Published in the Slovak Republic
European Journal of Contemporary Education
E-ISSN 2305-6746
2021, 10(1): 137-147
DOI: 10.13187/ejced.2021.1.137
www.ejournal1.com

Production of Comics in POWTOON as a Teaching-Learning Strategy in an Operations Research Course

Laura Plazola Zamora [a], Salvador Sandoval Bravo [a, *], Alejandra Gómez Padilla [a]

[a] Centro Universitario de Ciencias Económico Administrativas, Universidad de Guadalajara, Mexico

Abstract

This paper proposes the production of animated comics in POWTOON to serve as a visual collaborative tool and a teaching-learning strategy for a course on Operations Research. This proposal aims to achieve meaningful learning of the subject matter, incentivizing the creativity of undergraduate students of marketing and business at the Guadalajara University, given that the production of comics develops, in students, cognitive and practical abilities such as the following: reflection; critical thinking; observation; analysis; synthesis; analogy; systematization; a sense of collaboration; and, teamwork. To validate the substantial improvement in student performance after producing the comic, a paired two-sample means t-test was carried out for 35 undergraduate students of marketing and business at the Guadalajara University who were enrolled in the same Operations Research course. The results obtained show that student performance improved considerably after the production of the comics, facilitating both teaching and the students' significant learning. In this sense, the use of POWTOON demonstrated to be a good learning alternative, since the students for the realization of the comic were able to recover and review the information acquired, write a script, and organize images, videos, sounds, and text in a congruent and didactic way, even when it comes to complex topics.

Keywords: collaborative learning, undergraduate education, educational comics, teaching-learning strategy.

1. Introduction

Operations Research (OR) and decision making are of fundamental importance for economics and the administrative sciences, given that these disciplines involve the study of a series of formal procedures applicable to a large number of organizational situations, such as production,

* Corresponding author
E-mail addresses: Salvador.sandoval@academicos.udg.mx (S.S. Bravo), lplazola@gmail.com (L.P. Zamora), alejandra.gomez@cucei.udg.mx (A. Gómez Padilla)

transport, logistics, resource allocation, profit maximization, and cost minimization problems. These disciplines require the use of optimization and control models for supply, demand, production, and consumption functions, among others. The professional training of Guadalajara University undergraduate students includes the development of logical and mathematical abilities that enable them to make adequate business decisions, based on the application of quantitative tools. In this sense, an essential characteristic of decision making in business is that it is based on the rationality assumption. Therefore, organizations and companies act reflexively, possess information, calculate the risks and benefits of their decisions, and try to maximize profitability or minimize costs, namely, optimizing their expectations based on their limited resources. Thus, operations research methods enable the best possible options to be chosen, depending on the specific characteristics of each situation or problem.

Unfortunately, courses such as Operations Research, do not inspire the total interest of the students and always represent a challenge for the professors teaching such courses. At an undergraduate level, access to optimization and Operations Research concepts requires a lengthy process of abstraction which obliges the student to undertake rigorous mental activity, but which also offers a propitious field for the development of creativity.

The term learning strategies refers to the cognitive operations that the student undertakes in order to organize, integrate, and prepare information (Valle et al., 1999). These strategies are understood to be sequences of activities that are chosen to facilitate the construction, permanence and transfer of information or knowledge. This term also corresponds to those strategies used by the professor to mediate, facilitate, promote and organize learning (Campos, 2000). It is essential, for both the learning process and for students to learn, that the course content is meaningful to them (Barbosa et al., 2017).

Stemming from the aim of motivating students, active methodologies have emerged as an important instrument in the use of problematization as a teaching-learning strategy (Caldarelli, 2017). These active methodologies facilitate interaction among the student body, social integration, the ability to communicate and collaborate, the change of attitudes, the development of thought, and discovery, at the same time fostering attitudes of cooperation and solidarity (Silva et al., 2014).

According to Silva et al. (2012), active learning is associated with a collection of strategies for carrying out the learning process in such a way as to involve active student participation, among which strategies are problem-based learning, simulations and business games. The use of movies, comics and comic strips, conceptual maps, and improvisational theatre, among others, also contribute to the learning process (Ramírez, 2010; Rodrigues, Arroio, 2011; Carvalho, Dias, 2014; Oliveira, 2014; Kim et al., 2017).

The latest trends in education advocate working in groups as a predominant methodology, in which students themselves are the protagonists in the work undertaken in the classroom. Students do not learn solely from the professor and/or the textbook nor solely in the classroom, also learn from many other sources, such as communication media, their classmates, and society in general (Meso et al., 2011). There are many and varied tools used to facilitate communication and cooperation among those participating in a collaborative work project, ranging from email to collaborative online environments.

It is important that higher education institutions reflect on the changes that have occurred in the educational process. New educational proposals must prioritize the active and collaborative methodologies that can be combined with traditional methods (Silva et al., 2014), and must prepare teachers to plan strategies that increase their efficacy in the classroom (Barbosa et al., 2017).

This paper proposes the production of comics in POWTOON to be used as a visual collaborative tool and a teaching-learning strategy on the Operations Research course. This proposal aims to achieve the meaningful learning of the subject matter, incentivize the creativity of marketing and business students at the Guadalajara University. In this sense, the present study is distinguished from prior research by its use of comics, developed in POWTOON, as a complementary learning strategy for course content pertaining to Operations Research, which is studied particularly in higher education and on which no research is reported in the current literature. The present study then describes, in detail, both the teaching practice undertaken and the results obtained.

2. The comic as an educational tool

The comics are a visual resource for transmitting a message in an entertaining and enjoyable way, which can be used for educational purposes and which has become a tool that, further to facilitating distinct abilities, also promotes the formation of values and attitudes. The impact of the visual image, on its own, transmits sensations, feelings and emotions favorable for motivating students to study in each of the academic areas and, at the same time, becomes, itself, a source of learning (León, 2014).

Sones' (1944) classical study demonstrated the enormous impact of comics on popular culture, given that, in 1944, 95 % of all 8-14-year-old children and 65 % of 15-18-year-old adolescents read comic books, which both age groups thought were easy to read and depicted interesting stories. These readerships levels led to a broad and wide-ranging debate on the advantages of this tool for educational and instructional purposes.

Carter (2018) explores the characteristics of graphic novels, comics, and other visual tools of great value for classroom teaching, analyzing the abilities and competencies that can be taught using these educational resources. Furthermore, said author offers an explanation of the resistance, observed in academic environments, to the use of these resources as a product of policy and practice deeply embedded in traditional educational systems.

Tatalovic (2009) identified and reviewed a large variety of scientific comic strips and their application in both education and the popularization of science, finding a wide diversity of comics in terms of style, presentation, size, depth, and scientific discipline. His analysis highlights the potential benefits of comics for promoting scientific literacy across all educational levels, although it does recognize their limited utility outside the classroom.

Trnova et al. (2013) consider that the use of comics in scientific education may provide meaning for science, making it relevant, interesting, and accessible for students. They conclude that comics should be used adequately as a complementary teaching tool, given that they help to detect and correct some erroneous concepts, deepen comprehension of natural phenomena, and develop communication and problem-solving competencies in students.

Lazarinis et al. (2015) analyze the benefits of tools for creating comic strips for producing alternative attractive didactic material in different academic disciplines, despite the lack of technical training for teachers in comic strip design. They conclude that, despite the limitations, these didactic resources are often very useful for teaching.

Koutníková (2017) analyzes the application of comics (supported by conceptual maps) in preschool education, with the objective of teaching children to understand certain physical phenomena and ascertaining how the use of comics contributes to changing the perceptions of said phenomena. She shows that comics represent a modern pedagogic resource that makes the study of nature interesting and understandable for preschool children.

Green and Myers (2010) analyze the use of comics in medical education and patient care, considering that comics represent a new and creative form of learning about and teaching public health topics, such as those related to patient care, medical education, and social criticism of the medical profession.

Gonik and Smith (1993) develop, in comic form, a complete text dealing with descriptive statistics, probability, and inferential statistics, showing that it is possible to design a comic for an entire academic discipline. Gonik has also, either as author or co-author, published academic texts in diverse areas (algebra, economics, calculus, physics, and chemistry, etc), using comics as the main teaching resource.

Some successful experiences with the use of comics as a teaching-learning strategy for different disciplines. García (2013) uses comics as a didactic resource in the teaching of foreign languages. Alonso (2012) presents a didactic proposal which considers comics as a valuable tool for the teaching and learning of Spanish. Ramírez (2010) presents comics as educational support material for the subject of mathematics for children in the first grade of primary school. Barraza (2006) uses the comic as didactic material for history teaching at secondary level in Chile. Green (2015) and Kim et al. (2017) use comics as both a learning strategy and a strategy for forming students' professional identity during their medical training. Toh (2009) proposes the use of comics for teaching algebra to academically disadvantaged children. Chen (2015) compares an easy-to-use comic composition system (CCS) and drawing on paper in order to identify the level of confidence in elementary school students as they learn how to draw.

There are various applications that could be used as tools for creating material to enable students to actively participate in their learning process, some of which are specific to the production of comics, such as Pixton, Storyboard, and Comic maker, among many others.

According to León (2014), the construction of comics leads the student to reflect and engage in critical thinking and reasoning, and, in the same way, enables the student to develop thought processes, such as observation, comparison, classification, analysis and synthesis.

In this exercise, the students used an online application called POWTOON (https://www.powtoon.com/) to create videos and animated presentations with objects, text, images and sound, which may be either predetermined or uploaded by the user.

POWTOON is commonly used in the academic environment for communicating an idea through animated videos. The final result is a cartoon of a person speaking and displaying dialogue boxes written by the user, giving the appearance of a comic.

Recent studies have successfully used POWTOON in distinct educational experiences, with, for example; Rioseco et al. (2017) incorporating POWTOON as a learning activity in a course on the use of technological innovations as a didactic resource for pedagogic programs. Bravo-Acosta and García-Vera (2020) use POWTOON as a collaborative learning tool under the flipped classroom model for developing multiple intelligences in students. Highlighted among other similar studies is the analysis conducted by Herawati et al. (2019) about the development of educational videos on POWTOON-based work and energy topics to support learning under a flipped classroom model.

Fig. 1. Screenshot of a video prepared by the students on the Operations Research II course

This tool is useful in collaborative learning activities, such as alternative evaluation, or to incentive students to create content for the class and thus raise their academic performance.

The following can be listed as advantages of using POWTOON (Rioseco et al., 2017):

1. It enables the development and presentation of any topic of interest.
2. It captures the attention of the audience (students)
3. It is easy to use.
4. It includes a wide variety of resources.
5. It is easy to share via social networks.
6. It makes classes more dynamic.
7. It requires the students to read, analyze, and synthesize the topics assigned, in order to then present them.
8. It enables a higher level of comprehension and assimilation of the content assigned.
9. Different types of formats can be incorporated, widening their potential and flexibility by means of audio and visual (both static and dynamic) resources.
10. Communication is clearer, more concise and more fun.
11. It is free to use and compatible with various operating systems.

The main disadvantages are that it requires much more work than some other applications, while a video cannot be edited if the application is not connected to the internet, and it cannot be downloaded.

3. Implementation of the strategy

The course Operations Research belong to the basic subjects for the Guadalajara University's Marketing and International Business undergraduate degree programs. The curriculum for these programs includes two Research Operations courses, the first of which (IO1) mainly covers topics related to complete linear programming. The second course, titled Operations Research II (IO2), aims to ensure that the student applies optimization techniques to the resolution of problems in real situations focused on decision-making as part of the process of managing organizations.

The content of IO2, comprises the five units listed below:

1. Decision-making models.
2. Multiobjective Programming.
3. Markov Chains.
4. Inventory Models.
5. Queueing Models.

Further to the extent of its content, this course is particularly complex for the students on these degree programs. According to Guadalajara University registers, the fail rate for the first Operations Research course (IO 1) is approximately 40 %; however, there are no global registers for the second course.

The exercise of producing comics was implemented in the course II from the first semester of 2019 (2019-A) academic year. The group comprised 40 students from the Marketing and International Business undergraduate degree programs, of which 65 % were women and 35 % men. It is important to note that the group of 40 students were all students enrolled in the said course with one of the authors of this document who teaches the subject, and in this sense, the results of this learning experience can be considered as a case study.

Over the length of the course, 3 mid-term exams were applied, in which the following results were obtained: 62 % of students passed the first mid-term and 38 % failed; 22 % passed the second mid-term and 78 % failed; and, in the third mid-term, 69 % passed and 31 % failed.

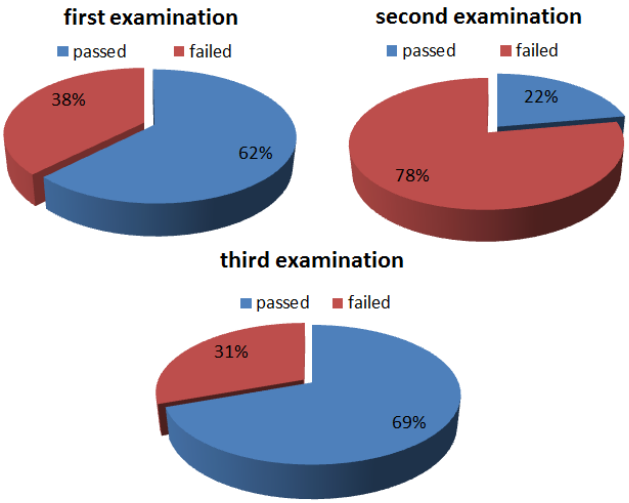

Fig. 2. Percentages for passing and failing mid-term exams
Source: Prepared by the author based mid-term exams results

The weighting assigned to each mid-term exam was 20 points for the first mid-term, 20 points for the second, and 15 points for the third. The students were notified of both this weighting and the content to be included in each mid-term at the beginning of the course.* As can be observed in Figure 2, which presents the results for each exam, a higher fail percentage was obtained for the second mid-term exam. The subjects evaluated by this exam were multi-objective programming and multi-criteria decision-making.

* The course was graded on a scale of 100 points, with a passing grade of at least 60 for the course to be obtained based on the exams, coursework, and a final project.

With the aim of providing students a better understanding of the subjects of the second mid-term exam, the strategy of producing comics was implemented. It is important to note that this experiment was not explicitly planned at the beginning of the course, but was implemented, in response to the poor performance of the students, especially in the second mid-term exam. In this sense, this strategy was devised like an alternative learning experience based on the instructor reflections and sought to explore the use of this visual tool both to foster autonomous learning in the students and to reinforce the knowledge and abilities developed via the thematic content included in the second mid-term exam.

The students used POWTOON to explain both the methods and the solution of multi-criteria and multi-objective problems. The main intention was to involve students in the production of comics which could be used to show the potential for the development of abilities for undertaking research and preparing summaries, as well as their analytical capacity, and at the same time learning the course content.

Listed below are the instructions the students followed to produce the comic, from assignment the topic to presenting the comic to their classmates and teacher; likewise, these steps can be adapted by other teachers who wish to implement this methodology in their courses.

1. For the production of the comics, the students worked in three-person teams, which were formed based on affinity among the classmates. The assignment topics were the following: multi-objective programming models; the restrictions method; weighted goal programming; lexicographic goal programming; analytical hierarchical programming (AHP), as used for discrete multicriteria decision making problems; and, the PROMETHEE method.
2. The teams were given two weeks to produce the comic. The work began with the search for information on the subject to be developed and the related aspects that were to be covered by the comic.
3. The teams then began to work on producing the script, which would include the protagonists and their characteristics, the setting and the dialogue. The students were required to research and learn to use the POWTOON software independently, although their teacher could respond to their general doubts about how it works.
4. The comic produced by each team was required to include a theoretical section explaining the concepts and algorithms related to the method assigned. It also had to include a practical section developing a concrete example of the method's application in the administrative economic sciences, in terms of minimizing costs, maximizing profit, or optimizing the use of time in a production process, etc.
5. The presentation of the comic by each team was required to last five to six minutes, while the topic must be explained in such a way that it could be understood by anyone educated to a minimal level of mathematics.
6. Finally, the presentation was made for discussion in class. Time was set aside for questions and answers at the end of the presentation. The members of the team that had presented the topic were responsible for answering their classmates' questions.

All the previous steps were monitored by the teacher in order that the students could make the pertinent reorientations both in the use of the software and the methodology, as well as in the theoretical part of the topics. The professor provided complementary comments during the question and answer sessions.

Fig. 3. Screenshot of a video made by the IO2 students

It should be noted that the present study does not aim to quantify the influence of the instructor's support in the feedback given on the topics selected for the production of the comics. However, a personal analysis of the errors made may lead to significant student learning. Given that it consists in more than simply passively receiving information from the professor, this process of error review may help students to modify their learning strategies (Lee, 2020). Additionally, the professor's feedback serves as a point of reference which will enable the student to self-evaluate and correct their errors, further to identifying their strengths and weaknesses, thus leading them to be self-regulating learners (Juwah et al., 2004).

The collaborative creation of content for courses is a learning experience that strengthens the development of abilities and competencies in students. The opportunity to become creators and not only consumers helps the students perfect their research, writing, and critical thinking abilities, further to the benfits of working in a collaborative peer-reviewed environment. In summary, they will discover the mechanisms via which knowledge is created (Monaco, Martin, 2007; Jain, 2015).

According to Jain (2015), students today are more adept at learning via technology and in a more visual manner, preferring environments that are more inclusive and respectful to the contribution of the team and which offer solid learning among one's peers. Furthermore, there is evidence that the use of animation promotes learning in students when used with both words and images, based on the theoretical foundation that students are more capable of making mental connections when the words and their corresponding images are worked on simultaneously (Mayer, Moreno, 2002). The use of POWTOON is, therefore, a good alternative for achieving significant learning by requiring that the student, in order to produce the comic, is able to recover and review the information acquired, write a script, and organize the images in a congruent chain of events. The video produced will be used to demonstrate the students' comprehension of the content and to help teach their classmates, even more so if it deals with a complex topic.

4. Results

After the presentations, an additional second mid-term exam was applied. On the first application of the second mid-term exam, the average grade was 40/100 with a failing rate of 78 %. On the second application of the second mid-term exam, the average grade was 89/100 with no students failing. It should be noted that both exams presented the same topics (multi-objective programming and multicriteria decision-making) with similar difficulty levels. The exams consisted in six open questions, in which the student had to construct and solve models of practical situations referring to economic and administrative topics. Figure 4 presents the results of the four mid-term exams applied, with a notable difference between bars 2 and 4, which represent the second mid-term and the additional exam, respectively.

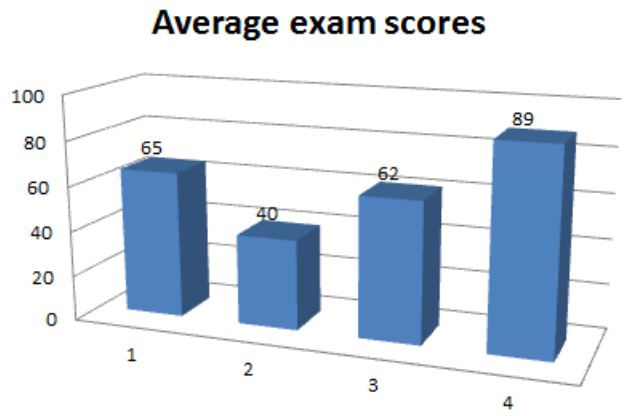

Fig. 4. Average scores corresponding to the mid-term exams
Source: Prepared by the author based on mid-term exams results

Figure 4 shows an evident increase in the average performance of the 35 students who took the recovery exam for the second mid-term exam (5 of the 40 students who made up the initial group did not take the recovery exam due to having obtained a good score in the first application of the second mid-term exam, so they preferred not to risk his obtained score).

To validate the substantial improvement in student performance after taking the comic, a paired two-sample means *t*-test was carried out for the 35 students who took the second partial exam and the recovery test for that exam, assuming the mean of the recovery exam is significantly higher than the second partial exam. Table 1 below strongly supports the hypothesis.

Table 1. Paired two sample means *t*-test

	Second mid-term exam	Recovery exam
Mean	40.21	89.24
Variance	759.23	141.42
Observations	35	35
Hypothesized mean difference	0	
df	34	
t stat	9.35	
t critical one-tail (α=.05)	1.69	
P(T<=*t*) one-tail	0.0000	

Source: Prepared by the author based on the second partial exam and recovery exam results in R.

In this sense, the experiment conducted during this course was successful, given that, on producing their comic, the students had to go into more detail on the concepts and methodologies corresponding to the topics cited above. This enabled them to produce a high-quality video, in which the topics assigned were presented with clarity and rigor, both in theoretical and practical terms, which was then reflected in a significantly improved student performance. Certainly, part of the performance increase can be explained by the similar tests that were applied; but, on the other hand, the improvement in motivation and the academic evaluation of the subjects of the course due to the realization of the comic was very remarkable. In these sense, the results confirmed that the use of these tools represents a good way of presenting, explaining and describing ideas and concepts, with the comic proving to be a fun alternative for achieving the learning objectives. In fact, due to these encouraging findings, the professor who implemented the production of comics in Powtoon decided to continue this teach-learning strategy in his subsequent courses with very favorable results.

5. Conclusion

The production of the comic by the students facilitates collaborative work and the exchange of ideas, and emphasizes the role of the teacher as a facilitator of learning. The results show not only the potential of comics as a didactic resource that promotes creativity and analytical abilities, but also how comics can facilitate students' learning.

In this particular case, it is evident that the production of comics and animated videos positively influenced the significant improvement of students' performance. In the specific case of Operations Research, the use of the comic as a teaching strategy enables the reversion of negative attitudes and beliefs about the subject and the learning of it, and helps to understand its utility in real day-to-day situations.

With this tool, the students actively participate in the construction of their knowledge, about which they are able to investigate, reflect on, discuss and reconstruct. Moreover, the environment generated in the classroom enables the development of learning strategies. This tool is an effective resource for learning about operations research and for enabling the teacher to innovate in the classroom.

References

Alonso, 2012 – *Alonso, M.A.* (2012). El cómic en la clase de ELE: una propuesta didáctica [The comic in the ELE class: a didactic proposal]. *Suplementos marco ELE*. 14: 2-89. [in Spanish]

Barbosa et al., 2017 – *Barbosa, A.D., Tavares, G.D., Kruta de Araújo, A.C.* (2017). The comics as teaching strategy in learning of students in an undergraduate management program. *Mackenzie Management Review*. 18(1): 40-65. DOI: https://doi.org/10.1590/1678-69712017/administracao.v18n1p40-65

Barraza, 2006 – *Barraza, E.M.* (2006). La historieta y su uso como material didáctico para la enseñanza de la historia en el aula [The comic strip and its use as didactic material for the teaching of history in the classroom]. *Perspectiva Educacional*. 47: 73-97. [in Spanish]

Bravo-Acosta, García-Vera, 2020 – *Bravo-Acosta, A.E., García-Vera, C.E.* (2020). Flipped classroom with powtoon to develop multiple intelligences. *Dominio de las ciencias*. 6(3): 4-25.

Caldarelli, 2017 – *Caldarelli, P.G.* (2017). A importancia da utilizacao de práticas de metodologías ativas de aprendizagem na formacao superior de profiddionais da saúde [The importance of using practices of active learning methodologies in higher education for health professionals]. *Sustinere*. 5(1): 175-178. DOI: http://dx.doi.org/10.12957/sustinere.2017.26308 [in Portuguese]

Campos, 2000 – *Campos, Y.C.* (2000). Estrategias de enseñanza aprendizaje [Teaching-learning strategies] [Electronic resource]. URL: http://www.camposc.net/0repositorio/ensayos/00estrategiasenseaprendizaje.pdf [in Spanish]

Carter, 2008 – *Carter, J.B.* (2008). Comics, the canon, and the classroom. In Frey, N., Fisher, D. (eds). *Teaching visual literacy: using comic books, graphic novels, anime, cartoons, and more to develop comprehension and thinking skills*: 47-60. Corwin Press: USA.

Carvalho, Dias, 2014 – *Carvalho, F.J., Dias, M.F.* (2014). Improvisação e competências comportamentais em processo decisório: uma proposta pedagógica baseada no teatro de improviso [Improvisation and behavioral skills in decision-making: a pedagogical proposal based on improvisation theater]. *Proceedings of the XXXVIII Encontro da ANPAD*. 1-16 [Electronic resource]. URL: http://www.anpad.org.br/diversos/down_zips/73/2014_EnANPAD_EPQ8.pdf [in Portuguese]

Chen, 2015 – *Chen, L.C.* (2015). My comic-utilizing "comics composition system" to improve students´self-efficacy and satisfaction of arts learning. *International Journal of Learning and Teaching*. 1(1): 33-37.

García, 2013 – *García, I.M.* (2013). El cómic como recurso didáctico en el aula de lenguas extranjeras [The comic as a didactic resource in the foreign language classroom]. Unpublished Master Thesis, Universidad de Cantabria, España. [in Spanish]

Gonik, Smith, 1993 – *Gonik, R., Smith, W.* (1993). The Cartoon Guide to Statistics. HarperPerennial: New York.

Green, 2015 – *Green, M.J.* (2015). Comics and medicine: peering into process of professional identity formation. *Academic Medicine*. 90(6): 774-779. DOI: http://dx.doi.org/10.1097/ACM.0000000000000703

Green, Myers, 2010 – *Green, M.J., Myers, K.R.* (2010). Graphic medicine: use of comics in medical education and patient care. *BMJ*. 340: 574-577. DOI: https://doi.org/10.1136/bmj.c863

Herawati et al., 2019 – *Herawati, R., Sulisworo, D., Fayanto, S.* (2019). The development of learning videos on powtoon-based work and energy topics to support flipped classroom learning. *IOSR Journal of Research & Method in Education*. 9(4): 51-58.

Jain, 2015 – *Jain, A.* (2015). Teach me, let me learn! millennial learning. *Indore Management Journal*. 8(1): 64-71.

Juwah et al., 2004 – *Juwah, C., Macfarlane-Dick, D., Matthew, B., Nicol, D., Ross, D., Smith, B.* (2004). Enhancing student learning through effective formative feedback. Higher Education Academy Generic Centre: York, UK.

Kim et al., 2017 – *Kim, J., Chung, M.S., Jang, H.G., Chung, B.S.* (2017). The use of educational comics in learning anatomy among multiple student group. *Anatomial Sciences Education*. 10(1): 79-86. DOI: https://doi.org/10.1002/ase.1619

Koutníková, 2017 – *Koutníková, M.* (2017). The application of comics in science education. *Acta Educationis Generalis*. 7(3): 88-98. DOI: https://doi.org/10.1515/atd-2017-0026

Lazarinis et al., 2015 – *Lazarinis, F., Mazarakis, A., Verykios, V.S., Panagiotakopoulos, C.T.* (2015). E-comics in teaching: evaluating and using comic strip creator tools for educational purposes. *2015 10th International Conference on Computer Science & Education (ICCSE)*. DOI: https://doi.org/10.1109/ICCSE.2015.7250261

Lee, 2020 – *Lee, W.* (2020). An experimental investigation into the application of a learning-from-mistakes approach among freshmen students. *SAGE Open*. 10(2), 1-10. DOI: https://doi.org/10.1177/2158244020931938

León, 2014 – *León, N.G.* (2014). Creando, dibujando... aprendiendo matemática a través del comic [Creating, drawing... learning math through comic]. *Cuadernos de Investigación y Formación en Educación Matemática*. 9(12): 111-123. [in Spanish]

Mayer, Moreno, 2002 – *Mayer, R.E., Moreno, R.* (2002). Animation as an aid to multimedia learning. *Educational Psychology Review*. 14(1): 87-99. DOI: https://doi.org/10.1023/A:1013184611077

Meso et al., 2011 – *Meso, K.A., Perez, J.D., Mendiguren, T.G.* (2011). Las redes sociales como herramientas para el aprendizaje colaborativo presentación de un caso desde la upv/ehu [Social networks as tools for collaborative learning presentation of a case from the upv/ehu] [Electronic resource]. URL: https://es.slideshare.net/RagdeAtocsauc/las-redes-sociales-como-herramientas-para-el-aprendizaje-colaborativo-presentacin-de-un-caso-desde-la-upv-ehu [in Spanish]

Monaco, Martin, 2007 – *Monaco, M., Martin, M.* (2007). The millennial student: a new generation of learners. Athletic *Training Education Journal*. 2(2): 42-46. DOI: https://doi.org/10.4085/1947-380X-2.2.42

Oliveira, 2014 – *Oliveira, R.M.* (2014). Problem based learning como estratégia de ensino: diagnóstico para a aplicabilidade no curso de ciéncias contabeis da Universidades federal do Paraná [Problem-based learning as a teaching strategy: diagnosis for applicability in the accounting science course at Federal Universities of Paraná]. Unpublished Master Thesis, Universidade Federal do Paraná, Brasil. [in Portuguese]

Ramírez, 2010 – *Ramírez, A.V.* (2010). La historieta como material de apoyo educativo [Comic as educational support material]. Unpublished Bachelor Thesis, Universidad Nacional Autónoma de México. [in Spanish]

Rioseco et al., 2017 – *Rioseco, M.H., Paukner, F., Ramírez, B.* (2017). Incorporating powtoon as a learning activity into a course on technological innovations as didactic resources for pedagogy programs. *International Journal of Emerging Technologies in Learning*. 12(6): 120-131. DOI: https://doi.org/10.3991/ijet.v12i06.7025

Rodrigues, Arroio, 2011 – *Rodrigues, E. S., Arroio, A.* (2011). Comics: a tool for teachers and students in teaching and learning Science. *Natural Sciences Education*. 31(2): 49-59.

Silva et al., 2012 – *Silva, A.B., Lima, T.B., Sonaglio, A.B., Godoi, C.K.* (2012). Dimensões de um sistema de aprendizagem em ação para o ensino de administração [Dimensions of a learning-in-action system for teaching business]. *Administração: Ensino e Pesquisa*. 13(1): 9-41. [in Portuguese]

Silva et al., 2014 – *Silva, C. S., Giraldes, A. I., Pazin-Filho, A.* (2014). Estratégias inovadoras para métodos de ensino tradicionais – aspectos gerais [Innovative strategies for traditional teaching methods – general aspects]. *Revista da Faculdade de Medicina de Ribeirão Preto*. 47(3): 284-292. DOI: https://doi.org/10.11606/issn.2176-7262.v47i3p284-292 [in Portuguese]

Sones, 1944 – *Sones, W.W.D.* (1944). The comics and instructional method. *The Journal of Educational Sociology*. 18(4): 232-240. DOI: https://doi.org/10.2307/2262696

Tatalovic, 2009 – *Tatalovic, M.* (2009). Science comics as tools for science education and communication: a brief, exploratory study. *Journal of Science Communication*. 8(4): 1-17. DOI: https://doi.org/10.22323/2.08040202

Toh, 2009 – *Toh, T.L.* (2009). Use of cartoons and comics to teach algebra in matematics classrooms [Electronic resource]. URL: https://www.academia.edu/35538958/Use_of_Cartoons_and_Comics_to_Teach_Algebra_in_Mathematics_Classrooms_USE_OF_CARTOONS_AND_COMICS_TO_TEACH_ALGEBRA_IN_MATHEMATICS_CLASSROOMS

Trnova et al., 2013 – *Trnova, E., Trna, J., Vacek, V.* (2013). The roles of cartoons and comics in science education [Electronic resource]. URL: https://www.researchgate.net/profile/Josef_Trna/publication/272978319_The_Roles_of_Cartoons_and_Comics_in_Science_Education/links/54f42c810cf299c8d9e654a4.pdf

Valle et al., 1999 – *Valle, A., Barca A., González R., Núñez, J.C.* (1999). Las estrategias del aprendizaje: revisión teórica y conceptual [Learning strategies: a theoretical and conceptual review]. *Revista Latinoamericana de Psicología*. 31(3): 425-461. [in Spanish]