Physics Toys Effectiveness of Undergraduates' Understanding Physics Principles

Elif Ince[1]
Yavuz Acar
Senem Temur[2]

[1] *Istanbul University Hasan Ali Yucel Education Faculty Science Education, Istanbul, Turkey*
[2] *Istanbul University Institute of Educational Science, Istanbul, Turkey*
[2] *elifince@istanbul.edu.tr*

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Abstract
Physics education through physics toys is quite a popular method in foreign countries yet it is still not applied in our country. The aim of this study is to investigation of physics toys' effectiveness of students' physics prenciples explanation and their attitude towards physics toys. Selected physics toys include subjects of mechanic, electricity and magnetic field. In this sense, this study was carried out in order to observe how the results of this application would be in physics course. Since sampling has recently received General Physics 1 and General Physics 2 courses and their knowledge is fresh and this sampling was chosen since they would better understand principles of toys. It was concluded that, in POE teaching strategy which was applied in order to examine working principles of some toys, students who made correct prediction made correct explanation and likewise students who made correct observation were successful in explanation part. In addition, students were asked questions about physics teaching with toys and their attitude towards physics toys were analyzed. It was seen that more than 50% of students stated positive ideas about use of physics toys in physics course.
Keywords: Physics Education, Physics Toys, Prediction-Observation-Explanation.

Introduction

When pre-service science teachers are asked "What is the thing we call science?" they generally reply mechanic, Newton's laws of motion, electricity, heat etc. for physics; chemical reactions, chemical equations, molecule, mole etc. for chemistry; cell, plant, animals etc. for biology. Some students also mention laboratory and field study. According to their educational experience, science stands out as group of knowledge rehearsed from course books instead of concepts acquired as a result of systematic experiences. It is not strange that most of the students think in this way, because it is common both at university and at lower educational institutions that information is conveyed directly in science courses (Lawson, 2011).

In order to increase effectiveness of science education, a series of educational arrangements are required to actualize creative thoughts to be implemented when it comes especially to education and teaching.

Toys are instruments, which are used in developing physics skills of children, improving their power of imagination, and encourage thinking (Groiler, 2004). To prevent

misuse, toys should be used to entertain and teach students. While playing with toys, students start to use their higher-order thinking skills such as wish, improvisation, and creativity and thinking different and independence. Toys to be used in science education should not have many pieces, and should be simple, related with science as much as possible and designed compatible with that culture.

Various studies express that usage of toys is an effective method in explanation and consolidation of scientific terms. As it is mentioned in the study of Berk (1999), students learn scientific principles on their own by using their sense of "exploring and internalizing". Education of science requires making relation between old and new knowledge (Berk, 1999). Another study shows that, when it is observed how a toy operates under specific circumstances, students give meaning to events more easily. While student learns with toy, s/he observes the movements of toy in many senses and makes relations between these movements (Klag, 1996). Both studies show that use of toy is quite beneficial in learning a subject.

Toys used in the education of science include acquisitions such as curiosity, entertainment, and open-mindedness, direction, making relation, repetition and application. Toys enabling acquiring behaviours and skills in which effective thinking and rapid decision making skills are important. Toys strengthen body, mind and soul, enable using intuition and logic together, and help understanding daily technological applications which are some of the reasons of using them in education of science.

Science is a field, which is generally mentioned together with experiments and theories. Toys produced for this aim can exhibit various theories or experiments in an entertaining way and also cases given within science can be explained through them. Also, toys draw attraction of children at any age group and play important helping role in control of class for teachers. Toys can be useful for students at every level. Toys can be helpful in comprehending science subject in entertaining way for weak students. They impress much more sense of confidence in learning process for medium-level students. For higher-level student's toys provide opportunity to exceed their own capacity and improve creativity.

Toys can be used in many different ways in science education, but it is generally preferred to use them at the beginning of lesson. In this way an attractive introduction is enabled and an active learning process is initiated for the scientific term expressed through toy. When a subject is conveyed it can be consolidated with a toy and it is enabled for students to live and observe to subject, here it is provided for students to relate the subject with real and ask more creative questions. At the end of lesson, students can be given a toy and asked to relate the subject they have learned with the toy and determine Science principles included in the toy. Apart from these, students can be asked to rearrange the toy, make the toy more useful and even create a toy on their own.

Physics is one of the most important branches of Science Education and a difficult field of science in which many principles are required to be learnt and comprehended in intertwining way. In addition to this, physic principles are included in every event we observe, live and experience. Although physic is so close to the life of people, physics courses are not given the account they deserve by students. It is stated that when physics courses are compared with other courses in recent years, it is included in the courses which students are least interested in and it loses popularity (Sharma, 2004; Yaman, Dervişoğlu & Soran, 2004). The most important reason of this is expressed as that the issues are quite abstract and mathematical, it has a theoretical nature, and it is not directly related with society and people (Whitelegg & Parry, 1999). It is emphasized that when courses in science are taught, it becomes more attractive for students when their use in daily life is expressed (Hoffmann, Haeussler & Lehrke, 1998). Not making relation with daily life while teaching subjects in the

field of science is regarded as one of the reasons, which decrease interest towards these courses (Yaman et al., 2004).

Enabling interest of students towards course is stated to be prerequisite for an effective science teaching (Whitelegg & Parry, 1999). It is presumed that when students relate physics with real life which they actually regard futile and unnecessary, they would be able to understand better and be willing to learn (MEB, 2005).

Since Prediction-Observation-Explanation (POE) strategy enables students use their mental skills actively in laboratory environment, think process in the experiments and results they reached more, it is one of the most useful strategies (Tekin, 2008). In addition, POE strategy is quite an effective teaching strategy and it is predicted that in activities conducted based on this strategy, science courses have positive effect in increasing student success, increase interest and attitude of students towards the course, have positive effect on their motivation, enable active participation of them and be effective in their socialization, improve their skill of problem solving, conceptual learning and applying (Mısır, 2009). POE strategy features analyst identity of student in physics education and increase their success, and it is highly and easily applicable which plays important role in being preferred (Tekin, 2008).

Physics education through physics toys is quite a popular method in foreign countries yet it is still not applied in our country. For example; these toys which include various physics laws and used from secondary level up to even university such as newton's laws (Hutzler and Weaire, 2007), angular momentum (Featonby, 2005), electricity and magnetic field (Guilbert,1999; Taylor; 2001; Soodak, 2002), kinetic and potential energy (Van Hook, 2005), thermodynamic (de Sousa and Pina, 1997), archimedes laws (Kires, 2007), harmonic motion (Fisher, 2004) provided success in learning concepts and subjects of physics. In addition to this, these scientists stated that physics toys develop comprehension, learning, success, creativity and problem solving level of students.

Purpose of the Study

The aim of this study is to investigate of physics toys' effectiveness in understanding of physics principles using by Prediction-Observation-Explanation strategy and to determine students' attitudes towards physics toys in physics course.

METHODOLOGY

Participants

The sampling of study is composed of undergraduate students attending Istanbul University Education Faculty, Science Education Department at the first grade who received General Physics I and General Physics II courses with book contains topics of Beichner (2002). The undergraduates were from di□erent cities in Turkey. The socio-economic status of them was similar and the majority of them were from middle to upper class families.

Procedure

The aim within the scope of this study is to use physics toys that include subjects of mechanic, electricity and magnetic field that are among university physics courses and develop students' skill of making relation with daily life through using their information and interrogation. In this sense, this study was carried out in order to observe how the results of this application would be in physics course. This study was carried out at the end of semester. 8 toys related with mechanic and magnetic field were chosen. The reason for the selection of these toys is students took mechanic and electromagnetic field subjects in their courses. Since

sampling has recently received courses of Physics 1 and Physics 2 and their knowledge is fresh, this sampling was chosen since they would better understand principles of toys. These toys were;

1- **Fork and Toothpick:** Although forks seem to be hanging on the edge of glass in an impossible way, this structure is actually on a stable balance. Because; centre of gravity of fork – toothpick contact with the glass. The fire of toothpicks burns out as it gets close to the glass because the glass blocks use of oxygen necessary for burning and prevents the fire move on toothpicks.
2- **Ramp Walking Toy:** The toy drag at the edge of plane but never falls down. Although the toy that was patented in 1888 performs complicated motions, actually it is quite simple. When the rope that has weight at its end is swung as the toy is far from the corner, it applies a horizontal force on the toy and the toy is dragged towards the edge. Yet at the edge of plane, weight applies a vertical force so the toy does not go further and due to centre of gravity of toy, the toy tumbles but does not fall down.
3- **Space Terminator:** During collision, kinetic energy of three balls at the bottom is transmitted to the small at the top. What is important her is that materials to be used have to be in structure that would convey momentum and balls should be left in the same line horizontally. We can explain why supernova explodes more rapidly outwards through transmission of supernova.
4- **Magnetic Peg-Top:** Peg-tops spin with the effect of angular momentum. While the bottom point makes magnetic peg-top spin, when the friction with triangular structure that it interacts due to magnet increases, it loses speed and momentum and completes its spin in a shorter but visually more entertaining way.
5- **Curie Point Heat Engine:** When the magnet at the end of cable starts to heat until Curie point, it disappears until magnetic field cools down. Repetition of this process as long as the heat resource burns forms mechanic motion. Curie heat is the critical temperature where a ferromagnetic material loses its permanent magnetism and transforms into ferromagnetic state. Above Curie heat, heat energy causes magnetic moments to direct randomly and the material transforms into paramagnetic state. This heat is named Curie heat in the memory of Pierre Curie who studied on the field of paramagnetism.
6- **Gauss Rifle:** It is a mechanism, which gains acceleration as a result of magnetic potential energy and gradual collisions. The chain starts up with a single ball and ends up with another ball leaving the device at utmost speed. In the experiment, speeding up of ball is caused by adhesion of opposite poles and pushing away of same poles. If the number of magnets is increased or if using bigger magnets increases the magnetic force, balls would increase their speed.
7- **Faraday Train:** It is a mechanism composed of two magnets, a battery and spiral copper wire. Magnets transfer electricity and enables flow by forming a selonodial magnetic field around battery when it contacts with the bobbin. Battery pushes the magnet at both ends and moves along bobbin. Global neodium magnets enable sliding along bobbin with minimal friction.
8- **Levitron:** It can be named as turning on balance and levitation. Your peg-top can spin on air for 3 minutes in each trial. What is important is that magnetic peg-top should be suitable for this levitation and spinning should be neither too fast nor too slow. Morever, the weight of peg-top should be around 1 gram so that magnetic repulsion enabled by the magnet embedded in pie-like structure and force applied by gravity should be equal.

At the second stage of study, students were asked questions about physics teaching with toys and students' opinions were taken about physics toys.

Data Tools

Physics toys application was carried out for students in three stages by using POE strategy for 8 weeks. Toys were displayed to students as real, in prediction stage; they were asked, "What is this toy related with? Write down your predictions." In the explanation stage, they were asked: "Can you explain how this toy works?" If correct keywords are used in the estimation, it was scored "1" if not it was scored "0". If correct terms were exactly attained at observation stage, it was scored "2" if partially attained "1", if not attained it was scored "0". In the explanation stage, if the subject is totally understood and explained it was scored "3", if partially it was scored "2", if it was wrongly explained it was scored "1", if not explained it was scored "0". After all this process is completed, it was explained to students on what principles physics toys do operate. After these processes, students were asked to fill in "Survey of Attitude towards Physics Toys" and data were collected and the answers scored by researchers.

Data Analysis

In order to determine the relation between prediction, observation, explanation stages; spearman's rank correlation analysis was carried out and to see students' opinions on physics toys, students were asked questions about physics teaching with toys and percentage distribution was given.

FINDINGS

Data obtained in this section were analyzed and presented in tables.

Table 1. *Results of Spearman's Rank Correlation Analysis for Prediction-1 Score and Explanation-1 Score*

Score Types	N	R	P
Prediction-1 Explanation-1	41	0,576	0,000*

$p < .05$

As it is seen in Table 1, as a result of Spearman's Rank Correlation Analysis that was carried out in order to determine the relation between Prediction-1 score and Explanation-1 score, there was a positive significant linear correlation between score types in statistical sense.

Table 2. *Results of Spearman's Rank Correlation Analysis for Observation-1 Score and Explanation-1 Score*

Score Types	N	r	P
Prediction-1 Explanation-1	41	0,649	0,000*

$p < .05$

As it is seen in Table 2, as a result of Spearman's Rank Correlation Analysis, which was carried out, in order to determine the relation between Observation-1 score and Explanation-1 score, there was a positive significant linear correlation between score types in statistical sense.

Table 3. *Results of Spearman's Rank Correlation Analysis for Observation-2 Score and Explanation-2 Score*

Score Types	N	r	P
Prediction-2 Explanation-2	41	0,498	0,001*

p < .05

As it is seen in Table 3, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Observation-2 score and Explanation-2 score, there was a positive significant linear correlation between score types in statistical sense.

Table 4. *Results of Spearman's Rank Correlation Analysis for Prediction-3 Score and Observation-3 Score*

Score Types	N	r	P
Prediction-3 Observation-3	41	0,363	0,020*

p < .05

As it is seen in Table 4, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Prediction-3 score and Observation-2 score, there was a positive significant linear correlation between score types in statistical sense.

Table 5. *Results of Spearman's Rank Correlation Analysis for Prediction-3 Score and Explanation-3 Score*

Score Types	N	r	P
Prediction-3 Explanation-3	41	0,356	0,022*

p < .05

As it is seen in Table 5, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Prediction-3 score and Explanation-2 score, there was a positive significant linear correlation between score types in statistical sense.

Table 6: *Results of Spearman's Rank Correlation Analysis for Observation-3 Score and Explanation-3 Score*

Score Types	N	r	P
Observation-3 Explanation-3	41	0,645	0,000*

p < .05

As it is seen in Table 6, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Observation-3 score and Explanation-2 score, there was a positive significant linear correlation between score types in statistical sense.

Table 7. *Results of Spearman's Rank Correlation Analysis for Prediction-4 Score and Observation-4 Score*

Score Types	N	r	P
Prediction-4 Observation-4	41	0,431	0,005*

p < .05

As it is seen in Table 7, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Prediction-4 score and Observation-4 score, there was a positive significant linear correlation between score types in statistical sense.

Table 8. *Results of Spearman's Rank Correlation Analysis for Observation-4 Score and Explanation-4 Score*

Score Types	N	r	P
Observation-4 Explanation-4	41	0,555	0,000*

p < .05

As it is seen in Table 8, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Observation-4 score and Explanation-4 score, there was a positive significant linear correlation between score types in statistical sense.

Table 9. *Results of Spearman's Rank Correlation Analysis for Prediction-5 Score and Observation-5 Score*

Score Types	N	r	P
Prediction-5 Observation-5	41	0,318	0,043*

p < .05

As it is seen in Table 9, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Prediction-5 score and Observation-5 score, there was a positive significant linear correlation between score types in statistical sense.

Table 10. *Results of Spearman's Rank Correlation Analysis for Observation-5 Score and Explanation-5 Score*

Score Types	N	r	P
Observation-5 Explanation-5	41	0,562	0,000*

p < .05

As it is seen in Table 10, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Observation-5 score and Explanation-5 score, there was a positive significant linear correlation between score types in statistical sense.

Table 11. *Results of Spearman's Rank Correlation Analysis for Observation-6 Score and Explanation-6 Score*

Score Types	N	r	P
Observation-6 Explanation-6	41	0,687	0,000*

p < .05

As it is seen in Table 11, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Observation-6 score and Explanation-6 score, there was a positive significant linear correlation between score types in statistical sense.

Table 12. *Results of Spearman's Rank Correlation Analysis for Prediction-7 Score and Observation-7 Score*

Score Types	N	R	P
Prediction-7 Observation-7	41	0,437	0,004*

p < .05

As it is seen in Table 12, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Prediction-7 score and Observation-7 score, there was a positive significant linear correlation between score types in statistical sense.

Table 13. *Results of Spearman's Rank Correlation Analysis for Prediction-7 Score and Explanation-7 Score*

Score Types	N	R	P
Prediction-7 Explanation-7	41	0,416	0,007*

p < .05

As it is seen in Table 13, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Prediction-7 score and Explanation-7 score, there was a positive significant linear correlation between score types in statistical sense.

Table 14. *Results of Spearman's Rank Correlation Analysis for Observation-7 Score and Explanation-7 Score*

Score Types	N	r	P
Observation-7 Explanation-7	41	0,634	0,000*

p < .05

As it is seen in Table 14, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Observation-7 score and Explanation-7 score, there was a positive significant linear correlation between score types in statistical sense.

Table 15. *Results of Spearman's Rank Correlation Analysis for Prediction-8 Score and Observation-8 Score*

Score Types	N	R	P
Prediction-8 Observation-8	41	0,340	0,030*

p < .05

As it is seen in Table 15, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Prediction-8 score and Observation-8 score, there was a positive significant linear correlation between score types in statistical sense.

Table 16. *Results of Spearman's Rank Correlation Analysis for Observation-8 Score and Explanation-8 Score*

Score Types	N	r	P
Observation-8 Explanation-8	41	0,446	0,003*

p < .05

As it is seen in Table 16, as a result of Spearman's Rank Correlation Analysis was carried out in order to determine the relation between Observation-8 score and Explanation-8 score, there was a positive significant linear correlation between score types in statistical sense. Although thoughts of students who answered these questions before and after observation are different, it is highly correct that they had idea about physics principles of toys. Yet only a few students could explain these physics principles in details. At the second stage of study, students were asked questions about physics teaching with toys and percentage distribution was given in the table below.

As it is seen in Table 17; more than 50% of students stated positive views towards physics toys saying *"I think every physics toys includes more than one physics subject, more than one physics toy can be used in order to explain a scientific event, thanks to physics toys, I realized how various physics laws work which I actually know but could not figure how to apply, physics toys help us to relate daily life with physics laws, physics toys enabled me to animate problems in my mind, physics toys enabled me examine how various events happen, physics toys are not insufficient and waste of time, physics toys are not unnecessary, I would like to design physics toys myself, I would not only like to play with physics toys."*

Table 17. *Percentage of Views of Students About Use of Physics Toys*

Survey of Views towards Physics Toys	I Totally Disagree (%)	I Disagree (%)	I'm not Sure (%)	I Agree (%)	I Totally Agree (%)
I think every physics toys include more than one physics subject.	0	2,4	2,4	51,2	43,9
More than one physics toy can be used in order to explain a scientific event.	0	2,4	2,4	56,1	36,0
Thanks to physics toys, I realized how various physics laws work which I actually know but could not figure how to apply.	0	7,3	12,2	51,2	29,3
Physics toys help us to relate daily life with physics laws.	0	0	4,9	34,1	61,0
Physics toys enabled me to animate problems in my mind.	2,4	0	4,9	39,0	53,7
I would only like to play with physics toys.	22,0	48,8	19,5	7,3	2,4
I would like to design physics toys myself.	0	0	22,0	29,3	48,8
Physics toys enabled me feel that my knowledge of physics is sufficient.	7,3	14,6	39	31,7	7,3
Thanks to physics toys, I realized that Physics is not a difficult course.	4,9	2,4	36,6	41,5	14,6
Physics toys enabled me examine how various events happen.	2,4	2,4	2,4	56,1	36,6
Physics toys are unnecessary because scientific information is more important.	63,4	34,1	2,4	0	0
Physics experiments should be carried out instead of physics toys.	22,0	51,2	17,1	7,3	2,4
Physics toys are insufficient and a waste of time.	63,4	36,6	0	0	0

DISCUSSION AND CONCLUSION

In this section, results of findings obtained within the scope of study and discussion of literature about these results were given. The aim within the scope of this study is to investigate physics toys' effectiveness of students' physics prenciples explanation. In this sense this study was carried out in order to observe how the results of this application would be in our country. Sampling was chosen among students who have recently received General Physics 1 and General Physics 2courses.

It was concluded that, in POE teaching strategy which was applied in order to examine working principles of "Fork and Toothpick" toy by using their knowledge on "centre of gravity", students who made correct prediction made correct explanation and likewise students who made correct observation were successful in explanation part. Similarly, in POE teaching strategy which was applied in order to examine working principles of "Ramp Walking Toy" toy by using their knowledge on "force, centre of gravity", it was concluded that students who made correct observations in POE teaching strategy generally made correct explanations.

In POE teaching strategy, which was applied, in order to examine working principles of "Space Terminator" toy by using their knowledge on "kinetic energy, momentum", it was concluded that students who are successful in prediction were also successful in making

correct observation and explanation. Students who have high score in observation part also have high score in explanation part in parallel to observation results.

In POE teaching strategy which was applied in order to examine working principles of "Magnetic Peg-Top" toy by using their knowledge on more than one subject field such as "angular momentum, magnetism, momentum and speed" and, again in POE teaching strategy which was applied in order to examine working principles of "Curie Point Heat Engine" toy by using their knowledge on "magnetic field, oscillation, thermodynamic"; it was determined that students who made correct prediction were successful in observation part and students who made correct observation were successful in explanation part.

In POE teaching strategy, which was applied in order to examine working principles of "Gauss Rifle" toy by using their knowledge on "magnetic field, momentum and collisions", score of explanation part of students were high parallel to their observation score.

In POE teaching strategy, which was applied in order to examine working principles of "Faraday Train" toy by using their knowledge on "magnetic field, electricity, electromagnetism", it was concluded that students who made correct prediction were successful in making correct observation and correct explanation. Students who were successful in observation part of POE strategy about operation principle of this toy were also successful in explanation part.

In POE teaching strategy which was applied in order to examine working principles of "Levitron" toy by using their knowledge on "spinning movement, magnetism, gravitation", students who were successful in prediction part were also successful in observation part and those who were successful in observation were also successful in explanation part.

In recent years, many researchers have tried to increase attitude of individuals towards physics in the course of science by using different teaching strategies and techniques. POE is one of these strategies. Mısır and Saka (2012) concluded that physics courses which were carried out according to POE strategy would have positive effect on increasing students' success in physics courses, increase interest and attitude of students towards the course and effective in socialization. In the study carried out by Çelik (2013), he analyzed the effect of Prediction-Observation-Explanation (POE) strategy on attitude of students'towards the course of Chemistry and in removing misconception of students about the subject of Gases in general Chemistry curriculum in Classroom Teaching Undergraduate Program. It was concluded that POE strategy is more successful in increasing attitude of students towards the course of chemistry compared to traditional strategy. In the study carried out by Güven (2011), the effect of POE assisted Project-based learning method on the attitude of pre-service teachers about environment problems was analyzed. When the results of research were considered, it was observed that the teaching method (POE assisted PBL) which was used in the study was quite effetcive on the attitude of pre-service teachers about environment problems. Researches carried out on different subjects and disciplines put forward that POE strategy is effective on attitude of students (Bilen, 2009; Köseoğlu, Tümay and Kavak, 2002; Özyılmaz Akamca, 2008).

In the study carried out by Akgün et al. (2013), activities based on POE strategy for teaching the subject of 8th class science course pressure subject did not have a significant difference between study and control group students in the sense of their attitude towards science course. As a result of study of Aydın (2010) in which the effect of POE strategy on 7th class unit of Electricity in Our Life, simple electricity circuits were analyzed in the sense of different variables, there was not a significant difference between attitude towards science course of study group on which POE strategy was applied and control group students on which traditional method was applied. This case is parallel with the study of Tokur (2011).

At the second stage of study, students were asked questions about physics teaching with toys and their attitude towards physics toys were analyzed. More than 50% of students stated positive ideas about use of physics toys in physics course. In the study of physics toys development of Amir & Subramaniam (2006) which was carried out with students in 15-16 age group; they stated that most of the students use critical thinking and scientific process skills during development of toys and performed their scientific creativity during toy development. In the study of Les & Web (2012) which was carried out in order to analyze the effect of toys used as material in developing field knowledge of pre-service teachers on the subject of energy, they attained a positive result about that use of toys increased knowledge of students on the subject of energy and increased confidence of use of physics toys in the course. In the study of Lim (2013) about science teaching with toys, students stated that using toys increased their own creativity and self-confidence, makes the course entertaining and that physics toys increased their attitude and interest towards course.

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