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Development and Utilization of an Experiment-Based Balloon Rocket Learning Medium for Child-Friendly Physics Learning

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Abstract: This study aims to design a learning medium called the "Balloon Rocket" based on Newton's Third Law and to examine its feasibility for child-friendly physics learning. We used a qualitative approach. The rocket is made from a balloon, a straw, nylon string, adhesive tape, and two supports. Then, we presented it to the course lecturer and a class of 30 students, who assessed its feasibility. In the demonstration, a larger balloon gave more thrust, so the rocket moved faster and stayed steadier on the string, and a longer string let it travel farther. When air rushes out backward (the action), the balloon is pushed forward (the reaction). The lecturer and the students approved the medium as feasible for teaching Newton's Third Law. Finally, the materials are cheap, safe, good in quality, and easy to find, so teachers without a standard mechanics kit can consider the medium as a practical alternative.

Keywords: Balloon rocket; Child-friendly physics learning; Learning media; Newton's Third Law; Qualitative research

Introduction

Newton's laws of motion are core topics in senior high school physics because they lay the groundwork for how force and motion are understood. The third law says that when one object pushes on another, the second pushes back with a force of equal size and opposite direction. Students often find this law hard. Their understanding tends to be fragmented: many remember "equal and opposite" as a rule, and many read "action" and "reaction" as if one force causes the other (Bao & Fritchman, 2021). Even after instruction, this causal belief often remains (Chen et al., 2021). One likely reason is that lessons depend on verbal explanation and flat diagrams, so students rarely see action and reaction forces at work in a real situation.

Concrete teaching aids can help students grasp abstract physics ideas better than lectures alone. Masturoh et al. (2019) used a simple aid made from used household items and found that it improved students' understanding of Newton's Third Law; classroom observation also showed a generally positive response. Serhane et al. (2023) reported that senior high school students keep having trouble pairing the interacting forces, especially when "action" and "reaction" are used without a physical example to point to. Alfi and Tralisno (2025) developed a physics simulation medium on Newton's Law based on Technological Pedagogical Content Knowledge (TPACK) and reported very high validity and positive student response, which suggests that well-designed media, digital or physical, can strengthen conceptual understanding. Muchlis et al. (2018) built an Internet of Things-based teaching aid for Newton's Second Law practicum. Aids like this are still being developed, but devices that rely on electronic components may be out of reach for many schools.

Child-friendly media start from how young learners naturally explore the world. Recent work on early childhood science education treats children as active participants, not passive recipients, and calls for participatory and inclusive approaches that respect the different ways children make sense of phenomena (Delserieys & Kampeza, 2025). Play-based approaches follow the same idea. Christodoulakis and Adbo (2024) used play-based interventions to introduce preschoolers to abstract science ideas through experiments and visual representations, with a teacher who scaffolded children's thinking instead of handing over answers. Children's own spontaneous questions can also be an entry point into complex

content (Papantonis Stajcic et al., 2024). In guided play, the adult prepares the setting and sets a learning goal, while the child stays in control of the exploration (Weisberg et al., 2016). Zosh et al. (2018) describe play as a spectrum that runs from free play through guided play to direct instruction, and Yogman et al. (2018) stress the role of play in the development of young children. Open, everyday materials also invite children to try things out with forces and with cause and effect (Trina et al., 2024). In this article, "child-friendly" means media that are safe, cheap, easy to handle, playful, and hands-on, so that learners can see action and reaction for themselves and take part in the experiment. Most of this research is on young children, but the principles apply to any physics lesson that uses concrete, playful exploration to introduce an abstract idea.

These ideas fit a wider body of evidence on hands-on learning in science. In a systematic literature review, Tindan and Anaba (2024) concluded that hands-on activities consistently improve conceptual understanding, critical thinking, and engagement, although limited equipment and class time often get in the way. Physics classrooms show a similar pattern. Deslauriers et al. (2019) compared actively taught introductory physics courses with lectures from experienced, highly rated instructors; students in the active classes learned more, even though they felt they had learned less. Guidance matters too. Lazonder and Harmsen (2016) analyzed 72 studies and found that inquiry-based learning works when students are adequately supported, with guidance improving learning activities, performance success, and learning outcomes. A cheap medium built from materials students already have is therefore a practical answer to the equipment problem, and everyday or recycled materials have been used to help children link real objects with their representations (Fridberg & Redfors, 2024).

Even so, aids designed specifically for the action-reaction topic remain scarce compared with those for Newton's First and Second Laws, and standard school mechanics kits rarely include them. Teachers may also hesitate to run physics activities. Pahl and Tschiesner (2024) reported that trainee teachers showed lower preference and self-efficacy for physics and technology topics than for other subjects, which suggests that simple, easily repeated media are useful. This gap motivated our work. We present the "Balloon Rocket", designed for this topic and for child-friendly use, together with a simple experiment (changing balloon size and string length) that students can carry out themselves. This article aims to (1) describe how the medium was designed and made, (2) explain how it illustrates Newton's Third Law, (3) report the evaluation of its feasibility by a lecturer and classmates, and (4) describe how it can be used for child-friendly physics learning.

Methods

This study used a qualitative descriptive approach to design a physics learning medium based on a physics concept, Newton's Third Law, and to examine whether the medium is feasible for use in learning. Qualitative descriptive studies aim to describe a phenomenon and collect data directly from the people who experience it (Kim et al., 2017), which suits a feasibility check of this kind. The medium was presented to the course lecturer and to 30 students of one class group in the Physics Education Study Program at Universitas Negeri Semarang.

Selecting the concept. We chose Newton's Third Law because students often find it hard (Bao & Fritchman, 2021; Chen et al., 2021) and because aids for the action-reaction topic are scarce. The medium had to be cheap, safe, easy to assemble from available materials, and hands-on, so that learners could explore it on their own in a child-friendly way.

Designing and making the medium. We planned the string-track layout and the materials, and chose two variations to test: balloon size and string length. We then built the medium from one balloon, one plastic straw, nylon string, adhesive tape, scissors, and two supports (for example chairs or small poles). These materials are cheap, easy to obtain, and safe for students to use at school and at home.

Construction followed seven steps: (1) prepare the tools and materials; (2) cut nylon string 2 to 5 meters long, depending on the available space; (3) thread the straw onto the string before mounting it on

the supports; (4) tie both ends to the supports so the string is taut and straight; (5) inflate the balloon enough, without tying its neck, so air can escape freely during the trial; (6) tape the balloon to the straw, parallel to the string track; and (7) point the balloon's neck backward so the escaping air moves opposite to the balloon's intended direction.

Presentation. We presented and demonstrated the medium to the lecturer and the class. During the demonstration we compared small, medium, and large balloons on the same string length, and compared different string lengths with the same balloon size. We observed travel speed, travel distance, and how stable the balloon's path was along the string.

Evaluation and data analysis. The lecturer and the 30 students assessed whether the medium was suitable for its purpose and gave comments and suggestions. The data were our observations from the demonstration and the feedback from the audience. We analyzed them descriptively and qualitatively, by describing the observations and the feedback and relating them to Newton's Third Law and to the idea of child-friendly learning.

Results and Discussion

Working Principle of the Balloon Rocket Medium

The "Balloon Rocket" medium works on the basic principle of Newton's Third Law, expressed as $F_{action} = -F_{reaction}$, meaning that every action force produces a reaction force of equal magnitude in the opposite direction. When the balloon is inflated, the enclosed air creates high pressure inside the balloon. Once the neck of the balloon is released, the pressurized air rushes out in one direction as the action force, while the balloon is propelled in the opposite direction as the reaction force. The greater the air pressure inside the balloon, the greater the resulting thrust, causing the balloon to travel faster along the string track.

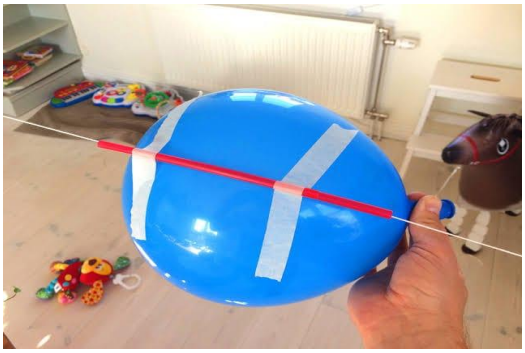

Figure 1. The Assembled Balloon Rocket Mounted on the String Track

Demonstration Results

Table 1 summarizes what we observed during the demonstration about the effect of balloon size on the balloon's motion along the string.

Table 1. Effect of Balloon Size on Balloon Rocket Motion

Balloon Size	Air Pressure	Travel Speed	Path Stability
Small	Low	Slow	Less stable
Medium	Moderate	Faster	Stable
Large	High	Fastest	Most stable

As Table 1 shows, balloon size clearly affects thrust. A small balloon gives little thrust, so it moves slowly and less predictably. A medium balloon holds more air and moves faster. A large balloon gives the strongest thrust, and its motion is faster and more stable along the whole track. The length of the track matters too: a longer track lets the balloon cover more distance before friction with the string and air resistance take away its momentum.

These observations agree with Alfi and Tralisno (2025), who reported that well-designed physics learning media on Newton's Law, whether physical or simulation-based, can clarify the relationship between force magnitude and the resulting change in motion. Overall, the demonstration showed that more air pressure in the balloon means a larger action force, and so a larger reaction force pushing the balloon forward, which agrees with Newton's Third Law.

Utilization of the Medium for Child-Friendly Physics Learning

The Balloon Rocket can be incorporated into guided-play activities, where students learn through exploration while working toward a clear learning goal (Weisberg et al., 2016). In this activity, the teacher establishes the objective of identifying the action and reaction forces involved in the balloon's motion and prepares the track and materials. Students, however, remain actively involved by inflating and releasing the balloon and deciding which variations to investigate. Previous research suggests that structured inquiry presented in a playful setting can help kindergarten children develop more connected ideas through activities such as defining a problem, exploring, modeling, and testing (Ioannou et al., 2024). Similarly, Jelinek (2024) found that constructing a concrete model before introducing a formal representation supported primary school students' understanding in an astronomy intervention. Since the Balloon Rocket activity is brief, visually engaging, and enjoyable, it can encourage participation among learners of different ages. Its low-cost materials also make it possible to repeat the activity in small groups or at home. In addition, a home–school partnership involving science kits and family science nights was associated with more science-related interactions at home (Young et al., 2024).

To make the activity child-friendly, teachers also need to provide appropriate guidance and maintain safety. Guidance is an important factor in successful inquiry-based learning (Lazonder & Harmsen, 2016). Young children conducting simple experiments may also need help planning the steps of an investigation, directing their observations, and keeping variables under control (García-Rodeja et al., 2024). During the Balloon Rocket activity, teachers can encourage students to predict the outcome, observe the balloon's movement, and explain which object exerts a force on the other. Particular attention should be given to the action–reaction relationship: the two forces act on different objects, the balloon and the air, and occur simultaneously as part of the same interaction. One force does not cause the other. This explanation may help address misunderstandings that arise when students interpret the terms action and reaction as a sequence of cause and effect (Bao & Fritchman, 2021; Chen et al., 2021). Students can also draw arrows to represent the two forces, allowing teachers to examine how they understand and represent the observed phenomenon (Kampeza & Delserieys Pedregosa, 2024). Teacher preparation is equally important, as professional development has been associated with increased teachers' science self-efficacy and improved self-regulated learning among children in their classrooms (Chen et al., 2024). For younger learners, balloons should be inflated by the teacher or with a hand pump, and the activity should be supervised to prevent children from putting fragments of burst balloons into their mouths.

Strengths and Limitations

The "Balloon Rocket" has several strengths. It is cheap and easy to build from materials students already have around them, its interactive nature attracts their interest, it works well for classroom demonstration, and it turns the abstract idea of Newton's Third Law into something they can observe directly. This agrees with Masturoh et al. (2019), who found that simple, low-cost teaching aids can produce a clearly positive learning response.

The medium also has limitations. It shows only one physics concept, its motion depends on how taut the string is, it needs more space than a narrow room offers, and results can vary from one run to the next if the apparatus is not assembled carefully. Tindan and Anaba (2024) and Serhane et al. (2023) raise a similar caution: a hands-on activity works only as well as its setup and its implementation in class, and without careful framing students may still misidentify which forces form the action-reaction pair. Bao and Fritchman (2021) report that fragmented understanding of Newton's Third Law is hard to change through traditional

instruction and that instruction explicitly targeting the central idea of interaction was needed. For this reason, the activity should be accompanied by explicit questions about the interaction between the two objects. Finally, the evaluation in this study was qualitative and limited to one lecturer and one class group of 30 university students, who are not the learners the medium is meant for. Their approval reflects a judgment of feasibility, not evidence of learning. We did not measure students' conceptual understanding, so the findings should not be generalized.

More broadly, this study offers an inexpensive, replicable way to teach Newton's Third Law in schools without a standard mechanics kit. Its simple experimental structure, varying balloon size and string length, can also be adapted by teachers or future researchers to collect more quantitative data, such as time-based measurements of speed and distance.

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Conclusion

We designed the "Balloon Rocket" using a qualitative approach. It can be built easily from a balloon, a straw, nylon string, adhesive tape, and two supports in a short, repeatable series of steps, and it works on Newton's Third Law: the air expelled from the balloon is the action force, and the balloon's motion in the opposite direction is the reaction force. In the demonstration, balloon size and string length influenced speed, path stability, and travel distance, and greater air pressure gave a greater reaction force. The lecturer and the 30 students approved the medium as feasible. Because it is playful, safe, hands-on, and can be supported by guided questions from the teacher, the medium has potential for child-friendly physics learning. Future work should test it with school students and measure its effect on their conceptual understanding.

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