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Reducing Alternative Conception of Action-Reaction Forces: The Impact of E-Rebuttal Texts After Learning and Over Time

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Abstract: The goal of this study was to reduce students' alternative conceptions (misconceptions) of action-reaction forces through the use of e-rebuttal texts. A mixed-methods approach, incorporating both quantitative and qualitative methods, was employed. The participants included 31 tenth-grade students (15 boys and 16 girls, aged 15-16 years) from a public high school in Sukabumi, West Java, Indonesia. The instrument utilized was a four-tier test consisting of 9 questions related to action-reaction forces: 3 verbal questions for the pre-test, 3 mathematical questions for the post-test (administered after learning), and 3 pictorial questions for the delayed post-test (administered over time). Data were analyzed based on categories of conception and correction of conceptions. The results indicated positive changes from the pre-test to the post-test, which remained consistent in the delayed post-test. The most significant rate of correction in students' conceptions from the pre-test to the post-test was observed in the Acceptable Change (ACh) category, while the highest percentage of changes from the post-test to the delayed post-test occurred in the No Change (NCh) category. It was concluded that e-rebuttal texts effectively reduce students' alternative conceptions (misconceptions) of action-reaction forces both immediately after learning and over time. Future researchers may consider utilizing learning models or strategies that involve group discussions to further facilitate the learning process.

INTRODUCTION

Education is a crucial tool for creating human resources who can adapt to contemporary challenges (Dudeja, 2023; Tanjung, 2020). Today's education not only focuses on knowledge but also on developing scientific attitudes and 21st-century skills (Berg et al., 2021; González-pérez & Ramírez-montoya, 2022; McPhail, 2020). Skills like critical thinking and problem-solving can be enhanced if students have a deep understanding of specific subjects. This thorough grasp allows students to apply knowledge creatively, analyze information effectively, and tackle a variety of problems with greater insight and innovation. Thus, understanding is the foundation for developing other skills. Understanding science content is particularly important in this technology-driven era. Technological advancements are greatly influenced by theories, laws, and concepts in physics. Therefore,

understanding of physics concepts is essential for students.

Students bring initial concepts from their everyday experiences into physics learning (Banda & Nzabahimana, 2021). However, these initial concepts often do not match scientific concepts, leading to alternative conceptions or misconceptions (Fratiwi, Samsudin, Ramalis, Saregar, et al., 2020; Mason & Zaccoletti, 2021; Samsudin et al., 2024). These alternative conceptions are frequently found in various physics concepts, especially fundamental ones like force concepts. Students continue to struggle with deeply understanding the relationship between acceleration, force, and mass (Fratiwi, Samsudin, Ramalis, & Costu, 2020). In line with this, a preliminary study conducted at a public high school in Sukabumi revealed that 65% of students have alternative conceptions regarding the concept of action-reaction force (Newton's Third Law). Given that this concept is fundamental to various topics in introductory mechanics, understanding it is crucial.

Students' conceptual understanding can be enhanced and alternative conceptions can be corrected through the process of conceptual change (Aleknavičiūtė et al., 2023; Resbiantoro et al., 2022). Many studies confirmation that conceptual change approaches are effective in improving students' understanding (Banda & Nzabahimana, 2021; Bouchée et al., 2022; Potvin et al., 2020; Samsudin et al., 2020; Suhandi et al., 2017). Posner et al. (1982) suggested that to change students' conceptions, certain conditions must be met: students need to be dissatisfied with their current concepts, and the new concepts must be comprehensible, believable, and practical. The four conditions projected by Posner et al. (1982) can be cultivated through a learning process. This is because one of the causes of alternative conceptions is external factors related to the learning environment.

Zhou et al. (2016) stated that science education should help build students' concepts and aid them in overcoming learning difficulties. However, often the learning process fails to correct initial alternative conception and might even worsen them. This failure often occurs because traditional teaching methods do not adequately engage students in questioning and refining their understanding. As a result, misconceptions remain unchallenged, leading to a deeper entrenchment of incorrect beliefs rather than promoting conceptual change and accurate comprehension. Preliminary studies indicate that physics teaching is still largely teacher-centered. Moreover, based on the survey results distributed to students, teachers often use textbooks in the teaching process. However, the textbooks used may not necessarily correct students' alternative conceptions.

One effective method to change students' alternative conceptions is using rebuttal texts, which challenge alternative conceptions and provide scientific explanations. Research has shown that rebuttal texts are effective in changing students' misconceptions (Aleknavičiūtė et al., 2023; Fratiwi, Samsudin, Ramalis, & Costu, 2020; Lem et al., 2017; Mason, 2018; Samsudin et al., 2021). Mason (2018) stated that rebuttal texts assist students in changing their misconceptions by presenting possible misconceptions, refuting them, and offering correct scientific explanations.

However, Bråten et al. (2020) noted that traditional texts can be less engaging, leading to reduced student participation in learning. To address this, using digital media can make texts more engaging and interactive, incorporating elements like videos, animations, or simulations (Fratiwi, Samsudin, Ramalis, & Costu, 2020; Spencer et al., 2020). Digital media can also help visualize abstract concepts, making them easier for students to

understand, especially for physics concepts.

Research conducted by Caleon & Subramaniam (2013) focused on examining the impact of refutational text combined through refutational videos to existing periodic wave phenomena, specifically aiming to address students' alternative conceptions. The integration of electronically-based rebuttal text has the potential to enhance students' conceptual understanding. Thus, we develop electronically-based rebuttal texts known as e-rebuttal texts, shown in Figure 1.

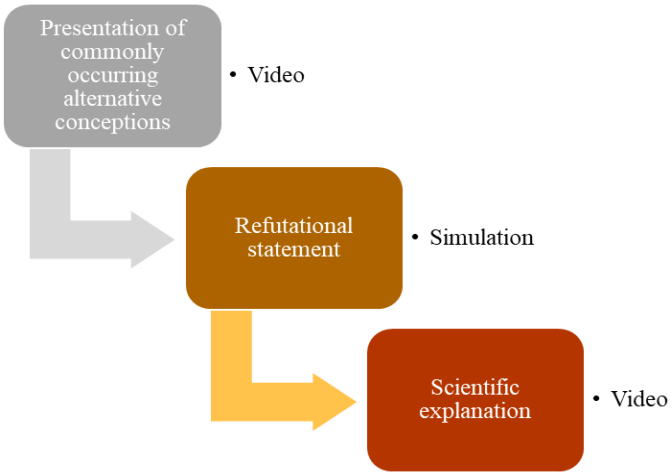


Figure 1. Sections of Rebuttal Text.

E-rebuttal text presents video of phenomena in the first part (to evoke students' alternative conceptions), simulations in the second part (to provoke confrontation), and scientific explanation videos in the third part (to provide scientific explanations). By using videos and simulations, it is hoped that abstract concepts can be visualized, ensuring that rebuttal text is not solely textual, which could otherwise lead to student boredom. Thus, the goal of this study was to decrease students' alternative conception (misconception) of action-reaction forces through e-rebuttal texts.

METHOD

The research method employed is mixed methods. Quantitative research methods are used toward determine the percentage of conceptual changes after the implementation of e-rebuttal text, while qualitative methods are used to understand the process of students' conceptual change. The research design utilized is embedded mixed methods that combines quantitative and qualitative research methods simultaneously. The research process through embedded mixed methods design is illustrated as in Figure 2.

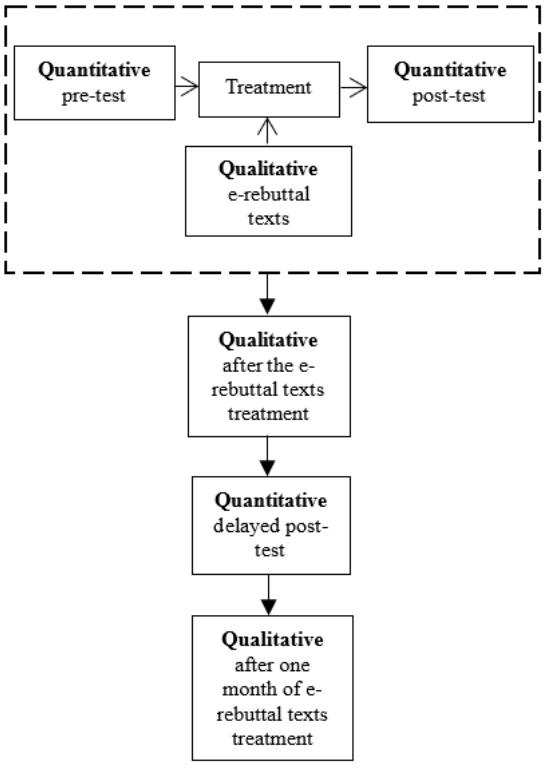


Figure 2. Embedded Mixed Methods Design.

In Figure 2, quantitative data were obtained from pre-tests, post-tests, and delayed post-tests. Qualitative data were collected during the learning process based on students' responses to e-rebuttal texts. Additionally, the process of conceptual change following the learning activities was analyzed qualitatively. Both quantitative and qualitative data were combined to interpret the research findings.

The sample comprised one class of 31 tenth-grade students (15 male and 16 female, aged between 15 and 16) from a public high school in Sukabumi, West Java, Indonesia.

The instrument utilized was a four-tier test consisting of 9 questions related to action-reaction forces: 3 verbal questions for the pre-test, 3 mathematical questions for the post-test (after learning), and 3 pictorial questions for the delayed post-test (over time). An illustration of the instrument is shown in Figure 3.

1.1 A truck collides with a sedan at a bend in a mountainous area. The truck driver could not avoid the collision due to the short visibility distance. The force experienced by the truck and the car during the collision is….
   a. The truck and the car do not exert forces on each other, but the car will be destroyed by the truck
   b. The truck exerts a force on the car but the car does not exert a force on the truck
   c. The truck exerts a greater force on the car than the car exerts on the truck
   d. The truck exerts the same amount of force on the car as the car exerts on the truck
   e. The car exerts a greater force on the truck than the truck exerts on the car

1.2 Are you sure about your answer to question 1.1?
   a. Yes
   b. No

1.3 Reason for your answer to question 1.1:
   a. The action-reaction forces are always equal in magnitude but opposite in direction and do not depend solely on the mass of the objects
   b. The action-reaction forces are influenced by the mass of the objects; the greater the mass, the smaller the force exerted
   c. The action-reaction forces are influenced by the mass of the objects; the greater the mass, the greater the force exerted
   d. The action-reaction forces are influenced by the speed of the objects; the greater the speed, the greater the force exerted
   e. The action-reaction forces are influenced by the speed of the objects; the smaller the speed, the greater the force exerted

1.4 Are you sure about your answer to question 1.3?
   a. Yes
   b. No

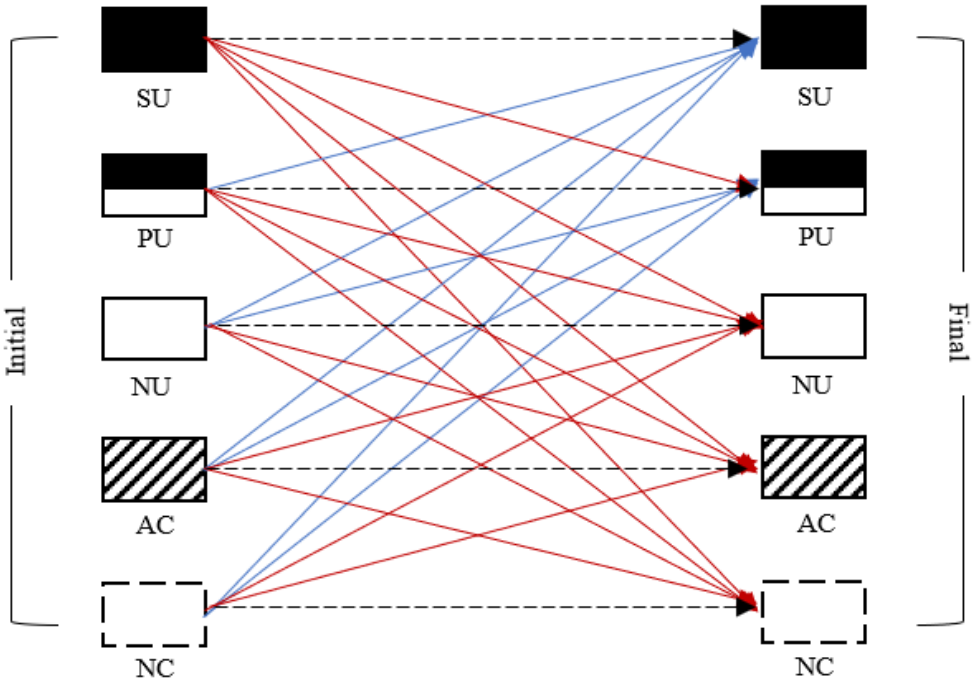
Figure 3. The Example Four-Tier Test in Verbal Representation.

Figure 3 illustrates that the first level consists of multiple-choice questions. The second level measures students' confidence in their answers, categorized as "yes" or "no". The third level asks for reasons behind their choices, and the fourth level assesses confidence in their reasoning, also categorized as "yes" or "no". Before being used in the study, the instrument was tested on 92 students. The analysis included validity and reliability testing using Rasch analysis. The validity test showed that the raw variance explained by measures was above 40 %, placing it in the 'appropriate' category. The reliability test produced a Cronbach's Alpha of 0.87, indicating 'high appropriateness'. Thus, the instrument was confirmed to be valid and reliable for use. Data were analyzed based on categories of conception and correction of conceptions. According to Gurel et al. (2015), student conceptions can be categorized into several types, as detailed in Table 1. The categories of student conceptual change are adapted from Samsudin et al. (2016). The categories of conceptual change have several possibilities as depicted in Figure 4.

Table 1. Categories of Conceptions for the Four-Tier Test.

Categories	Symbol	1-tier	2-tier	3-tier	4-tier
SU		√	Yes	√	Yes
PU		√	Yes	√	No
		√	No	√	Yes
		√	No	√	No
		√	Yes	×	Yes
		√	Yes	×	No
		√	No	×	Yes
		√	No	×	No
		×	Yes	√	Yes
		×	Yes	√	No
		×	No	√	Yes
		×	No	√	No
NU		×	Yes	×	No
		×	No	×	Yes
		×	No	×	No
AC		×	Yes	×	Yes
NC		If not filling one or more tier			

Note: SU=Sound Understanding; PU=Partial Understanding; NU=No Understanding; AC=Alternative Conception; NC=No Coding



Note: Blue line=Acceptable Change (ACh); Red line=Not Acceptable Change (NAC); Dashed line=No Change (NCh)

Figure 4. Possible Changes in Students' Conceptions.

RESULT AND DISCUSSION

The profile of student conceptions on action-reaction forces was obtained based on their responses to the four-tier test during the pre-test, post-test, and delayed post-test. The percentage of each conception is shown in Table 2.

Table 2. Percentage of Each Students' Conceptions on Action-Reaction Forces.

Categories	Test	The Question Number			Average (%)
		N1 (%)	N2 (%)	N3 (%)	
SU	Pre-	3	-	-	1
	Post-	29	23	3	18
	Delayed	42	33	42	39
PU	Pre-	19	26	29	25
	Post-	45	51	39	45
	Delayed	23	29	29	27
NU	Pre-	10	16	13	13
	Post-	-	-	3	1
	Delayed	-	-	6	2
AC	Pre-	68	55	58	60
	Post-	26	26	55	36
	Delayed	35	35	23	31
NC	Pre-	-	3	-	1
	Post-	-	-	-	0
	Delayed	-	3	-	1

Based on Table 2, for the Sound Understanding (SU) category, the pre-test had an average percentage of 1%, which increased to 18% in the post-test and further to 39% in the delayed post-test. In the Partial Understanding (PU) category, the pre-test had an average percentage of 25%, which increased to 45% in the post-test but decreased to 27% in the delayed post-test. In the No Understanding (NU) category, the pre-test had an average percentage of 13%, which decreased to 1% in the post-test and increased to 2% in the delayed post-test. In the Alternative Conception (AC) category, the pre-test had an average percentage of 60%, which decreased to 36% in the post-test and further to 31% in the delayed post-test. In the No Coding (NC) category, the pre-test, post-test and delayed post-test had average percentages of 1%, 0% and 1%, respectively.

This indicates that there is an improvement in students' understanding of the concept of action-reaction forces both immediately after the implementation of e-rebuttal texts and over a span of one month (delayed post-test). Furthermore, considering the percentage of misconceptions or alternative conceptions, there is a decrease after the implementation of e-rebuttal texts, and this decrease remains consistent even after one month of using e-rebuttal texts.

Nevertheless, after the implementation of e-rebuttal texts, the percentage in the SU category did not reach 100%, and alternative conceptions still occurred at 31-36%. This is because the alternative conceptions in students are resistant to change as they are deeply ingrained in their mind and require a significant amount of time to alter (Kesuma et al., 2020; Samsudin et al., 2017; Suhandi et al., 2020). However, e-rebuttal texts, which are available 24 hours a day without regard to time and place, can be utilized by students anytime and anywhere to change their alternative conception. Changes in students' conceptions of action-reaction forces for question N1 can be seen in Figure 5.

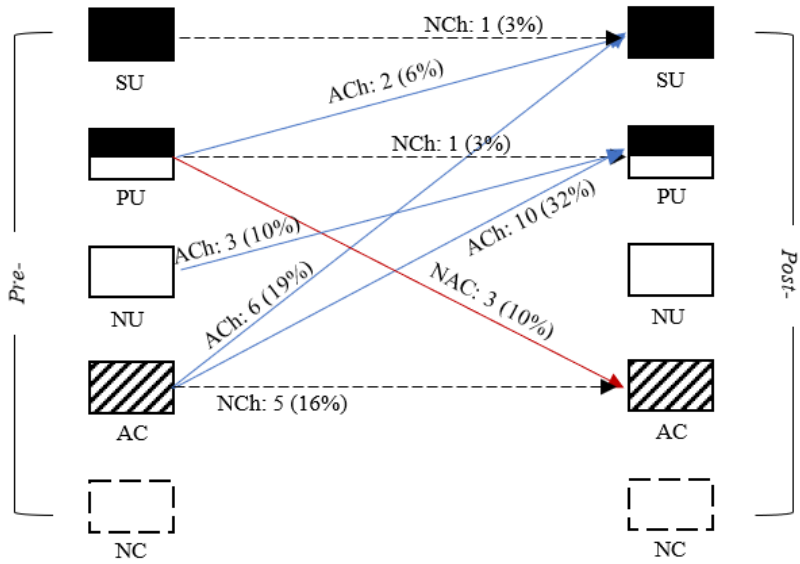


Figure 5. Conceptual Changes in N1 from Pre-test to Post-test.

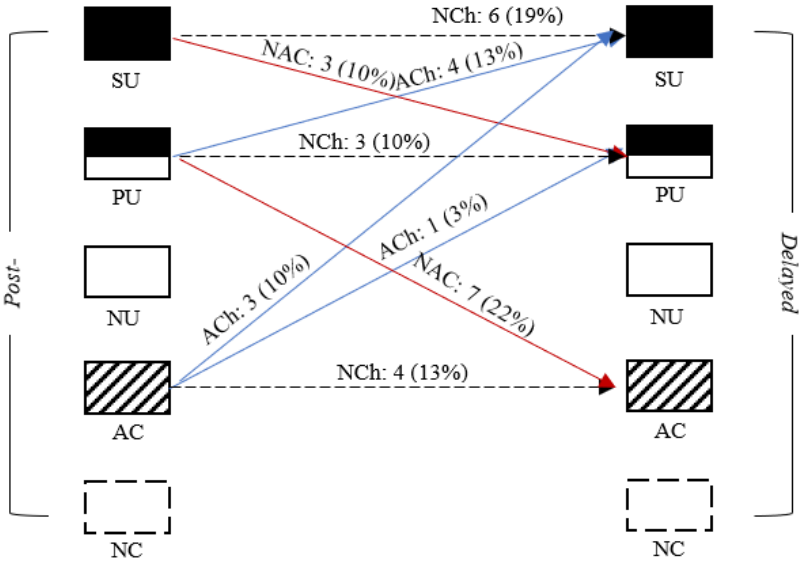


Figure 6. Conceptual Changes in N1 from Post-test to Delayed Post-test.

According to Figure 5, the highest overall change was in the Acceptable Change (ACh) category, accounting for 68%. Within this category, the most common transition was from AC to SU, indicating that students' conceptions were modified through e-rebuttal texts. In the No Acceptable Change (NAC) category, the changes totaled 10%. In the No Change (NCh) category, the most frequent instance was in AC, involving five students. The concept in N1 pertains to action-reaction forces in collision events. Students stated that action-reaction forces are solely influenced by the mass of objects (misconception). This aligns with the studies of Poutot & Blandin (2015), which found that students believe objects with greater mass exert greater force.

The process of conceptual change in question N1 from the post-test to the delayed post-test is shown in Figure 6. Based on Figure 6, the highest total change occurred in the No Change (NCh) category, totaling 42%. In the ACh category, the most frequent change occurred from PU to SU. This occurred

because there was enough time for students to reread the provided e-rebuttal texts, allowing their incomplete conceptions to become more complete. In the NAC category, the most frequent change was from PU to AC. In the NCh category, SU was the most frequently occurring category, indicating that students maintained their scientific conceptions.

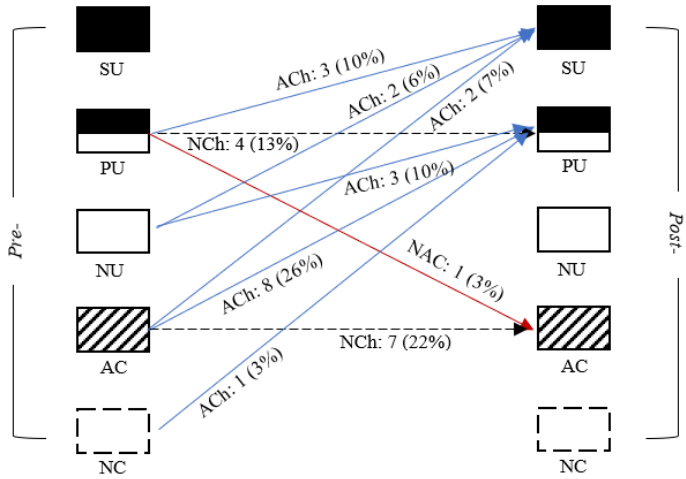
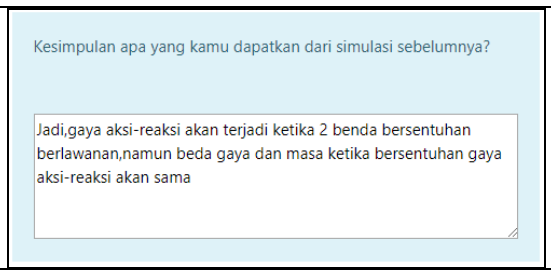


Figure 7. Conceptual Changes in N2 from Pre-test to Post-test.

Changes in students' conceptions of action-reaction forces for question N2 can be seen in Figure 7. According to Figure 7, the most significant overall change was in the Acceptable Change (ACh) category at 62%. Within this category, the most notable change was from AC to PU, which accounted for 26%. This suggests that students' conceptions were altered through e-rebuttal texts, although their understanding was still incomplete. In the No Acceptable Change (NAC) category, changes made up 3%. In the No Change (NCh) category, the most frequent instance was in AC, involving seven students, likely because AC is difficult to change.

The concept in N2 relates to action-reaction forces in the context of a car pushing a truck. During the pre-test, Student 10 (S10) did not have an Acceptable Change (AC). S10 believed that when a small car pushes a stalled truck, the force exerted by the car on the truck is less than the force exerted by the truck on the car. The reasoning was that action-reaction force pairs always exist when two objects interact, even if they do not cause the objects to move. S10's answer was incorrect, but the reasoning was correct, and they were confident in both, thus it was categorized as PU.



What conclusions did you draw from the previous simulation?

So, action-reaction forces will occur when two objects are in contact and opposite to each other, but despite differences in force and mass, the action-reaction forces will be equal.

Figure 8. S10's Responses on the E-Rebuttal Texts.

During the post-test, S10 stated that when the car pushes the truck, there is no action-reaction force. The car's engine runs, allowing the car to push the

truck, but the truck's engine does not run, so it cannot exert a force on the car. The reasoning was that action-reaction force pairs act on different objects, are in the same direction, and are always equal in magnitude. Both S10's answer and reasoning were incorrect, and they were confident in both, thus it was categorized as AC. Considering S10's answers, it suggests that students might also have AC, as shown in Figure 8.

The process of changing conceptions in question N2 from the post-test to the delayed post-test is shown in Figure 9. Based on Figure 9, the highest total change occurred in the No Change (NCh) category at 42%. In the ACh category, the most frequent change was from AC to SU. In the NAC category, the most common change was from PU to AC. In the NCh category, SU was the most frequently occurring category, indicating that students maintained their scientific conceptions.

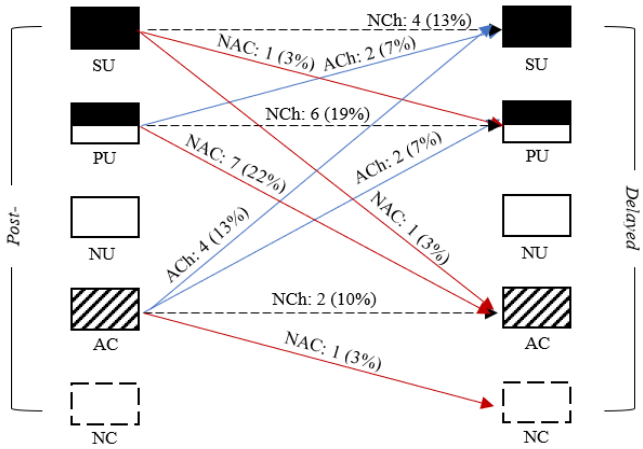


Figure 9. Conceptual Changes in N2 from Post-test to Delayed Post-test.

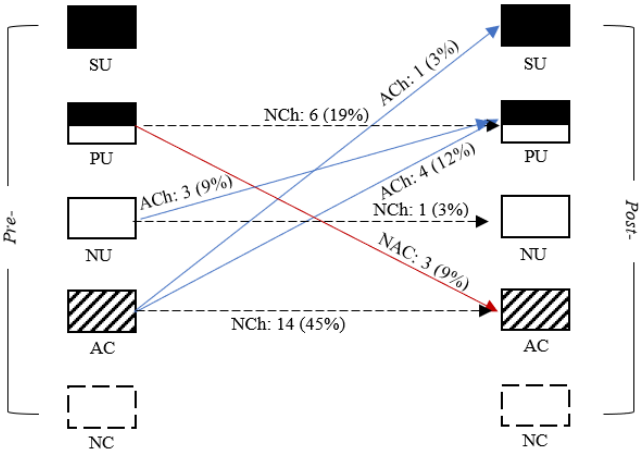


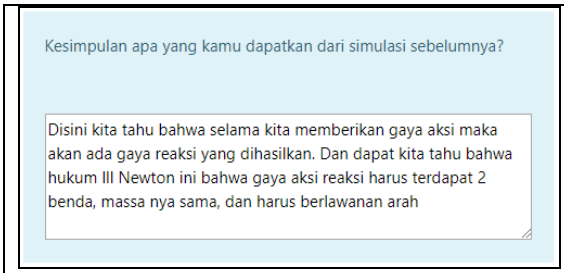
Figure 10. Conceptual Changes in N3 from Pre-test to Post-test.

Changes in students' conceptions of action-reaction forces for question N3 can be seen in Figure 10. Based on Figure 10, the highest total change occurred in the No Change (NCh) category at 67%. In the ACh category, the most frequent change was from AC to PU. This indicates that through the implementation of e-rebuttal texts, there was construction of students' conceptions, although these conceptions were not yet complete. In the No Acceptable Change (NAC) category, changes amounted to 9%. Within the NCh category, the most frequent change was in AC at 45%.

The concept in N3 pertains to the action-reaction forces on touching objects. During the pre-test, S07, S13, and S14 did not have AC. A force is applied to three blocks, A, B, and C, which are touching each other. During the pre-test, S07 stated that the action-reaction force pair is the force from block A to block B and the force from block B to block C. S13 stated that the action-reaction force pair is the pushing force and the force from block B to block A. S14 stated that the action-reaction force pair is the force from block B to block A and from block B to block C. S07, S13, and S14 reasoned that action-reaction force pairs act on different objects, are opposite in direction, and are always equal in magnitude. The answers from S07, S13, and S14 were incorrect, but the reasoning was correct, and both S07 and S14 were confident in their answers while S13 was not, thus they were categorized as PU.

During the post-test, S07 stated that the action-reaction force pair is the force from block A to block B and the force from block C to block B. The reasoning was that action-reaction force pairs act on the same object, are in the same direction, and are always equal in magnitude. S13 and S14 stated that the action-reaction force pair is the force from block B to A and the force from block B to C. The reasoning was that action-reaction force pairs act on the same object, are opposite in direction, and are always equal in magnitude. The answers and reasoning of S07, S13, and S14 were incorrect, and they were confident in both, thus they were categorized as having AC.

Analyzing the students' answers on the interactive refutational text media, it is likely that the students have AC, as shown in Figure 11. Based on Figure 11, it can be seen that S13 stated that action-reaction forces occur on objects with the same mass. From this response, it is evident that S13 had AC during the post-test.



What conclusions did you draw from the previous simulation?

Here we know that whenever we apply an action force, a reaction force will be generated. We understand from Newton's Third Law that the action-reaction forces involve two objects, have equal magnitude, and must be in opposite directions.

Figure 11. S13's Responses on the E-Rebuttal Texts.

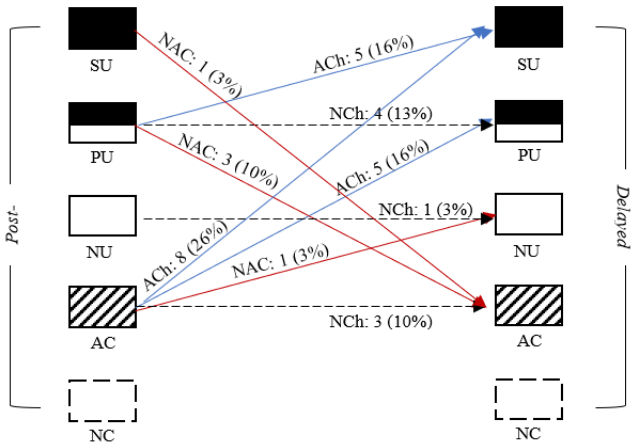


Figure 12. Conceptual Changes in N3 from Pre-test to Delayed Post-test.

The process of conceptual change in question N3 from the post-test to the delayed post-test is depicted in Figure 12. Figure 12 shows that the highest overall change was in the Acceptable Change (ACh) category at 58%. Within this category, the most common shift was from AC to SU. In the No Acceptable Change (NAC) category, the most frequent change was from PU to AC, accounting for 10%. In the NCh category, PU was the most frequent. S07 and S14 have changed their AC to SU. However, S01, S05, S18, and S27 had AC in the delayed post-test.

This occurred due to the considerable time gap between the post-test and the delayed post-test, which likely allowed for a significant lapse in the retention of newly acquired knowledge and concepts. During this interval, students might have experienced a reversion to their initial misconceptions or a lack of reinforcement of the learned material, thus impacting their performance and the stability of their responses in the delayed post-test. There might be a significant lapse in retention over time, which could impact performance in the delayed post-test (Lin et al., 2023). This suggests that a significant time gap between the post-test and delayed post-test could lead to a decline in retention and performance (Latimier et al., 2019).

CONCLUSION

Based on the research conducted, it can be concluded that using e-rebuttal texts can reduce students' alternative conceptions (misconceptions) about action-reaction forces. Overall, there was a positive shift from the pre-test to the post-test and delayed post-test. The highest percentage of concept changes from the pre-test to the post-test occurred in the Acceptable Change (ACh) category, while the highest percentage of changes from the post-test to the delayed post-test occurred in the No Change (NCh) category. The study has identified some shortcomings and areas for improvement to achieve better research results. Before using the e-rebuttal texts, teachers or researchers should check the availability of laptops or computers, as some simulations cannot be operated via mobile phones. Additionally, since the texts used is web-based, the availability of an internet connection also needs to be considered. Future researchers could add several text sections, such as simulations of action-reaction forces on overlapping objects. To facilitate discussions, future researchers could use learning models or strategies that involve students working in groups. E-rebuttal texts can be applied to all physics concepts, not only basic concepts but also more complex ones, especially those that are difficult to visualize, abstract, or hard to find in everyday life.

REFERENCES

Aleknavičiūtė, V., Lehtinen, E., & Södervik, I. (2023). Thirty years of conceptual change research in biology – A review and meta-analysis of intervention studies. In *Educational Research Review* (Vol. 41). https://doi.org/10.1016/j.edurev.2023.100556

Banda, H. J., & Nzabahimana, J. (2021). Effect of integrating physics education technology simulations on students' conceptual understanding in physics: A review of literature. *Physical Review Physics Education Research*, *17*(2). https://doi.org/10.1103/PhysRevPhysEducRes.17.023108

Berg, T. B., Achiam, M., Poulsen, K. M., Sanderhoff, L. B., & Tøttrup, A. P. (2021). The Role and Value of Out-of-School Environments in Science Education for 21st Century Skills. In *Frontiers in Education* (Vol. 6).

https://doi.org/10.3389/feduc.2021.674541

Bouchée, T., de Putter - Smits, L., Thurlings, M., & Pepin, B. (2022). Towards a better understanding of conceptual difficulties in introductory quantum physics courses. In *Studies in Science Education* (Vol. 58, Issue 2). https://doi.org/10.1080/03057267.2021.1963579

Bråten, I., Braasch, J. L. G., & Salmerón, L. (2020). Reading Multiple and Non-Traditional Texts: New Opportunities and New Challenges. In *Handbook of Reading Research, Volume V: Vol. V* (pp. 79–98). https://doi.org/10.4324/9781315676302-5

Caleon, I., & Subramaniam, R. (2013). Addressing students' alternative conceptions on the propagation of periodic waves using a refutational text. *Physics Education*, *48*(5), 657–663. https://doi.org/10.1088/0031-9120/48/5/657

Dudeja, M. (2023). Adaptation to Transformation of Human Resource Practices and Technology: Web 3.0 Metaverse. *Journal of Survey in Fisheries Sciences*, *10*, 1187–1196. https://doi.org/10.17762/sfs.v10i4s.1169

Fratiwi, N. J., Samsudin, A., Ramalis, T. R., & Costu, B. (2020). Changing students' conceptions of Newton's second law through express-refute-investigate-clarify (ERIC) text. *Universal Journal of Educational Research*, *8*(6), 2701–2709. https://doi.org/10.13189/ujer.2020.080655

Fratiwi, N. J., Samsudin, A., Ramalis, T. R., Saregar, A., Diani, R., Irwandani, Rasmitadila, & Ravanis, K. (2020). Developing memori on Newton's laws: For identifying students' mental models. *European Journal of Educational Research*, *9*(2), 699–708. https://doi.org/10.12973/eu-jer.9.2.699

González-pérez, L. I., & Ramírez-montoya, M. S. (2022). Components of Education 4.0 in 21st Century Skills Frameworks: Systematic Review. *Sustainability (Switzerland)*, *14*(3). https://doi.org/10.3390/su14031493

Gurel, D. K., Eryilmaz, A., & McDermott, L. C. (2015). A review and comparison of diagnostic instruments to identify students' misconceptions in science. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(5), 989–1008. https://doi.org/10.12973/eurasia.2015.1369a

Kesuma, G. C., Diani, R., Hasanah, N., & Fujiani, D. (2020). Blended Learning Model: Can It Reduce Students' Misconception in Physics? *Journal of Physics: Conference Series*, *1467*(1). https://doi.org/10.1088/1742-6596/1467/1/012044

Latimier, A., Riegert, A., Peyre, H., Ly, S. T., Casati, R., & Ramus, F. (2019). Does pre-testing promote better retention than post-testing? *Npj Science of Learning*, *4*(1). https://doi.org/10.1038/s41539-019-0053-1

Lem, S., Onghena, P., Verschaffel, L., & Van Dooren, W. (2017). Using refutational text in mathematics education. *ZDM - Mathematics Education*, *49*(4). https://doi.org/10.1007/s11858-017-0843-y

Lin, D. T. A., Choo, L. B., Ganapathy, M., & Kasuma, S. A. A. (2023). The Impact of Image-Driven Stimuli on Malaysian Young Learners' Receptive and Productive Vocabulary. *Asia Pacific Journal of Educators and Education*, *38*(1), 141–162.

https://doi.org/10.21315/apjee2023.38.1.8

Mason, L. (2018). The Role of Inhibition in Conceptual Learning from Refutational and Standard Expository Texts. *International Journal of Science and Mathematics Education*, *17*(3), 483–501. https://doi.org/https://doi.org/10.1007/s10763-017-9874-7

Mason, L., & Zaccoletti, S. (2021). Inhibition and Conceptual Learning in Science: a Review of Studies. In *Educational Psychology Review* (Vol. 33, Issue 1). https://doi.org/10.1007/s10648-020-09529-x

McPhail, G. (2020). Twenty-First Century Learning and the Case for More Knowledge About Knowledge. *New Zealand Journal of Educational Studies*, *55*(2), 387–404. https://doi.org/10.1007/s40841-020-00172-2

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, *66*(2), 211–227. https://doi.org/10.1002/sce.3730660207

Potvin, P., Nenciovici, L., Malenfant-Robichaud, G., Thibault, F., Sy, O., Mahhou, M. A., Bernard, A., Allaire-Duquette, G., Blanchette Sarrasin, J., Brault Foisy, L. M., Brouillette, N., St-Aubin, A. A., Charland, P., Masson, S., Riopel, M., Tsai, C. C., Bélanger, M., & Chastenay, P. (2020). Models of conceptual change in science learning: establishing an exhaustive inventory based on support given by articles published in major journals. In *Studies in Science Education* (Vol. 56, Issue 2). https://doi.org/10.1080/03057267.2020.1744796

Poutot, G., & Blandin, B. (2015). Exploration of Students' Misconceptions in Mechanics using the FCI. *American Journal of Educational Research*, *3*(2), 116–120. https://doi.org/10.12691/education-3-2-2

Resbiantoro, G., Setiani, R., & Dwikoranto. (2022). A Review of Misconception in Physics: The Diagnosis, Causes, and Remediation. *Journal of Turkish Science Education*, *19*(2), 403–427. https://doi.org/10.36681/tused.2022.128

Samsudin, A., Azizah, N., Fratiwi, N. J., Suhandi, A., Irwandani, I., Nurtanto, M., Yusup, M., Supriyatman, S., Masrifah, M., Aminudin, A. H., & Costu, B. (2024). Development of DIGaKiT: identifying students' alternative conceptions by Rasch analysis model. *Journal of Education and Learning*, *18*(1), 128–139. https://doi.org/10.11591/edulearn.v18i1.20970

Samsudin, A., Azizah, N., Sasmita, D., Rasmitadila, Fatkhurrohman, M. A., Supriyatman, & Wibowo, F. C. (2020). Analyzing the students' conceptual change on kinetic theory of gases as a learning effect though computer simulations-assisted conceptual change model. *Universal Journal of Educational Research*, *8*(2), 425–437. https://doi.org/10.13189/ujer.2020.080213

Samsudin, A., Rusdiana, D., Efendi, R., Fratiwi, N. J., Aminudin, A. H., & Adimayuda, R. (2021). Development of Predict-Observe-Explain (POE) Strategy Assisted by Rebuttal Texts on Newton's Law Material with Rasch Analysis. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, *6*(1), 103–115. https://doi.org/10.24042/tadris.v6i1.7641

Samsudin, A., Suhandi, A., Rusdiana, D., Kaniawati, I., & Coştu, B. (2016). Investigating the effectiveness of an active learning based-interactive conceptual instruction (ALBICI) on electric field concept. *Asia-Pacific Forum on Science Learning and Teaching*, *17*(1), 1–41.

Samsudin, A., Suhandi, A., Rusdiana, D., Kaniawati, I., & Coştu, B. (2017). Promoting conceptual understanding on magnetic field concept through interactive conceptual instruction (ICI) with PDEODE∗E tasks. *Advanced Science Letters*, *23*(2), 1205–1209. https://doi.org/10.1166/asl.2017.7539

Spencer, R., Comeau, E., Matchett, B., Biderman, M., Doria, N., Joy, P., & Numer, M. (2020). Interactive e-texts and students: A scoping review. *Canadian Journal of Education*, *43*(1).

Suhandi, A., Hermita, N., Samsudin, A., Maftuh, B., & Coştu, B. (2017). Effectiveness of visual multimedia supported conceptual change texts on overcoming students' misconception about boiling concept. *Turkish Online Journal of Educational Technology*, 1012–1022.

Suhandi, A., Surtiana, Y., Husnah, I., Setiawan, W., Siahaan, P., Samsudin, A., & Costu, B. (2020). Fostering high school students' misconception about boiling concept using conceptual change laboratory (cCLAb) activity. *Universal Journal of Educational Research*, *8*(6), 2211–2217. https://doi.org/10.13189/ujer.2020.080603

Tanjung, B. N. (2020). Human Resources (HR) In Education Management. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, *3*(2), 1240–1249. https://doi.org/10.33258/birle.v3i2.1056

Zhou, S., Wang, Y., & Zhang, C. (2016). Pre-service science teachers' PCK: Inconsistency of pre-service teachers' predictions and student learning difficulties in newton's third law. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(3). https://doi.org/10.12973/eurasia.2016.1203a