "neutral / no opinion".

The frequencies of responses for the ATP synthesis and cell cycle classes at the federal and state universities in the different years (2008-2010) were compared, and there were no differences among the topics or among the years. Thus, we combined all the RPG groups for the subsequent analyses of the students' opinions on the methodology.

Regardless of the slight differences in phrasing used in the questionnaires on ATP synthesis and the cell cycle, opinions on the RPG as an educational tool were grouped and are summarized in Figure 2. Before the class, 45% of the students were

already familiar with RPG games (Fig. 2A) but were neutral regarding its effectiveness in an educational setting (88.3% chose Option 3; Fig. 2B). After the class, this percentage dropped substantially to 10.5%, with 78.4% of the students considering the RPG an effective tool for learning (Chi-square = 195.4, d.f. = 4,  $P < 0.0001$ , fig. 2B). After the class, 81% of the students responded that they would use this method in a classroom (Chi-square = 73.3, d.f. = 4,  $P < 0.0001$ , Fig. 2C).

The pattern of responses concerning working in groups did not change. Most of the students felt comfortable working with their peers. Before the class, 79.1% answered that they worked well in groups, and this percentage rose to 85.3% after the class (Chi-square = 7.9, d.f. = 4,  $P = 0.095$ , Fig. 2D).

Overall, the students preferred the RPG-based classes to the lecture-based classes, although this was not unanimous (Fig. 2E). Before the class, 71.3% of the respondents were neutral regarding the assertion that the RPG was a better learning tool than formal lectures. After the class, 55.4% agreed with the statement, and 23% disagreed with it (Chi-square = 31.5, d.f. = 4,  $P < 0.0001$ ). Moreover, most of the students (88.6% on the after-class questionnaire) affirmed that RPG-based classes should be used as a complement to lectures (Chi-square = 23.3, d.f. = 4,  $P < 0.001$ , fig. 2F).

We corroborated the results presented here with informal conversations with some students after the classes and with written statements collected at the end of the course. One comment made by several students was that they might develop different perspectives on the subjects when learning in a RPG-based class. For example, they perceived that the events in ATP synthesis occur in parallel rather than in a sequence, as with the presentation in a textbook or in a lecture. Similar comments were made by those students that participated in the endocytosis RPG-based class.

Students also stated that peer discussion allowed them to address misunderstandings in a more meaningful way.

Some students who did not participate in any of the RPG-based classes voluntarily offered the information that they were afraid of missing material or not learning effectively by participating in a class different from a lecture.

### Scores on regular exams

Answers to 14 test questions were analyzed independently for differences between the RPG- and lecture-based groups in the 4 courses conducted in this study.

No differences were observed between students that took lecture-based versus RPG-based classes, except for the responses to one question about the cell cycle (table 1). On this question, RPG-group students at the federal university achieved

lower average scores than the scores from the reference group ( $t = 2.2$ ; d.f. = 91;  $P = 0.03$ , table 3).

**TABLE 3.**

Scores on an unannounced cell biology exam one year after the lecture- or role-playing game- (RPG) based class. Data reported as mean score  $\pm$  SEM ( $n =$  number of respondents).

Institution	Year	Question Topic	Lecture	RPG	P Value
Federal University	2009	ATP	4.5 $\pm$ 0.45 (24)	5.3 $\pm$ 0.51 (14)	.26
		synthesis	<b>1.8 <math>\pm</math> 0.31 (23)</b>	<b>3.0 <math>\pm</math> 0.57 (14)</b>	<b>.05</b>
		Cell cycle	2.4 $\pm$ 0.37 (24)	3.4 $\pm$ 0.73 (11)	.16
			1.1 $\pm$ 0.44 (21)	1.6 $\pm$ 0.92 (10)	.64
State University	2009	Endocytosis	5.1 $\pm$ 0.35 (37)	4.8 $\pm$ 0.33 (20)	.61
			4.9 $\pm$ 0.46 (37)	4.5 $\pm$ 0.55 (18)	.61
		Cell cycle	2.4 $\pm$ 0.39 (30)	1.6 $\pm$ 0.37 (18)	.18
			<b>1.5 <math>\pm</math> 0.32 (13)</b>	<b>4.1 <math>\pm</math> 1.26 (10)</b>	<b>.03</b>
	2010	Endocytosis	4.6 $\pm$ 0.35 (14)	5.3 $\pm$ 0.47 (17)	.24
			4.5 $\pm$ 0.38 (16)	4.2 $\pm$ 0.35 (17)	.61
		ATP	6.0 $\pm$ 0.45 (16)	6.1 $\pm$ 0.30 (17)	.91
		synthesis	5.2 $\pm$ 0.52 (17)	5.7 $\pm$ 0.42 (17)	.45

**Medium-term learning: scores one year after the class**

The aim of this analysis was to assess the students' medium-term knowledge retention. A total of 12 questions were analyzed independently (because the students in each class responded to 4 questions and we have applied this evaluation to 3 classes), and the data is presented in Table 3. The average scores for the RPG group were higher than those for the reference group on two of the 12 follow up questions administered one year later ( $t = 2.2$ ; d.f. = 36;  $P = 0.04$  and  $t = 2.3$ ; d.f. = 20;  $P = 0.03$ ).

**DISCUSSION**

This report proposes a way of teaching and learning that was accepted by students as an effective methodology. This finding contrasts with previous reports suggesting resistance by both students and teachers<sup>35</sup>. We believe that this acceptance is because the RPG encourages cooperation and active participation by the students. By telling a story in which everyone takes part, there is greater student interaction and, as a consequence, we may expect better performance in their construction of knowledge. The RPG can proceed in various different directions, in contrast to the more direct line of thinking gene-

rally associated with traditional lectures or by reading a book. This approach gives students different pathways to consolidate the new knowledge learned.

By observing the students during the RPG-based class, we may confirm the occurrence of peer instruction. Several studies have suggested the potential for this kind of interaction<sup>9,36,37</sup>. Students interact with each other when they explain the biological processes that are being discussed, as well as when they search through the provided resources together and debate possible ways to accomplish the tasks and to solve the problems proposed by the teacher. In accomplishing these tasks, their peers' explanations may help them to understand concepts, actions and decisions. Moreover, hearing an explanation from a colleague and examining his or her explanation may serve as a powerful exercise in metacognition<sup>9</sup>. The teacher helps students by pointing out and correcting misconceptions that arise during the class and by giving clues that help solve the problems. If students have the opportunity to understand why their answers are wrong and to discuss them with the teacher, they have a greater chance of making conceptual changes that help them to learn<sup>38</sup>.

The average grades attained by the RPG and reference groups in the formal evaluations were the same, but students considered RPG-based classes better learning opportunities than lectures. Grades in regular exams are substantially influenced by the student's own preparation before the exams, so we cannot rule out that this finding might be independent from the class type. However, the reference groups consisted of students from the same class (in the same time period), and they were interchanged during the course, so we attribute this result to the experimental conditions. We believe that active participation in constructing new concepts and connections on the topic being taught produces the opinion that this methodology is better for learning. For an RPG-based class to progress, active participation by the students is essential and this also emphasizes their responsibilities for their own education. In a lecture, their participation is optional. They can simply sit and listen to the teacher in a way that may lead to superficial or rote knowledge<sup>39,40</sup>.

Students did, however, decide that RPG-based classes should be used in addition to lectures. The reasons for this conclusion are not clear, but we may argue that resistance to new methodologies might constrain their participation. This resistance has been reported by Abeyratne<sup>41</sup>, discussed by Larsson<sup>40</sup>, and is supported by reports from some students that declined to participate in RPG-based classes. They said that they were not comfortable with learning using an unknown methodology.

In most groups, the classes were led by non-teachers (i.e., graduate or undergraduate students), some of whom were using this methodology for the first time. We expect that the involvement of more teachers in RPG-based instruction would improve the students' overall performance. The role of the teacher and the teacher's instructional style in the construction of students' new knowledge has been debated in several studies<sup>42-44</sup>. We argue that as teachers are trained and gain more experience with the RPG method, they will produce better results in terms of the students' quantitative performance.

Another interesting result was that students in the RPG group performed better than the reference group on two of twelve questions related to cellular biology: specific information in an unannounced exam given one year after the completion of the course. A paradigm of lecture-based formal education is that students retain information only until the exams, and then they discard the information. This paradigm is typical of the "transmission of knowledge" model that most educational institutions use<sup>3</sup> and is opposed to the meaningful learning model proposed by Ausubel<sup>14</sup>. We argue that the involvement of the student with the class content via the RPG is a factor that may lead to better performance in medium-term retention of knowledge, at least for some content. While trying to solve the problems proposed by the teacher in the RPG, students were required to apply the class knowledge to obtain the desired result. This application of knowledge was achieved via peer discussion or by searching through books, rather than by passively listening to the teacher. This active participation in the class could result in an effective learning process and information comprehension by the students, leading to the integration of the new content into the student's previous knowledge network. In a preliminary study, we found that once the students knew the class dynamics (i.e., the RPG-based class format), they performed better on quantitative evaluations (data not published).

By performing roles directly related to the content to be learned, students had the opportunity to gain a different perspective on the cellular processes. For example, they reported that they had never thought about the events during ATP synthesis occurring in parallel because books (or lectures) generally present these events as sequential (e.g. glycolysis à citric acid cycle à electron transport chain à ATP synthase). The RPG allowed them to perceive the process as a whole, in which each event occurs independently, and in parallel, as the substrates became available. Students also commented that peer discussion allowed them to address misunderstandings in a more meaningful way. The peer discussion allowed individuals with a similar language to discuss and provide each other

with reasonable explanations. This led to a better understanding of the material, as reported by Smith and colleagues<sup>9</sup>.

Although RPGs have long been used in education in some areas<sup>27-29,45</sup>, there are no published studies that have used this specific methodology to teach cellular biology or other medical courses. The originality of our research reveals possibilities for improving and using RPGs to teach many different health science courses. We believe that this methodology gives the students the opportunity to understand and acquire the skills that underlie simple specific knowledge acquisition, such as working in a team<sup>46,47</sup>, conflict resolution<sup>48,49</sup> and problem solving by peer discussion<sup>36,50,51</sup>.

This study revealed some of the limitations of cooperative learning. Teaching using RPGs was a greater challenge. Teachers had to be very well prepared because students tended to ask more questions when actively participating than when passively listening. The challenge faced by the teacher when using this methodology is thus greater, and as Gillies and Khan observed<sup>44</sup>, the cooperative learning experience is influenced by the teacher's discourse. An RPG-based class often covers less material than a lecture-based class. However, we believe that the increase in comprehension and the inspiration to seek more knowledge compensate for this limitation. Teachers tend to be orthodox and reluctant to change their teaching style<sup>35</sup>. Despite our efforts to recruit teachers, only one actually took part in the study by learning how to direct an RPG class. Nevertheless, all students who participated in the classes as teachers were very enthusiastic about the format, and most continued to participate throughout the entire three-year study period.

## SUMMARY AND CONCLUSIONS

In this study, we propose a new methodology to teach and learn cellular biology, using RPG-based classes. Although we did not encounter major differences in quantitative evaluations on knowledge acquisition, we found that the students accepted the methodology and were willing to use it. These findings support our conclusion that the methodology is worthwhile and should be tested in different educational situations. We believe that the students could have produced better outcomes if they had been given the chance to participate more often in this type of class. As they have now had contact with this previously unknown method (each student took just one RPG-based class), they would be able to benefit from knowing the method in subsequent classes, leading to better knowledge acquisition.

We also conclude that this type of class may improve the acquisition of skills such as cooperation and creativity while

fostering a sense of belonging because of the intrinsic aspects of RPGs. RPGs require players to act together and in a coordinated fashion to succeed at the proposed challenges, which aids the social construction of knowledge.

#### ACKNOWLEDGEMENTS

We would like to thank all of the students and teachers who participated in the classes, as well as those who cooperated to create the stories. We also thank the Cellular Biology and the Biochemistry and Molecular Biology Departments at the Federal University of Paraná (UFPR) and the Anatomy, Cellular Biology, and Physiology and Biophysics Department at the State University of Campinas that allowed us to conduct this study. We also thank Dr. Lucelia Donatti, Dr. Silvia Maria Suter C. Cadena and Dr. Maria Berenice R. Steffens at UFPR and Dr. Elenice A. de Moraes Ferrari at the State University of Campinas, for allowing us access to the students in their classes.

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#### AUTHORS' CONTRIBUTION

Os autores participaram na discussão do projeto, dos resultados, revisão do artigo final.

#### CONFLICTS OF INTEREST

Declarou não haver.

#### CORRESPONDENCE ADDRESS

Marco Antonio Ferreira Randi  
Departamento de Biologia Celular. Universidade Federal do Paraná  
Curitiba  
CEP: 81531-980 Cx Postal. 19088 PR  
E-mail: mafrandi@ufpr.br