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RESEARCH ARTICLE

Integrating Discrepant Events and Refutation Instruction to Enhance Conceptual Change and Misinformation Resistance in Physics Learning

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Abstract
Scientific literacy which involves critical thinking, understanding concept and applying science skills to real life situation is the cornerstone of quality education and informed citizenship. But according to PISA 2022 results, Philippines ranked below global average in science literacy which indicate the need for strategies that could enhance conceptual understanding of the students. Discrepant Events and Refutation Instruction is deemed suitable in improving conceptual understanding, reducing science misconception and combatting science misinformation. The study aims to explore the integration of discrepant events and refutation instruction in improving the conceptual understanding and enhancing resistance to science misinformation of the students. Two Grade 12 - STEM class with the same populations were used as experimental and control group. A quasi-experimental method was applied in the study and a pre-test was administered to check the student' conceptual knowledge which revealed that both groups is in the developing level. The result of the study showed a highly significant improvement in the students' conceptual understanding, but only minimal reduction in terms of students' resistance to science misinformation. The research findings served as a stepping stone in the improvement of instruction and effective teaching models in Science Education particularly in Physics.

Keywords : Cognitive Conflict Theory, Conceptual Change Theory, Conceptual Understanding, Discrepant events, Refutation Instruction, Refutation Text Theory, Science Misinformation Resistance

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INTRODUCTION

In the digital age, the dissemination of scientific knowledge faces growing challenges due to the increasing prevalence of science denial and disinformation. These issues have been exacerbated by the rapid spread of misleading information through online and social media platforms, shaping public understanding and influencing students' beliefs about science (Lewandowsky et al., 2020). The spread of misinformation undermines scientific literacy, which is a cornerstone of quality education and informed citizenship. Consequently, educators must employ effective instructional strategies that not only promote conceptual understanding but also develop learners' ability to critically evaluate scientific claims. This concern aligns with the United Nations Sustainable Development Goal (SDG) 4, which advocates for quality education that fosters critical thinking, and SDG 16, which emphasizes building peaceful and just institutions founded on truth and evidence-based reasoning (United Nations, 2020).

In science education, particularly in physics, misconceptions among students remain a persistent challenge. Based from the Programme for International Student Assessment (PISA) 2022 which was usually conducted by the Organization for Economic Co-operation and Development (OECD), with an average score of 373 in science, the Philippines ranked 79th out of 81 participating countries. The score obtained is actually below the OECD average score which is 485 (OECD, 2023). The said performance showed that there is a significant gap in the student's scientific literacy and its application to real life contexts. The low aptitude in science is commonly associated with misconceptions and misinformation. Aside from that, students often enter classrooms with pre-existing beliefs about natural phenomena—such as motion, force, or energy—that conflict with scientific explanations (Chi, 2008). Moreover, traditional lecture-based approaches have been shown to be insufficient in addressing these misconceptions because learners tend to assimilate new information into their existing mental models rather than reconstructing their understanding (Treagust & Duit, 2008). To address this, educators have explored conceptual change strategies that induce cognitive conflict and encourage conceptual restructuring.

One effective strategy for fostering conceptual change is the use of discrepant events, which are demonstrations or phenomena that challenge students' predictions and create a sense of surprise or disequilibrium (Gonzalez-Espada, Birriel, & Birriel, 2010). Another promising approach is refutation instruction, which explicitly presents a misconception, refutes it, and provides the correct scientific concept (Tippett, 2010). This strategy has been shown to facilitate the replacement of inaccurate beliefs with scientifically accurate ones and to improve learners' resistance to misinformation (Kendeou & O'Brien, 2021) and when combined with inquiry-based learning it has a high potential in inducing cognitive conflict and in enhancing conceptual understanding (Aligo, B. L. 2025).

Although discrepant events and refutation instruction have each demonstrated effectiveness in promoting conceptual understanding, studies have generally examined them in isolation. The combined use of these strategies remains underexplored, particularly in the context of physics education where misconceptions are deeply rooted and persistent (Sinatra & Lombardi, 2020). This gap in the literature highlights the need to examine how an integrated instructional approach—one that combines discrepant events with refutation instruction—can simultaneously foster conceptual change and misinformation resilience among learners.

This study, therefore, aims to investigate the effectiveness of integrating discrepant events and refutation instruction in enhancing students' conceptual understanding in physics and strengthening their ability to resist misinformation. The results of this study are expected to provide empirical evidence on how these complementary strategies can be used to promote deeper learning and critical scientific reasoning. Moreover, the study contributes to the realization of SDG 4 (Quality Education) by improving science pedagogy and SDG 16 (Peace, Justice, and Strong Institutions) by promoting truth-based learning and informed decision-making. By addressing the current gap in science education research, this study seeks to develop an evidence-based instructional framework that can be used to enhance conceptual learning and misinformation literacy in physics classrooms.

Despite numerous curriculum reforms and advances in science pedagogy, many students continue to hold persistent misconceptions in physics concepts such as motion, energy, and force. These misconceptions often resist change even after conventional instruction, limiting students' ability to apply scientific reasoning in real-world contexts. Moreover, in an era marked by widespread science denial and misinformation, students struggle to critically evaluate the accuracy and credibility of scientific claims presented in media and social platforms. The persistence of misconceptions and susceptibility to misinformation highlight a pressing need for innovative instructional interventions that promote conceptual change, critical reasoning, and misinformation resistance (Kendeou & O'Brien, 2021; Lewandowsky et al., 2020).

The integration of discrepant events—which create cognitive conflict by confronting learners' misconceptions with unexpected phenomena—and refutation instruction, which explicitly corrects false beliefs and reinforces scientific explanations, has shown promise in improving conceptual understanding (Tippett, 2010; Dreyfus et al., 1990). However, there remains a research gap in examining how these two strategies, when used together, influence both conceptual understanding and resistance to misinformation in science learning, particularly in the context of physics education. Furthermore, empirical evidence on the extent to which refutation instruction supports cognitive resolution following discrepant events remains limited, especially among graduate and secondary science learners.

This study seeks to determine the effectiveness of combining discrepant events and refutation instruction in improving students' conceptual understanding in physics and enhancing their resistance to science-related misinformation.

Specifically, this study seeks to answer the following questions:

1. What is the level of students' conceptual understanding in selected physics topics before and after exposure to discrepant events with refutation instruction?
2. Is there a significant difference between the pretest and posttest scores in students' conceptual understanding after exposure to discrepant events and refutation instruction?
3. What is the level of students' resistance to science misinformation before and after exposure to the intervention?
4. Is there a significant difference between the pretest and posttest scores in students' resistance to science misinformation?
5. Is there a significant relationship between students' conceptual understanding and their resistance to misinformation after the intervention?

Null Hypotheses:

H1: There is no significant difference between the pretest and posttest mean scores in students' conceptual understanding after exposure to discrepant events with refutation instruction.

H2: There is no significant difference between the pretest and posttest mean scores in students' resistance to science misinformation after the intervention.

H3: There is no significant relationship between students' conceptual understanding and their resistance to misinformation after exposure to discrepant events with refutation instruction.

METHODOLOGY

The study employed a systematic process of data collection to ensure the reliability and validity of results. This research was conducted in three main stages that were done successively. The first stage was simply the preparation stage which ensures the readiness of all the necessary materials before the conduct of the study. Once approval was granted, orientation sessions was conducted with the participating students to explain the purpose of the study, ethical considerations, and data confidentiality protocols. The second stage was implementation, where the participants were divided into two groups: the experimental group (Vanadium), which received instruction using refutation text integrated with discrepant events, and the control group (Platinum), which received traditional instruction. Both groups had undergone a pretest to assess their baseline conceptual understanding and attitudes toward science-related misinformation. The pretest was use to validate instruments adapted from existing conceptual and belief inventories in physics education. Following the pretest, the experimental group was exposed to a series of lessons incorporating refutation texts—which explicitly present common misconceptions, refute them, and provide scientifically accurate explanations—and discrepant events designed to trigger cognitive conflict. The control group was taught using conventional lecture-based methods aligned with the same curriculum content.

Interpretive Scale for Science Misinformation	
Range	Descriptive Equivalent
4.20 – 5.00	Strongly Agree
3.40 – 4.19	Agree
2.60 – 3.39	Neutral

Descriptive statistics such as mean, standard deviation, and percentage was used to summarize students' performance levels and will provide an overview of their conceptual understanding before and after the intervention. To determine significant differences between the two groups, independent samples t-test and paired samples t-test was utilized. The Analysis of Covariance (ANCOVA) was also to control for initial differences in pretest scores and assess the true effect of the instructional intervention on posttest outcomes. Qualitative data from classroom student journals reflections was analyzed thematically to provide deeper insights into how refutation and discrepant events contribute to conceptual change and cognitive engagement. Emerging themes related to students' misconceptions, belief revision, and learning experiences was identified through thematic coding. The triangulation of quantitative and qualitative data strengthened the validity of findings and allow for a richer interpretation of the intervention's effects. All statistical analyses were conducted using statistical software such as SPSS or JASP, and the level of significance was set at $p < 0.05$. The interpretation of results followed the theoretical assumptions of Conceptual Change Theory, Refutation Text Theory, and Cognitive Conflict Theory, ensuring that findings are grounded in established frameworks for learning and conceptual understanding in science education. The interpretive scale for conceptual understanding was aligned with the proficiency levels of the Department of Education under DepEd Order No. 8, s. 2015, which categorizes learners into Beginning, Developing, Approaching Proficiency, Proficient, and Advanced. These levels reflect a progression from minimal understanding to higher-order thinking and knowledge transfer, consistent with conceptual change theory."

Interpretive Scale for Level of Conceptual Understanding	
Range	Descriptive Equivalent
21 – 25	Advanced
16– 20	Proficient
11 – 15	Developing
6 – 10	Emerging
0 – 5	Pre-conceptual

1.80 – 2.59	Disagree
1.00 – 1.79	Strongly Disagree

RESULTS AND FINDINGS

Table 1. *Level of Students' Conceptual Understanding in Selected Physics Topics*

Group	Test	Mean	SD	Descriptive Equivalent
Experimental	Pretest	11.23	2.32	Developing
	Posttest	16.69	3.94	Proficient
Control	Pretest	11.94	2.47	Developing
	Posttest	15.11	3.57	Developing

Table 1 shows the mean scores of students' conceptual understanding in selected physics topics in both the experimental and control groups. The experimental group - students exposed to refutation instruction with discrepant events improved from a developing level (M=11.23, SD=2.32) to a proficient level (M=16.69, SD=3.94). In contrast, the control group- students who received conventional instruction, showed a slight increase in mean scores (M=11.94, SD=2.47 to M=15.11, SD=3.57) but remained at the developing level from pretest to posttest.

Table 2. *Difference between the pretest and posttest scores in students' conceptual understanding after exposure to discrepant events and refutation instruction*

A paired samples t-test was performed to compare pre and post test scores of the students after exposure to discrepant events with refutation instruction. Results revealed a significant increase in their scores from pre-test *(M=11.23, SD=2.32)* to post-test *(M=16.69, SD=3.94)*; t(29)=8.87, p<.001.

Table 3. *Level of Students' Resistance to Science Misinformation Before and After the Intervention*

Group	Test	Mean	SD	Descriptive Equivalent
Experimental	Before	3.21	0.42	Neutral
	After	2.76	0.30	Neutral
Control	Before	3.09	0.28	Neutral
	After	2.95	0.25	Neutral

Group	Mean Score	SD	t-value	p-value
Pre-test	11.23	2.32	8.87	.000**
Post-test	16.69	3.94		

**Highly Significant at 5% Level of Significance

Table 3 shows the weighted mean scores of students' resistance to science misinformation before and after exposure to the intervention. The mean score in the experimental group decreased from (M = 3.09, SD = 0.28) to (M = 2.76, SD = 0.30), both corresponding to a Neutral level. Similarly, in the control group, the mean score decreased from (M = 3.09, SD = 0.28) to (M = 2.95, SD = 0.25), also Neutral.

Table 4. *Difference between the pretest and posttest scores in students' resistance to science misinformation*

A paired samples t-test was performed to compare the students' resistance to science misinformation between pretest and posttest scores. For the control group, results show that there was a statistically significant decrease from pretest (M=3.09, SD=0.28) to posttest (M=2.95, SD=.25), t(34)=2.35, p=.025. For the experimental group, resistance scores also decreased significantly from pretest (M=3.21, SD=.42) to posttest (M=2.76, SD=0.30), t(34)=5.52, p=<.001. These

Table 5. *Relationship between students' conceptual understanding and their resistance to misinformation after the intervention.*

Variable	1	2	Mean	SD
1. Conceptual Understanding	-	.04	16.69	3.94
2. Science Misinformation	.04	-	2.76	0.30

Note. N=35. Pearson correlation coefficient r=0.04, p=.841^{ns}

A Pearson correlation analysis was conducted to determine if there was a significant relationship between students' conceptual understanding and their resistance to science misinformation after the intervention. Results revealed no significant relationship between these variables, *r (33) = 0.04 and p-value of .841*.

Group	Test	Mean Score	SD	t-value	p-value
Control	Pretest	3.09	0.28		
	Posttest	2.95	0.25	2.35	.025*
Experimental	Pre-test	3.21	0.42		
	Posttest	2.76	0.30	5.52	<.001

*Significant at 5% Level of Significance **Highly Significant at 5% Level of Significance

Table 6. *ANCOVA Results for Students' Conceptual Understanding Controlling for Pretest*

Source	SS	df	MS	Fc	p-value	Partial η^2
Pretest	172.97	1	172.97	14.70	<.001*	0.18
Group	71.69	1	71.69	6.10	0.016*	0.08
Error	788.12	67	788.12			

Note. Adjusted posttest means: Experimental: 16.92, (SE=0.58), Control= 14.88 (SE=0.58). Means are adjusted for pretest scores (covariate value=11.59). Model explained 19% of variance (Adjusted $R^2 = .192$).

An analysis of covariance (ANCOVA) was conducted to test whether group means - students exposed to discrepant events and refutation instruction and students taught with traditional instruction- differed significantly in their conceptual understanding while controlling for the pretest scores (prior) achievement. Results revealed that the intervention-discrepant events with refutation instruction in teaching Physics had a significant positive effect on students' conceptual understanding beyond what can be explained by prior achievement, *F(1,67)=6.10, p=.016,* $\eta^2 = .08$. Adjusted posttest means indicated higher performance in the experimental group (M = 16.92, SE = 0.58) compared to the control group (M = 14.88, SE = 0.58) demonstrating that the method was effective. The covariate (pretest) also had a significant effect, *F(1, 67) = 14.70, p < .001, partial* η^2

= .18, confirming that prior achievement influenced posttest scores, but the intervention effect remained significant after controlling for it.

Table 7. *ANCOVA Results for Students' Science Misinformation Controlling for Pretest*

Source	SS	df	MS	Fc	p-value	Partial η^2
Pretest	172.97	1	172.97	14.70	<.001*	0.18
Group	71.69	1	71.69	6.10	0.016*	0.08
Error	788.12	67	788.12			

Note. Adjusted posttest means: Experimental: 2.75, (SE=0.0.047), Control= 2.95 (SE=0.047). Means are adjusted for pretest scores (covariate value= 3.15). Model explained 9.7% of variance explained (Adjusted $R^2 = .097$).

An analysis of covariance (ANCOVA) was conducted to test whether group means – students exposed to discrepant events and refutation instruction and students taught with traditional instruction- differed significantly in their resistance to science misinformation while controlling for pretest scores. Results revealed a significant effect of instructional method, $F(1, 67) = 9.263$, $p = .003$, partial $\eta^2 = .12$. Adjusted posttest means indicated stronger resistance in the experimental group ($M = 2.750$, $SE = 0.047$) compared to the control group ($M = 2.952$, $SE = 0.047$), demonstrating that the intervention was effective. The covariate (pretest) was not a significant predictor, suggesting that prior resistance did not substantially influence posttest scores.

DISCUSSION

Table 1 shows the mean scores of students' level on conceptual understanding in selected physics topics in both the experimental and control groups. After the pre-test were administered at the same day to both groups, data were analyzed and were found out that the control group have a mean score of 11.94 and 11.23 for the experimental group, meaning they are at the same level of conceptual understanding which is under the developing stage with a score range of 11-15. After the intervention were given, the result revealed that the experimental group - students exposed to refutation instruction with discrepant events improved from a developing level to a proficient level. In contrast, the control group- students who received conventional instruction, showed a slight increase in mean scores (M=11.94 to M=15.11) but remained at the developing level from pretest to posttest. Based from findings of the study, the experimental group exhibit a significant improvement in their level which is from developing to proficient level and was supported by several researches stating that discrepant event has a positive impact on students conceptual understanding (Anggoro et al. (2019) and it can also be used to promote questioning, discussion and argumentation among students (Ho & Chin 2009).

Table 2 shows the comparison between students' pre-test and post-test scores in conceptual understanding after exposure to discrepant events and refutation instruction. The pre-test mean score was 11.23 (SD = 2.32), while the post-test mean score increased to 16.69 (SD = 3.94). The computed t-value of 8.87 with a p-value of .000 indicates a statistically significant difference between the two sets of scores. This finding leads to the rejection of the null hypothesis, confirming that the intervention produced a measurable improvement in students' conceptual understanding. The marked increase in mean scores demonstrates the effectiveness of discrepant events and refutation instruction in facilitating conceptual change. By confronting students' misconceptions through surprising phenomena and explicitly refuting incorrect ideas, the intervention enabled learners to reconstruct their prior knowledge and achieve deeper understanding. This result is consistent with the conceptual change framework, which emphasizes the importance of challenging learners' preconceptions to promote deeper learning (Posner, Strike, Hewson, & Gertzog, 1982). Similarly, research has shown that refutation texts are particularly effective in reducing misconceptions and enhancing comprehension (Guzzetti, Snyder, Glass, & Gamas, 1993).

Table 3 shows the statistical data which indicate that the experimental group after exposure to intervention, remained at neutral level, just like the control group which supports Limón (2001) who pointed out that one explanation for the minimal change in the level of science missinformation is due to the failure to promote meaningful conflict in the learner's mind. The interventions used was only fixated on the cognitive processes of the learners and it failed to include the learners' differences in learning styles, attitudes, attitudes and beliefs about learning, and most especially their abilities to do reasoning. In addition, Chi (2008) also revealed that learners do not spend more time reading the refutation text due to the reason that they are not fully engage with the correct explanation and will likely revert back to their initial misconception resulting in not so impressive result. Another factor for the little effect is due to the persistent nature of misconceptions. Science researches found out that misconception is really prevalent, and very difficult to alter which prevents the acquisition of new learnings (Shtulman & Valcarcel, 2012). This shows that students tend to stick with their previous opinions even after being confronted with correct information. Overall, the slight change in the levels of student's misinformation can be attributed to the low promotion of conflict in the learners' mind, minimal student engagement and attention, and the prevalent nature of students' misconception. These findings revealed that discrepant events and refutation texts be enhanced more and should be used for a longer period of time to produce highly significant effect on the student's resistance to misinformation.

Table 4 shows the difference between the pretest and posttest scores in students' resistance to science misinformation. The result of the paired samples t-test show that there was a statistically significant decrease from pretest to posttest scores of the students. The significant decrease in the pretest to the post-test of the experimental groups statistically rejects hypothesis #2. After the implementation of the discrepant event combined with the refutation strategy, the post-test results showed a highly significant improvement. Studies on refutation text was proven to be effective in promoting and enhancing conceptual change and addressing misconceptions which eventually leads to effective learning (Mason et al. 2018, Schroeder, N. L., & Kucera, A. C. 2022). Studies of Yani et al., (2025) and Akmam, A., et al. (2025) provided empirical evidence supporting the integration of cognitive conflict strategies with generative learning approaches in Physics Education. Consistent with the effect of the intervention – discrepant events and refutation instruction, the study revealed that integrating the two strategies showed a significant improvement in the reduction of student's resistance to science misinformation as well as their 21st century science literacy skills.

An analysis was conducted to determine if there was a significant relationship between students' conceptual understanding and their resistance to science misinformation after the intervention. A no significant relationship between these variables were revealed which failed to reject the null hypothesis #3. These findings suggest that the students' ability to resist science misinformation was not directly associated with their conceptual understanding in this sample and may be influenced by other factors than the conceptual understanding alone, such as critical thinking skills which was explained by the recent study of Osborne and Allchin (2024). Their study highlighted that the concept of science education is less important in fighting misinformation. Students may have a perfect conceptual understanding on the lesson but still not free from misinformation only because they don't know who to believe regardless of their own knowledge. In addition, people with high science knowledge but low curiosity were still vulnerable to culturally motivated misinformation because science curiosity plays as a great predictor in resisting misinformation than simply memorizing science concepts. (Landrum et al., 2017). This study suggests that understanding alone does not determine belief accuracy.

CONCLUSION

The study aimed to determine the effectiveness of integrating discrepant events and refutation instruction to enhance conceptual change and misinformation resistance in Physics learning. The findings revealed that in terms of students' performances, there is a significant increase in their post-test scores compared to their pre-test scores which indicates that the intervention used were truly effective. The improvement in the students' performances maybe credited to the use of discrepant events and refutation instruction that created conceptual change as well as challenged and corrected the students' misconceptions. These findings were supported by the different studies of Mason et al. 2018, & Yani et al., (2025) which tackles about the students enhanced performances due to the integration of refutation instruction and cognitive conflict in the classroom.

However, in the study even though the conceptual understanding of the students were improved, there is a minimal reduction when it comes to the resistance of students to science misinformation. This only means that relying just on conceptual understanding is not enough to totally combat science misinformation. Even though it is proven that both discrepant events and refutation instruction are effective in enhancing the understanding of the students, there is still a need to utilize additional strategies in order to strengthen the resistance of students to misinformation such as the Conversational Inoculation, a method to help people build resistance to misinformation through dynamic conversations with a chatbot (Szabó et al., 2026). In conclusion, the study emphasized the importance of utilizing engaging and challenging strategies and approaches in teaching Physics.

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