

Use of Comic-based Learning Module in Physics in Enhancing Students' Achievement and Motivation

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ABSTRACT

This study investigated the effect of using a comic-based learning module in Physics as a learning tool on students' conceptual understanding and motivation. A mixed method approach using a quasi-experimental pre-test-post-test design was used in this study. An adapted 50-multiple choice test items and the physics version of the "Science Motivation Questionnaire-II" (SMQ-II) were used to measure changes of students' conceptual understanding and motivation respectively. Two intact classes of 68 Grade 8 students in a public school in Cavite, the Philippines participated in this study with corresponding parental consent. Quantitative data were analyzed using Paired-Sample t-test and qualitative data were gathered from students' interviews. After the integration of the comic-based learning module for 4 weeks, results showed that it provided significant increase on students' conceptual understanding in Physics. Meanwhile, the four components of students' motivation such as intrinsic motivation, self-efficacy, self-determination, and grade motivation showed significant increase. Finally, students' learning experience on the use of the module as revealed on focus group discussion showed that the module helped them to understand better the Physics topics being discussed and to become more motivated to learn Physics. Future studies would have to consider the appropriateness and suitability of comic-based learning module in other subject areas and grade levels.

KEYWORDS: comic-based learning module; physics; achievement; motivation

INTRODUCTION

Increase of students' achievement in Physics is one of the goals of Physics education in the Philippines (Torio, 2015). However, many students find Physics to be a difficult subject which leads to their low achievement and poor performance in the subject (Aina, 2013). This led Physics educators to identify the underlying cause of students' poor achievement and it was found out that students' conceptual understanding (Aysegül and Devecioglu, 2010) and motivation (Torio, 2015) are two of the factors that should be considered to attain optimal achievement rate in Physics.

Studies have shown that students find it difficult to understand Physics concepts (Aysegül and Devecioglu, 2010) which include topics about force, acceleration, laws of motion, and work-energy theorem (Atasoy, 2008; Bayraktar, 2006). These topics have been viewed by students from high school to college as abstract concepts which are difficult to learn (Atasoy and Akdeniz, 2005). In addition to that, students were found out to have low motivation toward learning physics because of the long-time undesirable reputation of physics as a difficult subject and the computational demands in learning physics (Torio, 2015). In an effort to address these problems, the use of comic-based learning module in Physics that suit today's generation of students was developed (Adesoji, 2008).

Comics as an art can generally be seen in daily newspapers that are typically colorful or black and white with words and images

(Muzumdar, 2016). It is generally underrated as an educational tool as it is frequently seen as nothing more than as a pastime, yet studies in different fields have shown that it can be more than just a mere pastime (Tatalovic, 2009). In fact, there are growing number of studies on the use of comics as a tool in the fields of medicine, communication, art, business, and education (Cheesman, 2006). In addition to these, studies on the use of comics as a pedagogical tool for teaching and learning date back to the 1940's have shown desirable educational outcomes such as (1) development of reading and writing skills, (2) enrichment of subject vocabulary, (3) development of problem-solving skills, (4) strengthening motivation, (5) acquisition of scientific knowledge, and (6) detection and elimination of misconceptions (Bolton-Gary, 2012). Also noted by Affeldt et al. (2018), the use of comics in science education suits today's students' media experiences better than the traditional text-based learning as its content contains short messages set in meaningful context created by specific images.

According to Muzumdar (2016), there are certain characteristics of comics that distinguish them from other learning materials and other media. Such characteristics of comics are (1) comics are narrative, (2) comics have juxtaposed panels, and (3) comics are permanent. Comics are a storytelling device that narrate stories in either a humorous or serious context and are presented in the form of pictures and text. The narrative in comics is presented in a sequence of frames or panels with the following: Word or speech balloons, caption outside the panel,

or sound effects and pictures of words within the panel. These panels are arranged in a spatial arrangement that differentiate comics from other forms of media such as television and films. This strength of comics is called as visual permanence where the reader has the full control over how quickly the viewing processes and it can be held, flipped through, bookmarked, read, and re-read (Collver and Weitkamp, 2007).

LITERATURE REVIEW AND RESEARCH QUESTIONS

Comics Development

The art of comics began in the middle of the 19th century (Meskin, 2008) and its purpose is usually for caricature and humor used primarily for entertainment (Trnova et al., 2013). Bolton-Gary (2012) stated that the word comic comes from the Greek word “kōmōidia” which means “comedy” while Trnova et al. (2013) argued that the word comic comes from English word “comic strip” which means a strip of comic images. Some critics contend that comics are a hybrid from of art and literature while others argue that comics are a new and separate art (Arroio, 2011). Also reported by Arroio, 2011, comics are a graphic medium in which images are utilized to convey a sequential narrative using text ambiguity, symbolism, design, iconography, literary technique, and stylistic elements of art to build a subtext meaning. Other researchers define comics as a media visual used to express ideas through images combined with text to convey information (Hosler and Boomer, 2001); a form of art that uses no moving pictures which are arranged in such arrangement to build up story (Yulianti et al., 2016); and a sequential art associated with text telling of short stories (Tatalovic, 2009).

Comics evolved from a single image or a single-panel cartoon and when combined with two or more cartoons in a series, connected by the same idea or story, comics will be formed. An image is called a panel that is accompanied with text inserted into speech balloons to create the story of the comics (Trnova et al., 2013).

Comics in Science Education

In science education, the genre of comic books is called as “science comics” which aim to communicate science or to educate readers about science ideas (Muzumdar, 2016). In India, the popular form of science communication through comics is called “scientoons.” These comics contain cartoons accompanied by a dialogue of an Indian scientist and a science communicator about the different topics in science such as parasitology and Brownian movement. Another example of single-frame comics developed to improve physics education and public interest in science are called “concept cartoons” (Naylor and Keogh, 2010).

There is a body of literature which has determined the effect of comics in science education. In a study conducted by Ozdemir (2017), he found that a comics story implemented in his class contributed in simplifying the concepts and caused long-term learning due to its visual nature. Affeldt et al. (2018) added that the use of comics in a classroom setting has the potential

of attracting learners to learn science and of motivating those with lower reading abilities to be more engaged in reading due to the simple language being used. Meanwhile Lin et al. (2015) revealed that students who used a comics book had developed an increased interest and enjoyment of learning while the participants who used a textbook had a decreased in their interest and enjoyment. Finally, Yulianti et al. (2016) showed that comics can be used as a powerful learning media to interpret the knowledge and application of science, because the use of images in comics in learning science is more stimulating and interesting than the sole explanation of scientific facts.

Research Questions

The study aimed to investigate the effect of using comic-based learning module on students’ conceptual understanding and motivation toward learning Physics. More specifically, this research aimed to answer the following questions:

1. How effective is the use of comic-based learning module in enhancing students’ conceptual understanding and motivation as reflected on their pre-test and post-test scores and the interviews?
2. After the implementation of comic-based learning module, is there a significant increase on students’ conceptual understanding and motivation?

METHODOLOGY

Research Design

A mixed method approach using a quasi-experimental pretest-posttest design was used in this study. Quasi-experimental pre-test-post-test design is a research design used to provide information about the effects of a certain intervention before and after its implementation (Park et al., 2009). In this study, the researchers implemented a quasi-experimental pre-test-post-test design to describe the effects of the implementation of an intervention which was the comic-based learning module. In addition, quantitative data were gathered through the pre-test and posttest to describe the changes on students’ conceptual understanding and motivation toward learning Physics. Then, students’ interviews in the form of focused group discussion (FGD) were used as the qualitative data to further substantiate the results obtained from the quantitative data. FGD is a qualitative assessment technique used to discuss issues, problems, and experiences of a selected set of participants (Bennett et al., 2010). In this study, some students were selected to be interviewed to discuss their experiences throughout the implementation of comic-based learning module.

Research Locale and Participants

This study was conducted in a public school in Cavite, the Philippines. Convenient sampling technique was employed by the researchers in determining the participants of the study. Convenient sampling is a sampling technique used by researchers to collect data from a conveniently available group of participants (Lavrakas, 2008). In this study, one of the researchers was teaching Grade 8 students in a public school in Cavite, the Philippines which resulted to choosing her students

as the participants of the study. Two intact classes with a total number of 68 students with age ranging from 12 to 14 years old in the school year 2018–2019 volunteered to participate in the conduct of this study with both their and their corresponding parental informed consent. Since the participants of this study were still minor students, consent forms were given to them and to their parents.

Research Instruments

The instruments used in this study were the following:

Comic-based learning module

The researcher developed a comic-based learning module in Physics. The module is composed of an introduction to Physics and lessons about forces, Newton's Laws of Motion, work, and energy. The developed comic-based learning modules followed the facets of comics format framework of Collver and Weitkamp (2007).

Achievement test

Fifty multiple choices test items about Physics taken from the past 2 years', first quarter periodic examination was used to measure students' conceptual understanding. Each item was scored one point for every correct answer. The pre-test was administered prior the first lesson on the comic-based learning module and post-test with parallel test items with the pre-test was given after the integration of the module. Table 1 shows the number of items per lesson in the pre-test and post-test.

Science motivation questionnaire-II (SMQ-II)

In this study, the Physics version of the SMQ-II adapted from Glynn et al. (2011) was used. The SMQ-II is a 25-item Likert-type instrument with five components such as intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation developed and validated for efficiently investigating students' motivation to learn physics. It has a range of 0–4 having a verbal interpretation of “never” for 0, “rarely” for 1, “sometimes” for 2, “often” for 3, and “always” for 4. Table 2 shows the five components of SMQ-II, number of statements per component and sample statement.

Research Procedure

The main focus of this study was to investigate the effect of using comics-based learning modules on students' conceptual understanding and motivation toward learning Physics. To do this, researchers first secured a letter of permission that was addressed to the principal of school. This is to ensure the agreement between the researcher and the school administrator. Afterward, the following phases were followed:

Phase 1: Pretest

Before giving the comics-based learning module, the participants took a 50-item multiple choice test and SMQ-II to describe their initial conceptual understanding in Physics and motivation toward learning Physics, respectively.

Phase 2: Integration

The comics-based learning modules were used to teach Physics to two Grade 8 sections for four weeks. One week was allocated

Table 1: Pre-test and Post-test test items

Module	Pretest	Posttest
Force	18	16
Newton's Laws of Motion	17	17
Work and Energy	15	17
Total test items = 50		

Table 2: SMQ-II dimensions and sample items

Component	Statement number	Sample statement
Intrinsic motivation	1, 3, 12, 17, 19	Learning science is interesting
Self-efficacy	9, 14, 15, 18, 21	I am sure I can understand science
Self-determination	5, 6, 11, 16, 22	I study hard to learn science
Grade motivation	2, 4, 8, 20, 24	I think about the grade I will get in science
Career motivation	7, 10, 13, 23, 25	My career will involve science
SMQ: Science motivation questionnaire		

for the discussion of each lesson. Before the start of the class, students were given 10 min to read the comics-based learning module. During the discussion of the topics, the teacher used PowerPoint presentations that were also in the form of comics. Some contents of the module were also flashed in the PowerPoint presentation so that students would be engaged in the use of comics in the classroom.

Phase 3: Post-test

At the end of the integration, the participants took a test parallel to the pre-test that served as the posttest.

Phase 4: Interview

An interview with random students in the form of FGD was conducted to also substantiate the quantitative data gathered. Through a developed interview protocol, students were asked about their experience during the administration of comic-based learning module in their class.

Data Analysis

The effect of comics-based learning module on students' conceptual understanding in Physics was investigated using the pre-test and post-test scores in the 50-item multiple choices test. Weighted mean, standard deviation, t-test for paired samples, and the effect size were used to describe the gathered data. Motivation toward learning physics was examined through the pre-test and post-test results of SMQ-II. t-test for paired samples and effect size were run on the data to describe the effects of the comic-based learning module to the students' motivation toward learning Physics.

FINDINGS

Comics-based Learning Module on Students' Conceptual Understanding

Table 3 shows the pre-test and post-test mean scores in the 50-item multiple choices test of the students who participated

in this study along with the standard deviation and t-value and p-value from the t-test and the effect size.

After the implementation of the comic-based learning module for 4 weeks, a significant increase ($t(67) = 8.20, p < 0.05$) on students' conceptual understanding in Physics is revealed as shown in the difference between the pre-test scores ($M = 23.13, SD = 5.66$) and post-test scores ($M = 29.21, SD = 3.07$). The significant results obtained from the t-test were supported by the yielded large effect size with Cohen's d equal to 1.00. This indicated that approximately, for every 3 students who used the module, there was one (1) who improved in terms of the knowledge the students gained. Here are some of the comments of students which describe how they see an increase in their conceptual understanding of the topics as coded from the interview:

"Nakatulong po yung comics na module para mas lalo po naming maintindihan ung topics na dinidiscuss ni Ma'am. Hindi naman po lahat sa amin ay may libro yung comics ay malaking tulong para may mabasa po kami."

[The comics module helped us to better understand the topics being discussed by Ma'am. Since not all of us have books, the comics module is a big help for us to have something to read.]

"Nakatulong po yung comics sa akin na matuto dahil po bukod sa maiksi at direct to the point and explanation, maraming pong binigay na examples. Tapos yung mga drawings din po ay nakatulong upang mas lalong maitindihan ung nakasulat sa comics. Nakakarelata po ako sa mga pictures sa comics dahil may mga ganon din po akong naexperience."

[The comics helped for me to learn because aside from being short and a direct to the point explanation, many examples were given. The drawings also helped me to better understand the text written in the comics. I could relate with the pictures in the comics because I also have experiences like that.]

"Kapag nagquiz kami dati nung wala pang comics, madalas bagsak po ako sa quiz or mababa yung score ko po. Pero nung nagkaroon na po kami ng sari-sariling comics, nagimprove naman po yung scores ko."

[When we were having a quiz when we did not have comics yet, I would usually fail the quiz or have a low score. However, my scores somehow improved after we had individual copy of the comics.]

"Nung magbigay sa amin ng comics feeling ko mas kaya ko pong magkaroon ng mataas na score sa quiz at makapagrecite kasi naging confident ako na tama yung mga sagot ko."

Table 3: Change on students' conceptual understanding in physics

Pretest mean	Pretest SD	Posttest Mean	Posttest SD	t-Stat	p-value	Effect size (d)
23.13	5.66	29.21	3.07	8.20	0.000*	1.00

n=68, Highest score = 50, *p<0.05

[When comics were given to us, I felt that I could get a high score in a quiz and I could recite because I became more confident that my answers were correct.]

Comics-based Learning Module on Students' Motivation

Students' motivation toward learning Physics was studied by comparing the mean pre-test and post-test scores of students the SMQ-II.

Table 4 shows the students' pre-test and post-test mean scores in the five different components of motivation assessed using SMQ-II. Four of the components of students' motivation: Intrinsic motivation ($t(67) = 6.86, p < 0.05$), self-efficacy ($t(67) = 7.23, p < 0.05$), self-determination ($t(67) = 3.98, p < 0.05$), and grade motivation ($t(67) = 7.18, p < 0.05$) showed significant increase while the career motivation ($t(67) = 2.14, p > 0.05$) did not show a significant increase. These results obtained from the t-test were supported by the yielded large effect size with Cohen's d values equal to 0.83, 0.71, 0.82, and 0.92 for intrinsic motivation, self-efficacy, self-determination, and grade motivation, respectively. Here are some of the comments of students which describe how they became motivated to learn Physics in their class:

"Dati kapag tinatanong po kami ni Ma'am, wala po kaming naisasagot kasi di naman din po talaga kami nagbabasa ng libro. Pero ngayon po naencourage kami magbasa dahil nakakatawa yung mga jokes po sa comics tapos nakakapagrecite pa po kami."

[When Ma'am was asking us before, we could not answer her because we were not really reading books. But now, we were encouraged to read because of the jokes in the comics and we were able to recite as well.]

"Nung nagbasa po ako ng comics, nagenjoy po ako dahil sa mga jokes tapos nakakatawa rin po yung iba pictures. Hindi lang po ako natututo pero naentertain din po ako nung binasa ko ang comics."

[When I was reading the comics, I enjoyed it because of the jokes written there and some of the pictures were funny. I was not just learning but I was also entertained when I read the comics.]

"Nung nagkaroon po kami ng comics, halos lahat na po kami ay nagrecite. Madalas din po kasi nagbibigay si Sir ng extra points kaya lalo pong nakakamotivate. Masaya naman din po ako kasi bukod sa mas enjoying yung klase"

Table 4: SMQ-II score summary

Components	Pretest mean	Posttest mean	t-Stat	p-value	Cohen's d
Intrinsic motivation	2.69	3.17	6.86	0.002*	0.83
Self-efficacy	2.86	3.18	7.23	0.002*	0.71
Self-determination	2.76	3.10	3.98	0.016*	0.82
Grade motivation	3.07	3.54	7.18	0.002*	0.92
Career motivation	2.82	2.83	2.14	0.099	0.04

N = 68 (Paired), Highest Score = 5, *p<0.05. SMQ: Science Motivation Questionnaire

namin sa Science, lagi pa kaming nakakakuha ng extra points para mas tumaas grades namin.”

[When we have comics already, almost all of us were able to recite during class discussions. Extra points were frequently given to us which really motivated us. I am happy that aside from our Science class is enjoying, we were earning extra points that make our grades become higher.]

DISCUSSION AND CONCLUSION

The results of this study are in agreement with Novianti and Syaichudin (2010) that using comics as a medium in learning science can increase students' understanding. Waluyanto (2006) stated that comics-based material has a potential to convey messages in a coherent, clear, and fun way. Tatalovic (2009) also noted that it improved enjoyment of reading science due to its humorous nature of narrating science ideas. Finally, Di Radoo (2006) added that comics with the visual appeal of the images made students to think about science concepts and related ideas in a visual entertaining way.

Glynn et al. (2011) describes intrinsic motivation as an innate satisfaction in learning science for its own sake. This improvement in the intrinsic motivation of the students can be attributed to the overall learning experience of the students while using the comic-based learning module and their linking of the concept of “fun” and “enjoyment” in Science. According to Guido (2013) students that demonstrate high intrinsic motivation processed reading material more deeply, achieved higher grades, and showed more persistence than students with high extrinsic motivation. As students achieve high intrinsic motivation, they will be more likely to attain better academic achievement, more favorable perceptions of their academic competence, and lower academic anxiety from childhood through their adolescence (Gottfried et. al., 2001).

According to Schunk (2001 as cited by Suprato, 2017), self-efficacy is more like a task-dependent construct where its goal is to monitor students' performance and capabilities to predict their learning outcomes accurately. It has also consistently been found to be a good predictor of academic achievement, study strategies, and persistence in the face of difficulty (Sharma and Branscum, 2009). The high self-efficacy of the students can be supported by the fact that students themselves are aware of the increase in their scores in written works and they anticipate upcoming tests and activities which they believe they can do well.

Self-determination is in accordance with the concept of basic psychological needs that are assumed to inherent and essential to fulfill growth and tendencies (Byman et al., 2012). These basic psychological needs are competence, autonomy, and relatedness (Ryan and Deci, 2000). Glynn et al. (2011) describes grade motivation as an extrinsic motivation which involves learning science as a means to a tangible end, that is, a grade. Researchers believed that the reason why this dimension got the highest effect size among the SMQ-II components

was that students became more motivated to participate in the class discussions and activities because extra points were given to them. During class discussions, researchers always asked questions to the students where answers could be seen from their module. Every time they were able to answer the questions, they were given extra points. In addition, every time the knowledge based-assessment and the word problems in the modules were being answered in the class, almost all of the students were doing their best to get a perfect score.

The last component of motivation being assessed is the career motivation of the students which got the lowest effect size. Glynn et al. (2011) describes this component, similar to the grade motivation component, but the tangible end is the career. The not significant result and the low effect size in this component can be accounted to the fact that students at this early stage have not been thinking yet of the career path that they are going to take. Thus, they have not been thinking yet that learning Science will produce a tangible end, and that is their career.

Participants of the study have a significant increase in their conceptual understanding of the topics and their motivation after undergoing science classes with comics-based learning module. This result is greatly associated to the use of comics-based learning module as supported by the significant difference on the results of t-tests and students' interview. Even though pedagogical content knowledge of teachers in teaching Physics plays a significant role in ensuring students' learning, the comics-based learning module can still be considered as significant factor to teach Physics. After integrating the comics-based learning module, students found the use of it be enjoyable, convenient, and authentic. With this, the developed comics-based learning module might be one of the solutions to the problem on the lack of innovative instructional materials that meaningfully connect science contents to our daily experiences. Through this material, teachers might be encouraged to promote fun ways of learning through reading comics and students might have an improved perception of physics as well as better understanding of the physics topics and increase on their physics achievement.

REFERENCES

- Adesoji, F.A. (2008). Managing students' attitudes towards science through problem-solving instructional strategy. *Anthropologist*, 10(1), 21-24.
- Affeldt, F., Meinhart, D., & Eilks, I. (2018). The use of comics in experimental science instructions in a non-formal learning environment. *International Journal of Education in Mathematics, Science and Technology*, 6(1), 93-104.
- Aina, K.J. (2013). Instructional materials and improvisation in physics class: Implications for teaching and learning. *International Journal of Research and Method in Education*, 2(5), 38-42.
- Arroio, A. (2011). Comics as a narrative in natural science education. *Western Anatolia Journal of Educational Science*, 3(7), 93-98.
- Atasoy, S. (2008). *Teacher Candidates on Newton's Laws of Motion Concept Worksheets Developed to Eliminate Misconceptions of the Effectiveness of Investigation*. Karadeniz Technical University.
- Atasoy, S., & Akdeniz, A.R. (2005). Newton's Laws of Motion Related to Teacher Candidates that they have Misconceptions. *National Educational Sciences Congress Pamukkale*. University Faculty of

- Education.
- Aysegül, S.A., & Devecioglu, Y. (2010). Student teachers' levels of understanding and model of understanding about Newton's laws of motion. *Asia-Pacific Forum on Science Learning and Teaching*, 11(1), 11-31.
- Bayraktar, S. (2006). *Turkish Pre-service Teachers' Misconceptions about Force and Motion*. International Science Education Conference.
- Bennett, J., Hogarth, S., Lubben, F., Campbell, B., & Robinson, A. (2010). Talking science: The research evidence on the use of small group discussions in science teaching. *International Journal of Science Education*, 32(1), 69-95.
- Bolton-Gary, C. (2012). Connecting through comics: Expanding opportunities for teaching and learning. *US-China Education Review*, 4(1), 389-395.
- Byman, R., Lavonen, J., Juuti, K., & Meisalo, V. (2012). Motivational orientations in physics learning: A self-determination theory approach. *Journal of Baltic Science Education*, 11(4), 379-392.
- Cheesman, K. (2006). Using comics in science classroom. *Journal of College Science Teaching*, 35(4), 48-51.
- Collver, J., & Weitkamp, E. (2007). Alter egos: An exploration of the perspectives and identities of science comic creators. *Journal of Science Communication*, 17(1), 1-22.
- Di Radoo, P. (2006). Teaching chemistry lab safety through comics. *Journal of Chemical Education*, 83(4) 571-578.
- Glynn, S.M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science motivation questionnaire II: Validation with science majors and nonscience majors. *Journal of Research in Science Teaching*, 48(10), 1159-1176.
- Gottfried, A.E., Fleming, J.S., & Gottfried, A.W. (2001). Continuity of academic intrinsic motivation from childhood through late adolescence: A longitudinal study. *Journal of Educational Psychology*, 93(1), 3-13.
- Guido, R.M. (2013). Attitude and motivation towards learning physics. *International Journal of Engineering Research and Technology*, 2(11), 2087-2094.
- Hosler, J., & Boomer, K.B. (2011). Are comic books an effective way to engage nonmajors in learning and appreciating science. *CBE-Life Sciences Education*, 10(3), 309-317.
- Lavrakas, J. (2008). *Encyclopedia of Survey Research Methods*. 1st ed. Sage Publication.
- Lin, S.F., Lin, H.S., Lee, L., & Yore, L. (2015). Are science comics a good medium for science communication? The case for public learning of nanotechnology. *International Journal of Science Education*, 5(3), 276-294.
- Meskin, A. (2008). Defining comics? *The Journal of Aesthetics and Art Criticism*, 65(4), 369-379.
- Muzumdar, J. (2016). An overview of comic books as an educational tool and implications for pharmacy. *Innovations in Pharmacy*, 7(4), 3-12.
- Naylor, S., & Keogh, B. (2010). *Concept Cartoons in Science Education*. Millgate House.
- Novianti, R.D., & Syaichudin. (2010). Development of mathematical learning comic media to improve understanding of fractional chapter story in grade V students. *Journal of Educational Technology*, 10(1), 74-85.
- Ozdemir, E. (2017). Comics in modern physics: Learning blackbody radiation through quasi-history of physics. *Studies in Educational Research and Development*, 1(1), 41-59.
- Park, H., Khan, S., & Petrina, S. (2009). ICT in Science Education: A quasi-experimental study of achievement, attitudes toward science, and career aspirations of Korean middle school students. *International Journal of Science Education*, 31(8), 993-1012.
- Ryan, R.M., & Deci, E.L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, 25(1), 54-67.
- Sharma, M., & Branscum, P. (2009). Comic books an untapped medium for health promotion. *American Journal of Health Studies*, 24(4), 430-439.
- Suprato, N., Chang, T.S., & Ku, C.H. (2017). Conception of learning physics and self-efficacy among Indonesian university students. *Journal of Baltic Science Education*, 16(1), 7-19.
- Tatalovic, M. (2009). Science comics as tools for science education and communication: A brief and exploratory study. *Journal of Science Communication*, 8(4), 1-17.
- Torio, V.A. (2015). Physics motivation and research: Understanding the 21st century learners of today. *International Journal of Education and Research*, 3(2), 125-134.
- Trnova, E., Trna, J., & Vacek, V. (2013). The Roles of Cartoons and Comics in Science Education. 10th International Conference Hands-on Science 2013. Educating for Science and through Science. Research Gate. pp. 240-244.
- Waluyanto, H.D. (2006). Comics as learning visual communication media. *Nirmana Visual Communication Design Journal*, 7(1), 45-55.
- Yulianti, D., Khanafiyah, S., & Sulistyorini, S. (2016). Inquiry-based science comic physics series integrated with character education. *Indonesian Journal of Science Education*, 5(1), 33-44.