A Comparison of Effect of Abstract Textbook and Real-Life–Based Physics Problems on Students' Attitudes and Perceived Relevance

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A thesis submitted to the School of Education and Humanities
in partial fulfillment of the requirements for the degree of

MASTER OF EDUCATIONAL SCIENCES
in 7M01503 - Physics

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Abstract

The purpose of this study was to investigate the effects of physics problems set within real-life contexts on students' understanding of physics and the relevance of physics to their lives. The study used a mixed-method design with 84 students responding to textbook physics problems and five context-based problems, and 52 of them participated the survey with multiple-choice, Likert-scale, and open-ended questions. Their results in both types of problem solving activities were compared and analyzed to test if there is any difference in overall achievements of students. Thematic analysis was implemented in order to make sense of the qualitative data as results of the open-ended questions.

Most studies found that context-based problems had a positive effect on students' interest and relevance to physics. Student learning, as measured by conceptual understanding tests, often improved, but the effect on performance was more mixed.

Results of the study indicated positive tendency in both problem solving and survey. Due to open-ended questions results, the vast majority of participants posed that realistic problems are deemed more interesting and encourage meaningful learning of physics, though this is only the case with a balanced set of problems.

Key words: real-life context, context-based physics problems, student engagement, perceived relevance, physics performance, conceptual understanding, abstract textbook problems.

Аннотация

Цель данного исследования заключалась в изучении влияния физических задач, основанных на реальных жизненных ситуациях, на понимание физики учащимися и осознание ее значимости в их жизни. В исследовании использовался смешанный метод: 84 учащиеся решали стандартные задачи из учебника по физике и пять контекстно-ориентированных задач, а 52 из них приняли участие в опросе, включавшем вопросы с множественным выбором, шкалу Ликерта и открытые вопросы. Их результаты в обоих типах решения задач сравнивались и анализировались, чтобы проверить, есть ли разница в общей успеваемости учащихся. Для осмысления качественных данных, полученных в результате ответов на открытые вопросы, применялся тематический анализ.

Большинство исследований показали, что контекстно-ориентированные задачи оказывают положительное влияние на интерес учащихся и их отношение к физике. Качество обучения, измеряемое с помощью тестов на концептуальное понимание, часто улучшалось, однако влияние на общую успеваемость оказалось более неоднозначным.

Результаты данного исследования выявили положительную тенденцию как в решении задач, так и в ответах на вопросы анкеты. Судя по результатам открытых вопросов, подавляющее большинство участников отметили, что реалистичные задачи кажутся им более интересными и способствуют осознанному изучению физики, хотя это справедливо только при сбалансированном наборе задач.

Ключевые слова: контекст реальной жизни, физические задачи, основанные на контексте, вовлечённость учащихся, воспринимаемая значимость, успеваемость по физике, концептуальное понимание, абстрактные задачи из учебника.

Аңдатпа

Бұл зерттеудің мақсаты нақты өмірлік жағдайларға негізделген физикалық есептердің оқушылардың физиканы түсінуіне және физиканың олардың өміріндегі маңыздылығына тигізетін әсерін зерттеу болды. Зерттеуде аралас әдіс қолданылды: 84 оқушы физика оқулығындағы стандартты есептерді және бес мәнмәтіндік (контекстік) есепті шешті, ал олардың 52-сі бірнеше жауап нұсқасы бар, Ликерт шкаласы және ашық сұрақтардан тұратын сауалнамаға қатысты. Оқушылардың жалпы үлгерімінде айырмашылық бар-жоғын тексеру үшін олардың есеп шығарудың екі түріндегі нәтижелері салыстырылып, талданды. Ашық сұрақтардың жауаптары нәтижесінде алынған сапалық деректерді мағыналық тұрғыдан түсіну үшін тақырыптық талдау қолданылды.

Көптеген зерттеулер мәнмәтіндік есептердің оқушылардың қызығушылығына және физиканың маңыздылығын түсінуіне оң әсер ететінін көрсетті. Тұжырымдамалық түсіну тестілері арқылы өлшенген оқушылардың білім алуы жиі жақсарды, бірақ жалпы үлгерімге тигізетін әсері әртүрлі болды.

Зерттеу нәтижелері есеп шығаруда да, сауалнамада да оң тенденцияны көрсетті. Ашық сұрақтардың нәтижелеріне сәйкес, қатысушылардың басым көпшілігі шынайы өмірге негізделген есептерді қызығырақ деп санайтынын және олар физиканы мағыналы түрде үйренуге ынталандыратынын атап өтті, дегенмен бұл есептер жиынтығы теңгерімді (балансты) болған жағдайда ғана жүзеге асады.

Түйінді сөздер: шынайы өмір контексті, контекстке негізделген физика есептері, оқушылардың қатысу белсенділігі, қабылданатын өзектілік, физика бойынша оқу жетістігі, тұжырымдамалық түсіну, оқулықтағы абстрактілі есептер.

1. Introduction

1.1 Real-Life Context in Physics

Real-life context refers to a learning activity or problem that takes place in the context of a familiar event. Contextualized physics problems highlight the underlying physics and the real world instead of mathematical relationships between idealized situations. These physics concepts are presented in terms of transportation, appliances, or nature, reframing physics education from mechanical calculations to interpreting physics within contexts meaningful to students.

In customary physics class, problems posed to students are often at too basic and abstract a level, focusing on mathematics rather than what students feel matters. In contrast, real problems lead students to interpret the situation, identify the variables and make assumptions under realistic conditions, allowing deeper and better understanding.

To avoid the theory-practice gap, contextualized learning is believed to activate prior knowledge, relate to experiences, and link new ideas to what is already known. This may be helpful for knowledge transfer and developing functional literacy, when physics is applied as a tool for reasoning and problem-solving in real-world contexts.

Another effect of real-life context on attitudes is its tendency to reduce the perception of physics as an abstract subject, and to increase students' motivation and engagement during physics lessons.

Contextualized problems can be more difficult than abstract problems, for a few reasons. The information that is not relevant to the problem can be distracting and affect cognitive load negatively, especially for lower-ability students. Hence there is a trade-off between authenticity and clarity.

Overall, physical context improves understanding, relevance, and engagement, but tasks must be well-designed to promote effective learning of the content.

1.2 Real-Life Context in Other Science Lessons

There is a real-life context in the literature of physics, biology, chemistry, mathematics, informatics and so on. Many studies have indicated that the learning of abstract scientific concepts will be more meaningful when they are presented in situations relevant to the daily life of students, their society or their future workplace. In biology, Abebe et al. (2023) studied the context-based instruction of heredity concepts. They found that a mix of context-based instruction and conventional instruction improved the quality of students' scientific reasoning. Since heredity concepts are considered remote and difficult to understand, and far from a student's immediate environment, Abebe et al. (2023) suggest using social, cultural and biological phenomena familiar to students to help them reason about invisible processes.

A similar trend can also be seen in ecology education, where students taught using context-based ecology lessons outperform those taught using less contextualized instruction (Appiah-Adjei et al. 2025). Further, the use of real-world contexts resulted in increased student interest and participation in the learning task, and their increased appreciation of ecology as a relevant school subject, suggesting that context not only promotes achievement, but can also improve students' perceived relevance.

Analogous applications of real-life contexts are utilized in chemistry education: Bortnik et al. (2021) argue that context-based testing can close the divide between the chemistry knowledge and chemistry usage of university students not majoring in science disciplines. They thus point to the usefulness of context-based assessment in building strong knowledge and transferability. Similarly, Pankajakshan et al. (2026) showed that integrating case studies and creative writing into general chemistry fostered the explicit linking of chemical concepts to real-world examples, the collaboration to conclusion, and the integration of these concepts into cohesive reasoning. These examples show that contextualization may bridge the abstract molecular level to macroscopic phenomena.

Most mathematics content in the real world is in the form of modeling and realistic context in word problems. However, a detailed study by Kohen and Orenstein (2021) of technology-related workplace problems shows that these, too, can be modeled in secondary school mathematics. Thus mathematical modeling is an interface between school mathematics and professional practice. Tong et al. (2022) found that Realistic Mathematics Education improved performance and student attitude on topics of ellipses, as it gives students an avenue for creating mathematical understanding through real-world scenarios.

Finally, Son and Kim (2025) adapted contextual learning to elementary informatics through a Living Lab model. Through computational thinking and teamwork, students engaged in solving authentic community-based sustainability challenges. These studies collectively show that incorporating real-world context across science-related lessons increases relevance, supports deeper learning, and develops transferable problem-solving skills.

1.3 Relevance of Physics

The relevance of physics is a major topic in physics education research. The learning of physics is not only measured in terms of its difficulty, but also in terms of its usefulness and meaning for students' lives, further studies and careers. Research shows that while students in different contexts agree that physics is a core subject in STEM, the majority experience physics as abstract, difficult or irrelevant. Flores-Godínez et al. (2025) highlight that while physics can be used as a tool for technological and economic development, school-related factors such as learning environments, materials, infrastructure, feelings, and community influence can obstruct student participation in physics studies. A study conducted in rural Mexico demonstrated how a low-cost STEM tool was used to increase students' interest, involvement, and attitudes towards physics, stressing the role of relevance in the learning process.

Mansour (2025) links interest in science to cultural factors (such as stereotypes), knowledge of science careers and learning opportunities. The author reports that students expressed higher science interest when they participated in science-related activity and when learning was linked to their interests and identities. Above all, it is important to physics, as physics is often viewed as a field that requires abstract thinking and strong mathematics, which may decrease motivation when applications to the real world are unclear.

This is particularly relevant among students other than physics majors. Mason (2021) and a related conference proceeding by Mason found that approximately 23% of life-science students believed that introductory physics was of little or no relevance to their studies. However, students who endorsed the relevance of physics showed expert-like attitudinal gains (particularly personal interest and world-view connection) to a greater extent than those who did not endorse relevance, indicating that relevance may not be purely a curriculum issue, but perhaps an attitude issue as well.

Also, Yadav et al. (2021) found too many Rwandan students thought that physics was boring or uninteresting to real-life experience, despite thinking it was worthwhile, and that making physics relevant (using examples, tools, and tasks to connect physics concepts to students' lives) was an issue in teaching and learning physics.

1.4 Significance of the Study

This study is important because it is one of the few studies to look at the effects of real-world context in physics problems on students' learning, performance and perceived relevance. In many classrooms, physics education is based on abstract problems, which may limit students' ability to connect classes with the real-world. This study focuses on this gap by comparing conventional problems to context-based problems in terms of student performance and attitude.

One of the contributions of this research is that the same group of students are used to solve the two types of problems, a more valid comparison. The final consideration is of both the quantitative data and qualitative feedback, thus providing a multidimensional perspective on performance and student experience.

The results of the study have implications for teaching, suggesting that contextualized problems have the potential to improve perceived relevance and student engagement but may also increase complexity for learners. This helps educators determine how to balance realism with the need for clarity in educational materials.

Overall, the findings support the position that efforts to promote functional scientific literacy can benefit from including physics learning in real-world contexts. The findings have broader implications for curriculum development in physics, suggesting that real-world situations should be brought into physics learning to make it more relevant to people's daily lives.

Overall, this study contributes to improving physics education by addressing perceived irrelevance and providing effective strategies to increase student engagement and understanding of physics.

1.5 Problem Statement

A constant challenge in modern physics curricula is the seeming misalignment between the theory and practice. Physics problems are usually boiled down to a few mathematical operations with idealized conditions and models of a physical system. While this problem-based approach may develop the students' technical problem solving skills, it may not show the importance of physics in their daily lives and future goals if the questions seem removed from their experience.

A contributing factor appears to be that physics is perceived as an abstract and difficult subject, not particularly related to life outside of the classroom. Consequently, it is not as engaging for students, and memorization rather than understanding is relied upon. Students may learn to apply formulas within familiar contexts, yet be unable to use them to understand novel phenomena or to solve real-world problems. This limits their ability to develop deeper conceptual understanding or functional scientific literacy.

Simultaneously, newer pedagogical approaches stress contextualized teaching and learning, introducing ideas using authentic examples from the real world. The extent to which real-life context should be used when solving physics problems is an open question. Contextualized tasks are expected to promote interest and may be more difficult because students have to deal with more data and make more assumptions, which increases load. This may lead to potential difficulties for students who have less background knowledge.

Despite the growing interest in contextualized approaches, little is known about the influence of context in real life on the performance of students on the contextualized learning problems compared with customary abstract learning problems. It is still a question whether the context effect is real or it is mainly a question of motivation and attitudes of students. There is also little evidence of how students themselves perceive the clarity, difficulty and usefulness of these kinds of problems.

Thus, the present study will address the question to what extent real-life context in physics problem-solving can benefit or hamper student learning and perception. More specifically, the aim of this study is to compare students' performance and motivation, understanding and perceived relevance when solving context-based and customary physics problems in a well-defined learning scenario.

Improving the efficiency of physics instruction is an important topic. Understanding the role of context in learning can inform the design of instructional materials and make them more designed not just to develop problem-solving skills, but to develop awareness of how to apply knowledge in meaningful situations. Consequently, this study seeks to provide a clearer basis for combining real-life context with teaching physics in a balanced and pedagogically effective manner.

1.6 Research Questions

1. How do students perceive the relevance, engagement and ease of understanding of physics problems based in real life?
2. How do students estimate the connection between real-life–based physics problems and the practical relevance of physics?
3. Is there statistically significant difference in students’ performance in abstract textbook physics problems and real-life-based problems?
4. What specific aspects of real-life-based problems do students find helpful or challenging in understanding physics?

1.7 Research Objectives

1. To examine if using real-life based physics problems can create a more positive attitude to learn physics compared to abstract textbook problems.
2. To evaluate perceptions of physics relevance to everyday life after solving physics problems based on real life situations.
3. To compare students' performance on abstract textbook physics problems and on real-life physics problems.
4. To identify what characteristics of the physics problems in the real world are helpful or unhelpful for students' learning of physics.

1.8 Hypothesis

H_0: There is no statistically meaningful difference in students' performance on abstract textbook physics problems, compared to real-life-based problems.

H_1: Students demonstrate higher scores on real-world physics problems than on textbook physics problems.

H_2: Students show more positive attitudes towards physics when problems are presented in real life contexts.

H_3: Students perceive physics as being more applicable to daily life after working with real-world-based physics problems.

2. Literature Review

2.1 Theoretical Framework

The standard physics curriculum has, for too long, been based on representations, in the form of analogies and idealizations, stressing formulae without meaning. Students learn to crunch numbers without understanding how physics relates to the world around them. Furthermore, context has been increasingly seen as part of learning, to the point that the outcome of understanding depends not only on the content of the task, but also on the task itself, the problem context, and the context within which the learning takes place (Finkelstein).

A central concept in this discussion is authenticity. Palm defines authenticity as the degree to which a school task, in terms of form and content, reflects a real-life situation in a reasonable way. Several factors can affect student responses including task (Palm), context of the task, how realistic the data is, and how the question is worded. In Palm's study students are more likely to use real world reasoning when presented with more realistic tasks (Palm).

This is an important issue because solving word problems is more than just computation. Nortvedt shows a strong correlation between reading comprehension and multistep word problem performance. For students, it is difficult to make a correct representation, to analyze the text and to perform the required computation. Problem solving combines both conceptual and textual understanding (Nortvedt).

More recent scholarly work has shown that authenticity has multiple related but different meanings. Schriebl et al. (2018) have identified three types of authenticity: real-world authenticity, disciplinary authenticity, and personal authenticity. Authenticity can be categorized into real-world authenticity, disciplinary authenticity, and personal authenticity. While authentic tasks are designed to reflect the practices of science, from students' perspective, the actual response of the learner may not match the expression of science, and an authentic task may not match students' experience of the task.

Related analyzes suggest that this might be the case; Nachtigall et al. suggested that authentic learning depends on a combination of design features (complex tasks, inquiry, real-life materials, collaboration, and authentic assessment), and Hüfner et al. suggested that contexts in science education could pursue different goals (relevance, motivation, accessibility, and scientific literacy) (Nachtigall et al.; Hüfner et al.). Likewise, Schlüter and Besser have suggested context, events, data, question, and purpose as components of authenticity, which could be a more systematic analysis scheme to guide task design (Schlüter & Besser).

Overall, the theoretical underpinnings of this model suggest that the way a physics problem is presented can affect how students approach the problem. Customarily, abstract physics problems tended to encourage procedural problem solving, while real-world physics problems encouraged interpretation, sense-making, and authentic application of physics concepts. This study therefore will compare students' performance and perceptions between the two types of physics problems: real life physics and textbook physics.

2.2 Application of the Real-Life Context in Physics Problems

If the first group of studies explains why real-life context is necessary, the second group takes an interest in how teaching should approach context in the classroom. This is where Bahtaji and Mann et al. become especially relevant, since they shift the focus from diagnosing a problem to pedagogic design. All these studies did not simply show that students have problems with realistic problems. They also showed that context-based instruction is a coherent teaching method. They contributed to the general notion of context-based instruction that real-life context should not just be an example added later to theory, but the organizing principle of all learning.

Bahtaji states that this contextual instruction must be intentional. According to Bahtaji, physics is commonly taught as concepts, formulas, and problems that bear little relation to students' social reality. In contrast, context-based learning introduces the physics concepts in relation to everyday life and society. In context-based learning, students do not merely learn to follow procedures, but are taught how to understand the importance of concepts, where they may be useful and how they may help solve problems outside the classroom. And so in this approach, the context does not disappear but becomes part of the path to understanding.

An important contribution from Bahtaji's work was her emphasis on the importance of designing learning materials, arguing that contextualized teaching would only work if the materials were organized in ways appropriate for transfer. Situations can be more familiar and static, or more complex and dynamic, but students do not move suddenly from everyday situations to abstract modeling of physics concepts. But they need a bridge. Using contexts that students can recognize provides a type of pedagogical scaffolding, growing out of their existing understandings towards more conceptually diverse applications. Bahtaji also shows that contextualized learning connects to constructivism, building on previous experiences. Context-based instruction builds on students' prior knowledge rather than ignoring students' preconceptions about the subject matter. It helps explain both why such approaches can produce transfer and why the context effect is more than mere motivation increase.

Simultaneously, Bahtaji argues context-based instruction does not solve all learning problems, and teachers must be intentional and the context materials must relate to the lesson goal. But Bahtaji also argues the students initially see the context as arbitrary, and the context can be distracting without a clear purpose. Thus, good contextualization is not random realism; it is controlled realism.

This is echoed in Mann et al.'s model. While Bahtaji's model focused on the design of teaching, the authors' model looked at what students knew about energy in relation to the human body. This context is one of the most easily accessed and familiar to teachers: the body is familiar, personally relevant, and often assumed to be naturally meaningful. However, the study shows that familiarity does not guarantee scientific understanding as even students may hold alternative conceptions about food, energy, respiration, heat and bodily processes.

This has implications for how context is used in teaching: while a familiar context may increase contextual salience, misinterpretations may be triggered if students are not guided. As Mann et al. note, students often rely on everyday language, such as the term "energy", which may be incompatible with scientific definitions. For this reason, Mann et al. say that context-based teaching must accomplish more than merely making physics relevant. It must also help students to move from everyday language to scientific language without severing the relationship between the two.

From the perspective of pedagogy, Mann et al. are of particular value in drawing attention to the issue that context-based teaching is not only about the motivational power of a real-world context, but also about finding contexts, such as the human body, where student understanding is fragile. They are salient, and they diagnose misunderstanding because they require students to integrate multiple ideas that are typically separated out in the different elements of the curriculum.

Bahtaji and Mann et al show context-based instruction is a teaching method rather than a collection of interesting cases. The research shows transfer and performance can be improved if contexts are explicitly designed and included in the instruction. Mann et al. argue that the right kind of meaningful but conceptually demanding context may help to reveal poor understanding, and so they need to be used carefully to provide conceptual guidance. Together, the two studies suggest that real life context works best when it is used systematically, is linked to students' own experience and is used to develop rather than replace understanding.

This is the second category of contexts, those that students can find themselves in in life, society, and public experience. The contexts are chosen because they are accessible, memorable, and able to make physics closer to what the students know, rather than because they were at the frontier of scientific research. The work of Heck et al., Jochen et al. and Echiburu et al. is particularly useful, as it presents three different ways of doing this: through the human body, newspaper stories and a major real-world event. What unites them all is the idea that physics problems are less about practicing the content of a textbook and more about using it to understand the world.

Heck et al. showed, with an authentic context in the familiar environment of the human body, that physics learning can take place when the body is not presented explicitly, using projects and investigations based on phenomena related to certain aspects of the body, such as gait or movement, or the response of the pupil. The body, I think, is pedagogically well chosen, because it is obviously the most familiar thing to us and yet it is composed of things that physics can quantitatively describe. So the body becomes a bridge between the everyday and the scientific. Students measure, interpret, and analyze data, use technology, create graphs, and relate the data and visualizations to physics, math, and biology. The body becomes, at least in part, a system, rather than simply a familiar context, through which students can conduct legitimate investigations.

This teaches us that mere familiarity isn't enough; if it were used solely as a background story, the body wouldn't necessarily be meaningful. Instead, as Heck et al. show, a familiar context becomes educationally powerful with students' inquiry into it. Thus, gait analysis is a context with movement, angles, graphs of angles, and interpretation; the pupil light reflex has measurement, video, timing, and modeling. These are not mere ornaments of the body: they are a way of making the body intelligible. Physics is not merely a language of the body; it can be understood according to the rules of physics in a particular way.

A more general approach in a similar vein found in Jochen et al. is that of newspaper story problems. The use of public resources instead of specialized laboratories and equipment means that a teacher can use a newspaper article or news report that contains a real-world event or a social issue related to physics, and immediately renders the context and content authentic. The students are not asked to imagine some artificial event created only for school. The event took place first outside of school, and it has consequences outside the school as well. Thus, the authors suggest that contextualization, in this sense, may result in better motivation and transfer.

The usefulness of the newspaper approach is that it makes the problem a different one: In a direct problem, the desired information is given to the student and the student is usually faced with the task of picking the right formula. In the newspaper story, the information is embedded. Students then must pick out information that is relevant and sometimes make inferences about missing information. This type of reasoning process is more realistic because real-world problems do not have all the information separated out. What students need to learn to be able to do is to distinguish between central and peripheral information, and this is exactly what newspaper story problems can train. In this sense, Jochen et al. use context to not only improve relevance, but also change the cognitive process of problem solving.

The work of Echiburu et al. provides a third, and particularly strong, example of a socially relevant contextualization. The challenges seem to have been based around the Beirut explosion, an event that attracted media attention around the world, and for which an important amount of public visual and audio data exists. It gives the context a different intensity than in the body-based and newspaper-based approaches, but the authors do not use the event for its sensationalist power. They then frame the problem in context and have students analyze video, map, image, or audio using mechanics, wave propagation, dimensional analysis, and estimating energy. Thus, the Beirut case is using real-world context not only to support evidence-based problem solving, but also to overcome the issues of passive context in complex socio-technical domains.

One of the most valuable things about this study is that it shows how a real event can support both qualitative and quantitative reasoning. They're not just talking about the event qualitatively. They need to make estimates of physical quantities based on real sources of evidence, and justify their interpretations based on that evidence. The Beirut problems occupy an important middle ground, between routine classroom tasks and real scientific inquiry. In addition to its social function, the event also encourages students to perform scientific inquiry by collecting data, selecting analysis methods, interpreting data, and comparing data with expectations from physics.

A feature of all three is that, in real-world physics, context may be implemented at a personal, social and/or public distance: the body promises personal relevance, newspaper news stories social and civic relevance, Beirut situational urgency and evidential richness. In all three cases, there are best effects when there is rather more than simply attention, and the situation requires analysis, interpretation, and explanation. Thus, everyday and socially relevant contexts provide a middle ground that is more directly relevant than isolated datasets produced in scientific experiments, but richer in their physics content than the textbook exercises that characterize other cases of real-world contexts.

A further level of contextualization also occurs when students are placed in a familiar context or a context that is relevant to their social lives, but also represented in the same kind of data, reasoning, and inquiry as in real science. The studies by Hyde, Montecinos et al., and Wee et al. are the clearest examples of these. They do not merely depict a context from everyday life. Students are presented with real data, and with scientifically relevant questions, and they are also engaged in the scientific practices of scientists with technology-improved observations. This differs from the school tradition of scientists solving idealized problems with their parameters and pathways predetermined. Thus the classroom context changes not only the scene of the action but also what doing physics is about.

Hyde also shows how Hubble constant data sets may be used in an introductory course not only with hypothetical numbers that only exist at the school level, but with real data that have real astronomical debates and history behind them. This is worthwhile because it captures physics as a living discipline, not as a collection of facts. This method can help bridge the divide between the exciting, new scientific discoveries that students hear about outside of school, and the material that they learn in class that is structured, but often dry. With Hyde's method, students can collect actual data in response to their inquiry question, instead of just inserting numbers from lab equipment into an equation. Having to interpret plots, compare models, and think about uncertainty and variation between data sets makes it possible to use the authenticity of the context as an example of how science is actually done. Scientific reasoning and data literacy can be strengthened through authentic contexts and students are generally motivated.

A related example was Montecinos et al., where they apply Newton's law of universal gravitation and Kepler's third law to show how classical physics is used in modern astrophysics. Kepler's laws are rather presented as just another step along the way, rather than the final words in the debate about the movements of the celestial bodies; their laws are treated as just another battle in a war already won. Montecinos et al. show that Kepler's laws continue to be used to explain the newly discovered planetary systems and this shows that the context of this study is not only interesting but also a new interpretation. The students are not satisfied to check the well-known law in a simplified system, but analyze many extrasolar systems, comparing the numbers and wondering about their differences. The study shows that real scientific data can be made available at the school level through the use of spreadsheets, graphs, and selected questions, without forcing students to follow a simple plot.

A prime example of the use of a real-life context in classroom studies is Wee et al. (2007) where students were introduced to the Tracker software and guided to carry out video analysis tasks over several weeks. This study is also prominent for considering how contextualization affects the overall structure of the classroom activity. In addition to a realistic problem statement, students are asked to choose which motion they want to investigate, measure or select video data, analyze the motion, interpret graphs, construct explanations, and communicate their findings. Within this perspective, the context here is part of the investigation, and therefore this is one of the stronger forms of authentic application, taking students from being solvers of predesigned exercises to participants in a simplified but realistic version of scientific work. Wee et al. note that questions in customary pedagogy are more likely to be isolated, simplified, teacher-directed, and teachers have a high level of control over the question rather than students having control of the question.

Some commonalities are obvious in the results of Hyde, Montecinos et al. and Wee et al. The authors suggest that, in the advanced context, the real-world context has three hallmarks: in addition to being real-world, it is interpret-model-solve as opposed to solve, the students engage in doing science as opposed to learning about science, and the context need not be near and familiar, but rather real in the sense of being scientifically authentic. Astronomy is another example. Exoplanets and cosmological expansion are not everyday contexts, but we can consider them real in the sense that they connect learning at school with the real-world activity of scientists researching these issues. The evidence is that higher levels of contextualization may be achieved by students learning physics as an interpretive activity rather than through a simplified, textbook-driven set of procedures.

2.3 Previous Research Results

There is a fairly large body of evidence that context-based instructions and contextualized problems can have a meaningful positive impact on education. Many of the studies do not measure the same thing, but the pattern is generally positive. From the works of Affriyenni et al., Assefa, Eshetu et al., Kurbanoğlu et al. and Musa et al. the pedagogical advantages of context-based teaching methods are obvious.

One clear finding among the studies reviewed was the positive effect of context-based learning on academic achievement. Musa et al. found that students who were taught using a context-based approach did better than those taught using lecture methods. Their results also showed that the experimental group had increased interest and retention. The importance of high-performance levels is clear, but context-based learning helps learning beyond performance. Indeed, it appears that context-based learning is even relevant for retention, that is, for durable, long-term learning. Similar findings were disclosed in the studies completed by Affriyenni et al. and Eshetu et al., thus implying that the application of scientific knowledge in authentic contexts helps learners better understand scientific concepts.

Another contribution of these studies is the attention given to student interest and motivation, as in science education, achievement and the willingness to work on the subject are connected. Context-based learning may also be effective for overcoming perceived lack of content relevance with real-world situations. Musa et al. noted a positive impact on student interest, and Assefa found that contextualized teaching was associated with positive educational outcomes. Thus, these studies suggest that contextualization operates both cognitively and affectively. In this way, it may affect the way that students feel and, thus, their academic outcomes.

Retention is another outcome that has been studied by Musa and his colleagues. They concluded that on retention, students in the context group outperformed students who received information via workbooks and lecture even more than on the achievement and interest measures, providing more evidence for context as an organizing principle for students' knowledge structures. On top of this Kurbanoğlu et al. report that a context-based questionnaire can also reduce test anxiety and promote positive attitudes to science. This is especially important because it shows that the benefits of contextualization are not limited to test scores.

The studies by Affriyenni et al., Assefa, Eshetu et al., Kurbanoğlu et al. and Musa et al. are all consistent with this trend. In all cases, the use of a context for teaching was positively related to better academic performance, higher interest, better memory, less anxiety and a more positive approach. This makes this group of studies strong evidence that meaningful contexts are a good way to improve students' learning and students' experience of science and physics.

The second group of studies gives a more mixed picture, however, and indicates that contextualization effects do not always manifest themselves as an improvement in test scores or grades. Sometimes, context-based instruction has resulted in increased interest, positive attitudes, or personal relevance even when the difference in academic outcomes was not statistically important from the control condition. This is why the studies by Tural and Cutrera are particularly interesting in showing that context-based learning may have good pedagogical value that is not measured by customary means.

When Tural investigated whether context-based or customary teaching methods affected the achievement of university physics students differently, he found that neither was more or less effective. While this weakens the case for contextualization, the qualitative data suggest that those in the context-based group showed more positive attitudes towards the subject of physics, greater curiosity, and more realization of the importance of physics in everyday life. This is important, because this is providing evidence that contextualization effects may work in areas that the tests are not measuring very well. Tural has also noted that the lack of difference in achievement may be because the test used customary problems to measure understanding. If contextual materials are presented to students but they are tested in conventional tasks, some benefits of contextual approaches may be missed.

An interesting side to Tural's results is that students felt the contextual material made the concepts more memorable, and they were more likely to think about real-life situations in physics terms. While he didn't find similar gains on the short-term tests, these are still valid educational results. Some scholars have argued that contextualization could help students forge a deeper and more meaningful relationship.

Cutrera thus overarches this interpretation with a broader theoretical framework. Hence, the study argues that contextualization is pedagogically useful because it bridges abstract formal knowledge with concrete meaningful situations, and that this adds to its value in terms of meaning making, transfer, and the use of disciplinary modes of reasoning. In this way, this study accounts for the fact that some studies with concerningly small effects on test scores also result in useful educational outcomes.

Tural and Cutrera offer a necessary counterpoint, that is not always seen in the literature when test score gains are low, to how contextualization is still a positive. This helped to avoid the review becoming too linear and offers a broader understanding of educational effectiveness in which achievement, engagement, attitude and meaning-making are all relevant indicators.

A third group of studies is of interest because it shows how the form of contextualization may make a difference, not just the presence of real-world context in the problem. For example, the task design, the context structure, the form of reasoning, and teachers' preparedness have been shown to also strongly affect contextualized instruction. Ayvaci et al., Pozas et al., Ültay and Tuveri et al. have all made this point from different angles, and come to the same conclusion.

The contributions of task characteristics are most clearly demonstrated by Pozas et al. They found that further contextualization is not better for interest and experience. The interest effects were dependent on the interaction between contextualization, complexity and topic. For a high-context mechanics task, for instance, contextualization increased interest, while in thermodynamics the low-context tasks interested students more than the high-context tasks. This suggests that contextualization does not work equivalently in every area of physics, thus explaining the mixed results of earlier contextuality studies.

Ültay found preservice physics teachers were at a medium level concerning the ability to generate context-based physics problems. Some of them made use of daily-life contexts, but did not relate to the underlying context. Others constructed tasks that appeared context-based, but would not function in this way in practice. Therefore, it is not easy to implement contextualized tasks with a good connection between task and context. If teachers cannot create a strongly connected contextual task, the expected advantages may not be realized in the classroom.

Additionally, value for context-based/conceptually rich problems exists not only in motivation but also in the way that these problems will affect problem structuring. Students who integrated conceptual knowledge and mathematical reasoning to indicate a better understanding of the problem arrived at better solutions than those who prematurely tried to solve the problem mathematically. In other words, richer contexts should serve to foster productive reasoning, not simply decorate tasks.

Ayvaci et al., Pozas et al., Ültay and Tuveri et al. have shown that contextualization is highly condition-dependent. The same type of contextualization may have helpful, weak or mixed effects depending on how complex the learning task is, how clear the conceptual structure is, on teachers' preparation, and on the way the learning situation is structured. Therefore, when using real-life contexts in physics problems, it should be seen as a pedagogically challenging tactic, more due to difficulties in implementation than due to intrinsic limitations of the tactic itself.

A fourth category of papers concerns studies that show how contextualization does not always lead to an improvement of students' learning experiences. Wei et al. are especially important in this respect because they successfully challenge the widely-held belief that contextualization of physics problems automatically leads to increased motivation and interest. In a parallel study with teachers and students, the authors found that teachers (but not their students) generally believed that contextualized problems promote engagement, and that while 8th graders (but not 9th to 11th graders) preferred contextualized problems, the 9th to 11th graders preferred decontextualized problems.

An implication of this is that the contexts used in physics education do not necessarily positively motivate every age or stage of learner, i.e. what causes positive motivation in elementary school children may not have the same effect on older physics students when physics becomes more formal and examination-oriented. This is an important developmental dimension, and Wei et al. therefore show that the reasoning for contextualization is not straightforward or universal.

Later, Wei et al. found out that participants of higher grade levels tended to rate contextualized problems as harder than de-contextualized ones, despite added reading time and length of the problem. This shows that recognizing the physics information as a part of the context of a story also adds another load to the cognitive process of problem-solving, rather than making it more interesting. In this respect, the results map closely to design-based studies such as Pozas et al. that indicate that some combinations of contextualization and complexity reduce interest or confidence.

Wei et al. note that, even when learner-centered contextualized instruction with teacher guidance is helpful, contextualized problems may be viewed negatively by learners because they are presented on tests or assignments as single stand-alone problems. This makes contextualized problems appear more cognitively demanding, requiring greater inferential leaps, and may explain why some studies have found helpful effects in classrooms while others have found students resistant to contextualized tasks.

Together, this fourth group discusses the idea (Wei et al.; Pozas et al., to a degree) that the real-life contexts of physics problems are useful but not in the same ways for all types of learners. Its value depends on the learners, where they are in their education, and how complex the task and the context are.

3. Methodology

3.1 Research Design

More specifically, the methodology in this study was a simultaneous mixed-method design, in which quantitative and qualitative approaches were used. The quantitative component of the study attempted to find statistically important differences in students' performance in the two instructional contexts. The qualitative component sought to describe the students' experiences, perceptions, and interpretations of the problem solving involved in the current study.

Each task was performed by the same participants, in a within subject comparative design. A total of 84 students participated in the study. Tasks were administered over two days: two sets of tasks that were evaluated, with the first set consisting of abstract physics problems and the second set consisting of contextualized physics problems. By having all subjects perform the two tests, subjects' scores on the two tests could be compared without worrying about individual differences.

A logical concept was provided to the development of the instructional materials. The basic problem set were five conceptual problems adapted from the physics textbooks by Dr. Serway and John W. Jewett, Randall D. Knight and several Russian-language books. The problems selected were conventional physics textbook or exam problems where the physics concepts probed were mathematically represented in an abstract way. The experimental set was composed of five contextualized problems designed specifically for this study. The problem statement questions were constructed in such a way that they included the application of the Physics principles, and were approved for content validity by the academic supervisor.

Multiple sources of data were utilized in addition to the students' performance data in order to explore the students' perceptions. As a part of the data collection process, a structured 50-item survey was completed by 52 of the 84 students. The questionnaire included three types of questions: 20 multiple choice questions about the students' views on different issues (not multiple choice questions with a right answer), 20 Likert scale statements about the students' attitudes, and 10 open-ended and free-form questions.

These ultimately yielded both quantitative data (scores in the abstract problem and the contextual problem assessment of 84 participants across conditions) as well as qualitative data (open-ended data on 52 participants).

The main purpose of this design was to compare not only the effectiveness but also the acceptability of the two problem-solving approaches, customary abstract problem solving and context based problem solving in real world situations, so that we could fully assess the impact of context on physics problem solving both on students' performance and perceptions.

3.2 Implemented Tools

The study employed several structured instruments, including two parallel forms of a diagnostic test in physics problem solving, a multi-component survey questionnaire, and written feedback from students about their perceptions and experience of learning during a sequential teaching experiment.

Assessment Tests. The primary measure was two parallel tests, each with five physics problems meant to probe students' understanding of the same conceptual domain.

The first test was a typical abstract problem: it was mathematical, very short, and provided an insufficient amount of context and examples. The problems were taken from the two standard college physics textbooks by Raymond A. Serway and John W. Jewett and Randall D. Knight, as well as from a range of educational texts in the Russian language. They illustrate the most common problems in elementary physics education.

The second test was composed of context-rich, real-world physics questions designed for use in this experiment. Context-rich, real-world questions are defined as questions in which the physics principles are applied to a real-world situation, requiring the student to describe the situation, as well as perform the calculation.

To ensure the two tests are comparable, the following problem sets were created:

- address the same physics topics
- require similar solution procedures
- and maintain comparable levels of difficulty

The academic supervisor appraised the contextual problems as valid, unambiguous, and consistent with the requirements of the curriculum.

In order to assess how students viewed problems of both types, a questionnaire of fifty items was administered to a representative sample of students, which was designed to assess a variety of aspects of student experiences with problems of both types.

The questionnaire items were divided into three categories:

1. Multiple choice questions (20 items). These materials were designed to elicit students' attitudes and preferences in various aspects of problem solving; correct answers were not provided.
2. Likert-scale items (20 statements) Both academic and social statements required students to state, on a numerical scale, how much they agree that they understood, were motivated or found the relevance desirable.
3. Open-ended questions (10 questions) These types of questions allowed for students to elaborate on each types of problem's perceived difficulties and advantages from their perspective.

3.3 Data Collection and Data Analysis

The data reported here were gathered from 84 students who completed two testing sessions in successive weeks when two items of physics problems were presented under controlled conditions. The data for both sessions comprised administration of customary abstract items from commonly used physics textbooks, such as those by Serway and Jewett and Randall D. Knight. The second set of five contextualized problems used here was formulated specifically for this dissertation and validated by the research supervisor, and was based on contexts familiar to learners. These problems were matched up with the physics problems used in the standard tests.

Because the same participants were used for both types of problems, differences for the two problem types can be said to be dependent (paired) rather than solely due to differences in physics ability.

In addition to the performance data, for a sample of 52 participants data was also collected via a questionnaire with 20 Likert scaling statements, 20 multi-choice questions without an explicitly correct answer, and 10 open-ended questions. The statements in the Likert scaling questionnaires were directed at the students' perceptions of the understandability, attractiveness and relevance of the contextual problems. The multiple-choice section of the questionnaire intended to cover and discover participants' general preferences and tendencies, while the open-ended section allowed participants to describe their experiences in their own words. In addition, 8 students submitted reflections in the form of short review essays, which provided qualitative data offering further context for the quantitative findings.

Quantitative analyzes were conducted with Jamovi statistical software. Descriptive statistics were calculated for the performance of students in both the customary and contextual conditions. These variables included the mean, standard deviation, minimum, and maximum scores. In order to test for a statistically meaningful difference between the two problem sets, a paired samples t-test was also employed. A dependent design was used instead of an independent design because the same participants completed both tests. In addition to reporting whether the difference between the two tests was statistically important, the size of the difference was calculated using a Cohen's d.

After difference scores were obtained by subtracting customary scores from contextual scores for each individual, they were assigned to categories. Percentages of students whose scores improved, stayed the same, or decreased were calculated to provide a more thorough view of the difference in performance between the groups. It also provided information about whether the overall effect was driven by a large number of people or a few.

An additional analysis was done to see if the difference would become apparent if the data were evaluated on a gender basis. To investigate this, an independent samples t-test was applied to the difference scores based on gender. The step was included to check if contextual problems had varied effects on demographic groups.

In order to discern any differences due to the topics of physics being studied, the data were parsed into content domains (mechanics, thermodynamics, electromagnetism, energy and astronomy). For each topic, difference scores were computed. Descriptive statistics revealed where the greatest differences in effect level were found. This offered perception into the domains where contextual problems had the greatest benefit.

The answers to the Likert-scale items were also averaged, resulting in a general perception score, which summarizes the general attitude towards contextual problems in the form of one score. Before we calculated the general perception score, internal reliability by means of Cronbach's alpha was calculated to evaluate the internal consistency of the questionnaire. Finally, descriptive statistics were used to determine the overall perception of students.

Frequency distributions and percentages were used to interpret the results of the multiple-choice questions to determine tendencies or preferences. Descriptive statistics were utilized as there were no right or wrong answers for the multiple-choice items. These were the most common results reported by the survey.

Finally, the open-ended question responses were analyzed using the simple thematic analysis methodology where student responses were analyzed and recurring themes were identified. Specifically, recurring themes of improved understanding, student engagement, real-world relevance, and perceived difficulty were identified within the open-ended student responses. Examples of these themes are provided as well.

The use of both quantitative and qualitative data analysis methods allowed for an in-depth analysis of student knowledge and student perception. The dissertation took a mixed-methods approach to provide a holistic view of student learning effects through the use of contextual physics problems from various learning environments.

3.4 Limitations and Difficulties

Several limitations and practical difficulties were encountered while working on this dissertation, and these need to be kept in mind when interpreting its findings.

However, the current study does have several limitations. One is that the sample size for statistical analysis, while determined to be sufficient, came from only one school with 84 participants, which may limit the generalizability of the results. In addition, because the sample was drawn from one academic context, the results may not be generalizable to students with different academic histories and experiences.

Second, the experimental design had the same group of students do customary problem sets and contextualized problem sets on successive days so that a more direct comparison could be drawn and potential confounding variables are controlled, but it could potentially produce testing effects. The differences in the students' performance on the second day might be attributed to the fact that students were familiarized with the problem structure during the first test, or due to fatigue, motivation or interest differences between the two days.

Another limitation of the contextual problems comes from the design of the contextual questions. Contextual questions were assigned to be equivalent questions in terms of the same physics content involved in the customary problems, but contextual questions may have longer wording and more text to process. This may add to cognitive load and make it difficult to determine whether students were performing differently due to their understanding of the concept or task difficulty.

These data, however, have some methodological limitations, since Likert-scale questions were based on self-report, which is subject to individual biases, affect or interpretation of what is asked. This limitation applies to multiple-choice questions that have no objectively best answer, too, since they also only reflect preference. These, however, can only be taken as confirming evidence, and not conclusive evidence of something.

To analyze the qualitative data, the open-ended survey responses were thematically analyzed following a condensed thematic model. While this method may capture some common themes, it does not capture the subtlety of each individual response. Interpretation of qualitative data is often subjective and the reliability of the responses categorization process is not guaranteed.

Finally, the duration of the experiment and the number of contextual problems (limited to five) were also practical limitations. An experiment with more problems or with a longer observation period would have increased the amount and reliability of the results.

Despite these limitations, the findings provide valuable insights into the impact of contextual physics problems on students' performance and perceptions, as well as the relationship between context and learning. The combination of quantitative and qualitative data in the study also improves the reliability of the findings.

3.5 Ethical Considerations

Ethical considerations were taken into account throughout the dissertation, particularly relating to the protection of research participants and the processes of data collection, data analysis, and presentation of results. In addition, the research was conducted in accordance with ethical principles generally accepted in academic research to protect research participants and ensure research integrity.

Participation in this study was voluntary, and students were informed of the aim, method and type of data that were being collected for the study. Participants were free to withdraw at any point without experiencing any negative consequences, and participants provided written informed consent prior to data collection, ensuring that they were notified of the fact that they were taking part in the study and how their responses were to be used.

The study was carried out on a strictly confidential and anonymous basis, with no reference to names or personal details made in the analysis or reporting of the study's results, and with all material provided by test participants being treated with discretion and with aggregate results supplied so that individual students could not be identified.

The researchers made sure that no one would be hurt or disadvantaged, that the problem-solving tasks used were geared toward the educational level of the students participating, and that no material was presented that was above and beyond the students' expected level. Results were released for research purposes only and not used for students' academic performance or assessments.

A further control used was that both customary and contextual problem sets were administered fairly in that the same assessment conditions existed for all participants in the same problem set condition and the same marking criteria were applied to both types of assessment to ensure objectivity in analyzing the results.

All ethical guidelines were followed for this questionnaire. The students were told to answer the questionnaire honestly, and not to feel compelled to give a specific answer. The use of open-ended questions encouraged participants to elaborate, leading to a more subtle understanding of their experiences in the study.

Finally, data confidentiality was protected and was held securely and used only for purposes of this study. Any results were reported truthfully and not manipulated or selectively re-reported (e.g., lying by omission). The procedures were designed to ensure an ethical, responsible, and academically sound research process.

4. Results

4.1 Quantitative Results

Quantitative findings of the dissertation, both with respect to student outcomes and students' perceptions of contextual physics problems, are presented in this section. Results from 84 students completing two problem-solving tasks and 52 students completing questionnaires support the quantitative findings. The quantitative approach allows for a systematic analysis of measurable differences between customary and contextualized problem-solving formats as well as between the students' attitudes towards either of the problem-solving formats.

In the first part of the analysis, we will look at problem solving performance, comparing the scores on customary abstract problems with the scores on contextualized problems and measuring the impact of contextualization on performance. Paired data gives a more accurate measurement of performance differences than comparing averages between groups and, rather than just comparing group averages, the results are analyzed through comparisons for improvement distribution across students, differences between demographic groups, and differences between particular physics topics.

The second part of the quantitative analysis focused on students' perceptions of contextual problems using the Likert-scale data, and the results were presented in terms of understanding, engagement, and relevance. In such cases an overall perception score and a reliability analysis are used to help interpret the student responses. The overall perception score gives a general idea of the students' perception while the reliability analysis checks the overall credibility of the measurement scale. The results also provide another source of information about contextualized learning.

4.1.1 Problem-solving results:

The related findings regarding students' responses to customary and contextualized physics problems are outlined below. The foci of the following sections are, respectively, the differences in achievement between the two contexts, the extent to which students' performance improved in the two contexts, and specific differences regarding students' gender and physics topic.

A paired samples t-test was conducted on the students performance in the abstract problem condition and the contextualized problem condition. The results showed that the students' scores differed considerably between the two conditions: $t(83) = -6.08$, $p < .001$. The average discrepancy (mean difference) between the two scores was -3.93, indicating that students generally performed better on contextual problems than on customary problems.

The standard error of the mean difference (0.646) indicates that the mean difference between groups was a relatively stable statistic, with an effect size (Cohen's d) of -0.66 indicating a moderate negative effect. This suggests that the difference is not only statistically important but also of considerable magnitude, corresponding to a medium to large effect.

Overall, results indicate that contextualized physics tasks yield a meaningful increase in student performance compared to customary abstract physics tasks.

Table 4.1 *Paired Samples T-Test*

Measure 1	Measure 2	Test	Statistic	df	p	Mean difference	SE difference	Effect size
Traditional	Experimental	Student's t	-6.08	83.0	< .001	-3.93	0.646	Cohen's d = -0.663

Note. H_a $\mu_{\text{Measure 1 - Measure 2}} \neq 0$

A Shapiro-Wilk test for normality of the difference scores (performance on the customary problem minus performance on the contextual problem) indicated an important departure from normality ($W = 0.949$, $p = .002$), suggesting that the normality assumption may not be met for the difference scores.

The paired samples t-test is considered quite strong to violations of the normality assumption, especially for relatively large N (N = 84), so these results can be interpreted with some confidence, notwithstanding that our data are not perfectly normally distributed.

Table 4.2 *Normality Test (Shapiro-Wilk)*

			W	p
Traditional	**-**	**Experimental**	.949	.002

Note. A low p-value suggests a violation of the assumption of normality.

Then, descriptive statistics were computed for customary problems and contextual problems separately. The mean for customary problems was 61.3 (SD = 18.7) and the median was 61.0. The mean score for contextual problems was 65.2 (SD = 16.0), while the median score was 66.0.

For the customary version, the standard error was 2.04, and for the contextualized version, it was 1.74. Thus the average mean score of either version of the test is stable. These results also show that students performed better when the problems were posed in a contextualized way rather than presented in a customary way. This also supports the results of the paired samples t-test.

Table 4.3 *Descriptives*

	N	Mean	Median	SD	SE
Traditional	84	61.3	61.0	18.7	2.04
Experimental	84	65.2	66.0	16.0	1.74

Distribution of Performance Differences:

To determine how improvement was distributed, the difference scores (contextual - customary) were also grouped by degrees of student gains. Students showed positive improvement overall, according to the results of this categorization. 32 students improved slightly (+1 to +5), 17 students improved moderately (+6 to +10), and 8 students improved dramatically (+11 to +15).

There was no change in performance for 9 of the students, a slight decline for 10 students (-1 to -5), moderate decline for 7 (-6 to -10), and a dramatic decline for 1 (-11 to -15).

In summary, of the 84 students in the treated group, 57 students (68%) saw an increase in their test scores and 18 students (21%) saw their test scores drop. This does not mean that test scores always increase for students, but the average increase is caused by the majority of students seeing the improvement.

Table 4.4 *Change Categories by Score Range and Count*

Change category	Range	Count
Dramatic positive change	+11 to +15	8
Moderate positive change	+6 to +10	17
Slight positive change	+1 to +5	32
No change	0	9
Slight negative change	-1 to -5	10
Moderate negative change	-6 to -10	7
Dramatic negative change	-11 to -15	1

Note. Positive values indicate positive change; negative values indicate negative change.

An independent samples t-test showed that there were no statistically important differences in amount of improvement between the female students and the male students, $t(82) = -0.42$, $p = .673$.

The effect size was small (Cohen's d = -0.09). The change in improvement for women and men was not a meaningful effect size. The mean difference of improvement was not statistically important for these genders; the 95% confidence interval for the mean difference is (-0.525, 0.339).

Overall, these findings seem to indicate that the improvement in performance across an intervention was not due to between-gender differences.

Table 4.5 *Independent Samples T-Test*

							95% Confidence Interval	
		Statistic	**df**	**p**	**Effect size**	**Estimate**	**Lower**	**Upper**
Difference	**Student's t**	-0.423	82.0	0.673	Cohen's d	-0.0933	-0.525	0.339

Note. H_a $\mu_{Female} \neq \mu_{Male}$

When comparing the improvement rates for female (N = 36) and male (N = 48) students with the group descriptive statistics, the mean of the improvement rate of female students (3.61, SD = 5.43) was slightly lower than the mean of the improvement rate of male students (4.17, SD = 6.32). The median of the set for both groups was 5.00, showing the groups gained similar amounts.

The standard errors were 0.904 for females and 0.912 for males with a negligible difference between the two. In all the results shown the male students had a higher mean difference than the female students. However, this difference is very small and in line with the results of an independent samples t-test, which shows no important difference.

Table 4.6 *Group Descriptives*

Measure	Group	N	Mean	Median	SD	SE
Difference	**Female**	36	3.61	5.00	5.43	0.904
	Male	48	4.17	5.00	6.32	0.912

Descriptive Statistics of Difference Scores by Topic:

Descriptive statistics were applied to see if there were differences in performance in particular content areas in physics, and the effect sizes also differed per content area.

Of all categories, the Astronomy category showed the greatest average improvement (M = 2.45, SD = 3.62). This was followed by the Energy category (M = 1.93, SD = 4.03), Mechanics (M = 0.76, SD = 4.03), Thermodynamics (M = -0.20, SD = 4.16) and Electromagnetism (M = -1.01, SD = 3.35), which showed a small decrease in performance.

The median (shown in parentheses) for all of the content areas is in the positive range for Astronomy (2.00), Energy (2.00), and Mechanics (1.00) but in the negative range for Electromagnetism (-1.00). From the minimum and maximum scores, great variability in all the content areas can be inferred.

In summary, contextual problems have a larger impact on the Astronomy and Energy domains, while they have less or even a negative impact on the Thermodynamics and Electromagnetism domains.

Table 4.7 *Descriptive Statistics for Difference Scores by Topic*

	Diff: Energy	Diff: Mechanics	Diff: Thermod.	Diff: Electromag.	Diff: Astronomy
N	84	84	84	84	84
Mean	1.93	0.762	-0.202	-1.01	2.45
Median	2.00	1.00	-0.500	-1.00	2.00
Standard deviation	4.03	4.03	4.16	3.35	3.62

Minimum	-8	-10	-9	-10	-4
Maximum	18	13	11	7	13

Note. Diff. = difference score.

In summary, the results suggest that context-based physics problems help learning more than standard problems, and that this holds true for most students, both genders, and most topics. However, the effect varies from one topic to another; the positive effects reported were larger in some topics than others, while in some topics, there was little or a negative effect.

4.1.2 Likert-scale results:

In this section the results from the Likert-scale questionnaire on students' attitudes towards the contextual physics problems are presented. The internal consistency of the survey instrument is then analyzed. Finally, an overview of the overall attitudes of the students based on the aggregated data is provided.

The reliability of the results was tested by calculating internal consistency of the Likert-scale questionnaire. The analysis showed that the analysis yielded a very high reliability mean of 3.53 (SD = 0.86), with a Cronbach's alpha coefficient of $\alpha = 0.959$. This result indicates excellent internal consistency of the instrument's items, that is, how closely items in the survey relate to the construct of students' perceptions of contextual physics problems.

Table 4.8 *Scale Reliability Statistics*

	Mean	**SD**	**Cronbach's α**
Scale	3.53	0.860	0.959

An item-level analysis was performed to look for item contributions to the overall scale. Item-rest correlations, the correlations between an item and the sum of the other items on the scale, were found to be highest in the range of 0.65 to 0.84.

The Cronbach's alpha if item deleted values were also high, in the range 0.95-0.96, indicating that no item was causing the overall scale's reliability to be distorted.

One item (Q14) showed a weak item-rest correlation (0.207) in comparison to others. Since the overall reliability is still high, it appears this item did not adversely affect internal consistency, but indicates that it may be less relevant to the construct.

The results of the present study confirm that the individual items are satisfactory measures of the factor and that the scale is reliable.

Table 4.9 *Item Reliability Statistics*

				If item dropped
	Mean	**SD**	**Item-rest correlation**	**Cronbach's α**
Q1	3.58	1.11	0.736	0.957
Q2	3.65	1.12	0.742	0.957
Q3	3.37	1.14	0.700	0.958
Q4	3.73	1.12	0.770	0.957
Q5	3.71	1.27	0.771	0.957
Q6	3.40	1.22	0.696	0.958
Q7	3.52	1.20	0.793	0.956
Q8	3.33	1.20	0.743	0.957
Q9	3.50	1.21	0.784	0.957
Q10	3.46	1.20	0.816	0.956
Q11	3.58	1.07	0.706	0.958
Q12	3.90	1.16	0.769	0.957
Q13	3.67	1.00	0.650	0.958
Q14	2.79	1.18	0.207	0.964
Q15	3.56	1.21	0.780	0.957
Q16	3.56	1.06	0.835	0.956

Q17	3.46	1.06	0.787	0.957
Q18	3.65	1.06	0.780	0.957
Q19	3.48	1.09	0.649	0.958
Q20	3.73	1.16	0.744	0.957

Descriptive statistics were performed on students' perception towards contextual physics problems. The overall mean was 3.53 (SD = 0.86), and the median was 3.60. The lowest and highest responses were 1.10 and 5.00, indicating diversity in individual responses. The mean value (above the neutral midpoint) suggests that students generally have a positive attitude towards context-based physics problems.

Table 4.10 *Descriptive Statistics for Overall Perception*

	Overall Perception
N	52
Mean	3.53
Median	3.60
Standard deviation	0.860
Minimum	1.10
Maximum	5.00

4.2 Qualitative Results

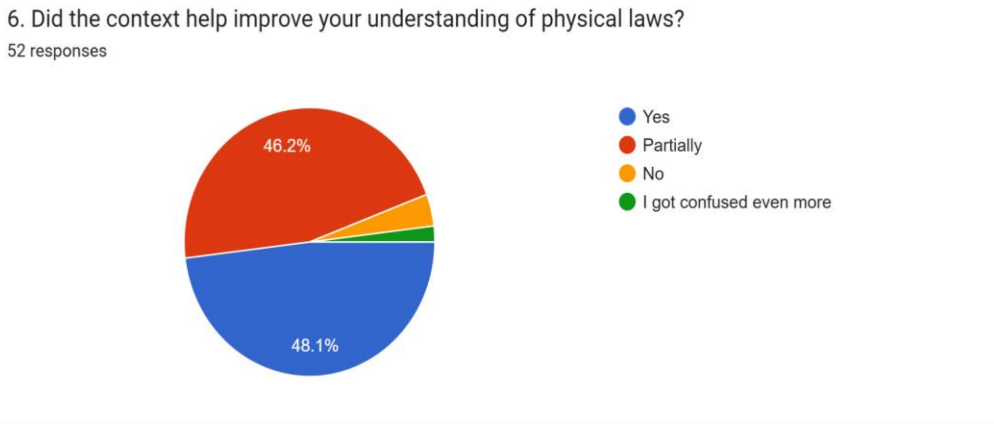
This was followed by the qualitative analysis of the multiple-choice responses, open-ended questions and student review essays. The qualitative data describes the general patterns in the choices and experiences of the students and provides more information about the contextual physics problems than the quantitative data does by itself.

4.2.1 Multiple-choice results:

To assess participants' sense of relevance and usefulness of the experimental problem sets, participants were asked whether real-world scenarios improved their understanding of the physical laws in a short survey. Self-reported data from this multiple-choice survey of N = 52 participants indicate a strong preference for contextualized problem formats. Almost half of the students (n = 25, 48.1%) answered "Yes" to this question, indicating that they viewed the contextualized problems as acting as a specific support to ease their understanding of the physics concepts. Another large proportion of students (n = 24, 46.2%) answered "Partially", indicating that although the cognitive demand was preserved for the physics concepts within each problem, the contexts provided a helpful mental model.

Only a small proportion of students expressed negative feedback about breaking customary abstract textbook patterns, with 3.8% (n = 2) of students reporting that the context did not contribute to their understa-nding in any way and one (1.9%, n = 1) reporting that the introduction of real-life variables caused confusion. The majority of participants (94.3% with some exceptions) seem to have perceived grounding abstract theoretical principles in real-world problem contexts as producing an at least partial improvement. Our results collectively suggest that the introduction of realistic constraint-driven problem contexts generally serves to maximize transfer of abstract principles to real-world contexts for most learners without overwhelming them with distracting contextual noise.

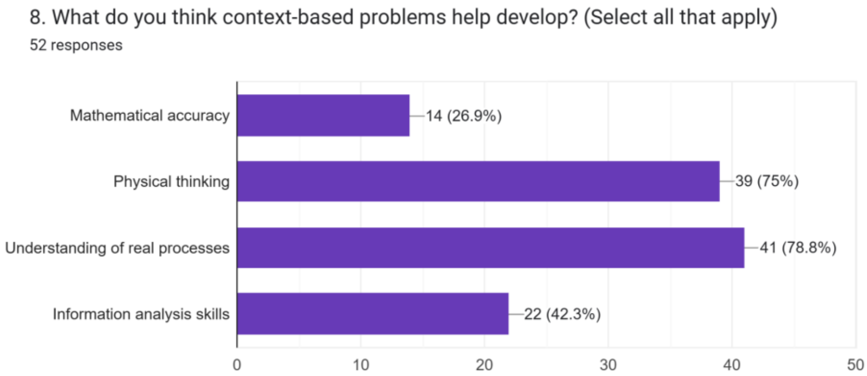
Figure 4.1. *Understanding of Physical Laws*



To further explore the cognitive benefits students believed they were receiving from working on the experimental problem sets, students were asked to identify which aspects of their skills context-based problems improved (N = 52). Students identified individual aspects of skill improvement for context-based problems, but were more likely to identify conceptual than mechanical skill improvement. The most frequently categorized benefits were "Understanding of real processes" (78.8%, n = 41) and "Physical thinking" (75.0%, n = 39). That the most frequent benefits were related to understanding physical processes and physical reasoning suggests that participants had understood what the main pedagogical aim of the presented contextual designs was: understanding that physical phenomena can be explained by physical laws. These results indicate that physics students expect real-world framing of problems posed in physical terms not to be just window dressing, but the vehicle by which physics theory is transformed into physical reality.

In comparison, smaller percentages of students recognized the contexts' influence on their mechanical/procedural skills development (26.9%, n = 14) and the development of Mathematical accuracy was the least mentioned. Nevertheless, a fairly meaningful minority of 42.3% (n = 22) commented on the development of "Information analysis skills" in this area. This suggests that students may be able to reconceptualize the problem in terms of information search and analysis skills, rather than as a calculation problem. This suggests that while abstract model-based tasks are associated with rote mathematical drills, contextualized tasks have the potential to shift cognitive focus towards evaluating variables and applying physical reasoning.

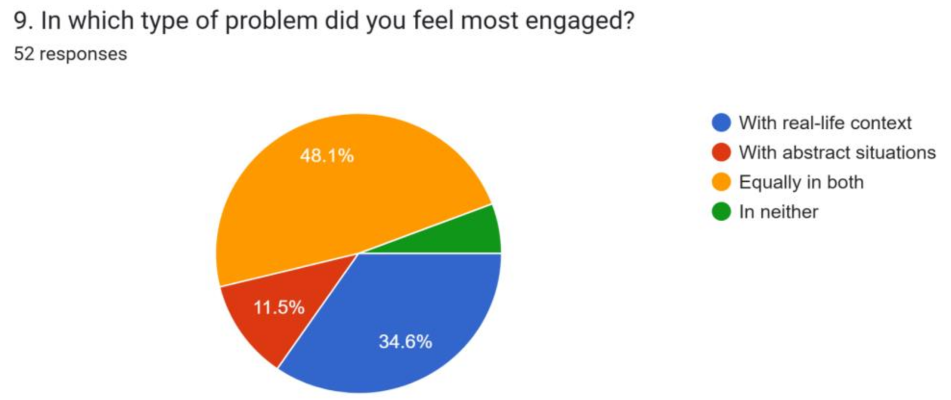
Figure 4.2. *Skills Developed by Context-Based Problems*



To investigate how the problem format affected the students' motivation, the college students were asked to determine which problem format gave them a greater interest in the problem. The proportion of how students chose the problem format (N = 52) is revealed in the table below. The largest single answer from our sample for both students combined was "Equally in both": 48.1% (n = 25). This indicates that the students did not see the narrative frame of the problem as important, suggesting the same physics problem could be presented in different narrative frames without consequences for understanding the physics concepts. The learning of these learners seems to be driven more by solving the underlying physics puzzle than by the situation in which the variables are presented.

However, for those that displayed a clear preference for the format of the problems, the experimental designs were often favored when the level of engagement with the task was dependent on the format. In the present study, 34.6% (n = 18) of the participants reported that they felt most engaged when solving problems in a "real-life context", while 11.5% (n = 6) of participants said the same in an "abstract situation". This gives a ratio of three to one. Very few subjects (5.8%, n = 3) also reported "In neither". Overall, these data suggest that while the range of problems presented in a customary introductory physics textbook may serve to maintain baseline levels of interest and engagement in the enormous majority of the population, the addition of real-world applications can provide a powerful means of engaging those who are otherwise disaffected by more abstract physical situations.

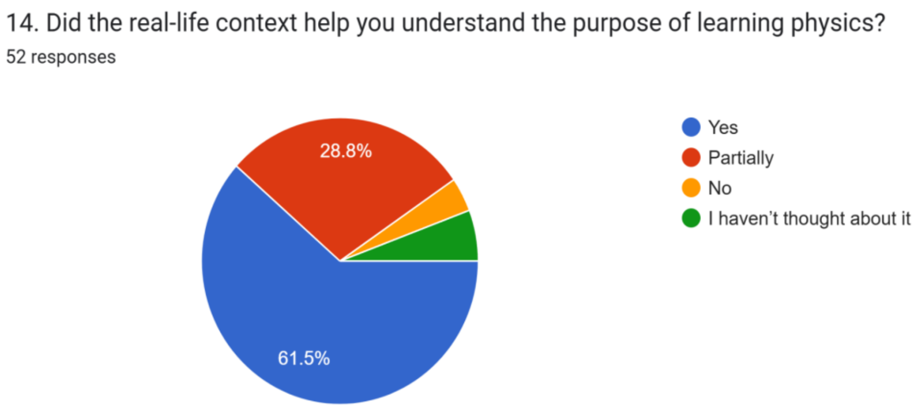
Figure 4.3. *Student Engagement by Problem Type*



To assess whether either of the experimental problem formats had an effect on students' epistemological beliefs of the whole discipline, participants were asked whether those real-life contexts helped them understand the purpose of why they were learning physics. Survey data (N = 52) indicated a large increase in students' perception of real-life relevance. The biggest sample (n = 32, 61.5%) answered "Yes", indicating that the contexts had helped students to understand the purpose of their physics learning. Another 28.8% (n = 15) of student responses indicated the contextual problems used in class "Partially" helped them understand this purpose. Overall, 90.3% of subjects agreed using real physical variables as opposed to simply abstract situations helped them understand why physics is a useful and important subject.

On the other hand, for a small proportion of the students, the difference in the way the problem was presented did not matter: 3.8% (n = 2) of the participants answered "No", meaning that the context did not close the divide regarding the subject's purpose. A small group of students (n = 3, 5.8%), did respond that "I haven't thought about it", but it is clear, whatever the pedagogical frame that is employed when teaching the physics, that embedding physics problems within a real-world context provides more than just a conceptual aid, rather it also shows to students the (wider) applicability of the discipline itself.

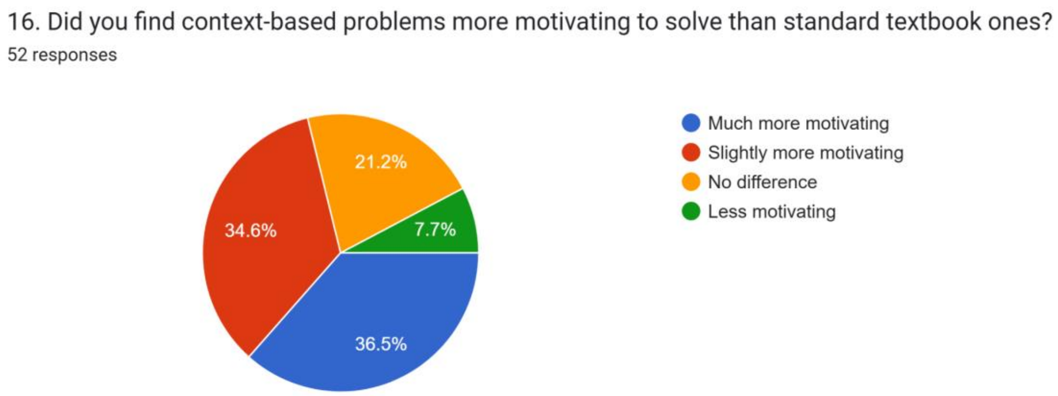
Figure 4.4. *Purpose of Learning Physics*



In order to estimate the subjective effect of the experiment variations on student motivation, students were asked to compare their motivation for context-based experiments to that of standard textbook problems using a survey (N = 52), which showed a strong positive effect of the contextual framing. A large majority of participants (n = 55, 71.1%) self-reported that they experienced more motivation when working on contextual physics problems. 36.5% of respondents (n = 19) reported the contextual physics problems to be "Much more motivating" and 34.6% (n = 18) reported the problems to be "Slightly more motivating". These results suggest that contextual physics problems may help to decrease cognitive fatigue from abstract, mathematical physics problems by giving real-world context to the development and application of physics theories.

This suggests that a portion of the cohort received no benefit or preferred the customary mode, as 21.2% (n = 11) of respondents selected "No difference". This suggests that for some learners, the physics mechanical problem is the primary problem to be solved, and the contextual problem is peripheral. A minority of students (7.7%, n = 4) found the contextual problems "Less motivating". This could be due to the increased cognitive load of having to extract relevant information from real-life contexts and the perceived lack of topic interest from students who had previously been provided with instructive, goal-bound parameters in customary problems. Nevertheless, the overall trend shows that shifting away from the purely abstract representation has been positive for improved motivation and persistence.

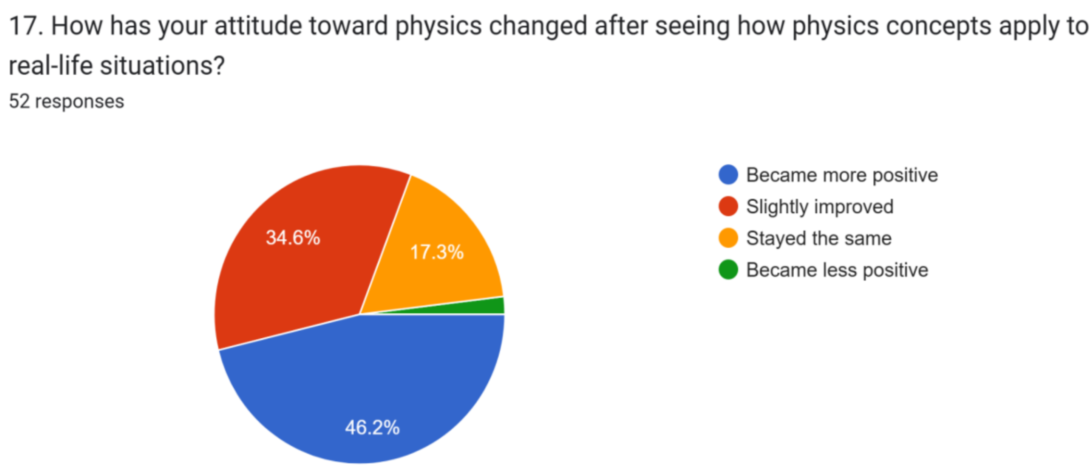
Figure 4.5. *Motivation to Solve Context-Based Problems*



To answer the research question, the example, the question posed to the participants is whether the real-world example had an effect on their attitude towards physics. Data from N = 52 showed a clear affective change. I.e. in general the student body engaged in a clear affective change. In fact, 80.8% of the whole group felt that their disposition to the subject improved. In fact, 46.2% (n = 24) replied that their disposition towards the subject "Became more positive" and 34.6% (n = 18) said it "Slightly improved". This suggests that the affective value of this pedagogical activity, the transference of previously perceived abstract principles in standard textbook problems to concrete, familiar situations, encourages students to appreciate the subject more. We conclude that a demonstration of the immediate relevance of the physical laws is a catalyst both for cognitive engagement and for a truly positive attitude to the subject matter.

However, a minority of the subjects did not change their attitudes. This suggests that attitudes can be stable and already present. A small percentage of subjects (17.3% or n = 9) indicated that their attitude "Stayed the same". This indifference response could indicate two groups of previous students - those who had a highly positive and fixed attitude to learning physics and those who had an indifferent attitude to learning physics with little change regardless of pre-specified framing. A total of 1.9% (n = 1) stated that their attitude to learning physics "Became less positive". While statistically insignificant, it may be the case that the extra cognitive load in undertaking a complex task or the confusion introduced by applying concepts in the presence of the messy and unpredictable world of real variables could contribute to some students becoming frustrated. However, overwhelmingly, studies suggest that the use of contextual problem-solving is a pedagogically effective method for improving students' attitudes for learning physics.

Figure 4.6. *Attitude Toward Physics*



4.2.2 Open-ended questions results:

The data from the open-ended responses were analyzed using thematic analysis, due to the flexibility of this method to systematically identify, analyze, and report patterns (themes) within qualitative data. The analysis followed Braun and Clarke's (2006) general approach to thematic analysis, consisting of six phases: (i) familiarization; (ii) generating initial codes; (iii) searching for themes; (iv) reviewing themes; (v) defining, naming, and (vi) writing up. Once the data were coded, categories with similar meanings were grouped into larger categories, in order to improve the transparency of the analysis process. It follows suggestions that qualitative thematic analysis should take an auditable decision trail to show the research trustworthiness (Nowell et al., 2017).

A total of 520 open-ended responses were collected from 52 participants replying to 10 items. Responses to open-ended questions that failed to contain substantive content (e.g. "idk", "no idea" and punctuation) were deemed ineligible to be considered. The coded responses were grouped according to themes observed in participants' comments about relevance, visualization, engagement, perceived difficulty, and suggestions for improvement with eight main themes emerging: perceived relevance and real-world applicability, concrete visualization, engagement and motivation, high cognitive demand and problem-solving difficulty, pedagogical usefulness for future students, need for more clarity, lack of novelty/neutrality, and use in authentic contexts.

The first major theme was relevance, as many students reported that context-based problems helped students connect physics concepts and equations with the real world, e.g., that contextual problems account for how formulas work in real life. One said contextual problems "make physics easier to understand because they connect formulas to situations I see in everyday life." Another said contextual problems show "how physics works in real life, not just in theory." Students' comments suggest that contextual problems might help students see physics as relevant.

The second dimension was that of visualization and understanding. A pattern was that when the situation was placed in a familiar or realistic context, it was easier for the students to picture it. Some participants reported being able to visualize forces, motion, aircraft, cars, or energy transformations. One participant stated that a car motion problem helped them visualize "the road, speed, and braking", while another participant reported that context helped them create "an image in my brain". Thus, situated learning can support learning by requiring students to visualize a physical situation before applying formulas to solve it.

The third theme was engagement, interest and motivation. Contextual problems were described by several students as more interesting than textbook problems. Space, aircraft and transportation, thermodynamics, energy, and technology were all considered interesting topics. One participant said that the contextual problems allowed physics to be seen as "more practical and interesting, not just about solving equations". Another said if they had seen such problems at school, they would have been "more engaged". These comments suggest that real problems make students' affective responses to physics more positive because they are less abstract.

A limitation to the fourth theme was the cognitive demand and problem-solving difficulty. Many students indicated that contextual problems were more difficult because of the additional text, extra information or wording. Some students indicated difficulty identifying the correct formula or determining what was relevant. These students noted that there was often a lot of text and it was difficult to determine what to use, and this could result in time wastage during exams. Thus, contextual problems may be engaging and relevant, but a long or unclear problem statement can weaken the benefits by increasing cognitive load.

The fifth theme was pedagogical use for future students. Some teachers thought contextualized problems could be used for instruction because they could reinforce to students the utility of physics. Some students indicated that the problems would help school students see physics as more than formulas and numbers. One student said it could help because "students will see how physics is connected to everyday life and become more interested in the subject." Another said it would help because students would "understand more physics, not the formulas." This result is not surprising because the students were future teachers and many students evaluated the problems mainly from a pedagogical perspective.

Theme six was clearer designs, shorter texts, and visual support. The students wanted real life contexts, but also offered suggestions for improvement. Some improvements participants suggested generally included shorter and simpler problems, using diagrams or pictures, clarifying the data, and using hints or cues. One participant's comment was to simply make the problems "shorter and add simple diagrams" while another said to use "the simplest English terms" and pictures. These responses suggest that contextualization in and of itself is not sufficient, and that problems must be well-designed.

The seventh theme was limited change, neutrality, or prior familiarity: some students did not feel that the context problems had made an important change in their views of physics. This was often because students thought that physics was already related to real life. Some of the students gave neutral or no major difficulty responses. In addition, this theme suggests that the students' attitudes were affected in a confirming rather than transformative manner after seeing the application in a real-world context.

The eighth theme was related to preferred contexts. The preferred contexts were astronomy, space, aircraft, aerodynamics, motion, transportation, energy, electricity, thermodynamics, sports, technology, and the human body. The students seemed to prefer physical contexts which were visually involving, technologically relevant, or related to everyday situations, which could be hints for designing context-based physics problems.

Table 4.11 *Themes Identified From Students' Open-Ended Responses*

Theme	Coded references	Participants mentioning theme	Interpretation
Perceived relevance and real-life applications	120	42	Students often connected contextual problems with daily life and practical applications.
Visualization and concrete understanding	78	39	Many responses suggested that contexts helped students imagine physical situations more clearly.
Engagement, interest, and motivation	52	27	Several students described contextual problems as more interesting, engaging, and motivating.
Cognitive demand and problem-solving difficulty	59	37	A recurring difficulty was that contextual problems contained more words and required careful reading.
Pedagogical usefulness for future students	55	47	Most comments about teaching emphasized that real-life problems could help future students understand physics better.
Need for clearer design, shorter wording, and simpler data	65	42	Students recommended shorter texts, clearer data, simpler wording, and more direct questions.
Limited change, neutrality, or prior familiarity	33	17	Some students reported no major change in perception, no difficulty, or prior familiarity with similar contexts.
Preferred real-life contexts and proposed scenarios	131	50	Students most often mentioned space and astronomy, aircraft and aerodynamics, sport, transport, and everyday technology as preferred contexts.

Note. Coded references indicate the total number of coded segments across all responses. Participants mentioning theme indicates the number of students whose responses included the theme. Because a single participant could mention more than one theme, totals exceed the number of respondents.

In short, qualitative data also generally support the quantitative findings that contextualized physics problems (i.e., problems with a real-world context) are perceived as more meaningful, more concrete, and more interesting than problems that are purely abstract. The data also suggest that contextualized problems need to be designed carefully in order to be helpful. The downside is that longer, ambiguous, and redundant prose is harder to process even if it is more informative. Thus, qualitatively, authentic context can improve attitudes and perceived relevance, but only if the text is short, clear, and supported by images.

5. Discussion

5.1 Interpretation

The overall results of the dissertation therefore strongly indicate that contextualizing physics problems in the real world positively affects student learning. Indeed, students score considerably better when solving contextualized problems rather than customary physics problems in abstract and artificial worlds, like a customary laboratory setting. The difference between conditions was statistically meaningful with moderate to large effect sizes, indicating that the difference observed in the experiment may be educationally meaningful. The distributions of performance were also compared. Since most students in the exam performed better in the contextualization condition, the results indicate that the effect of contextualization is not restricted to a small group of students.

The similarity of the effects across genders lends some support to the robustness of the effects, as no statistically meaningful differences were found between male and female students' performance on contextualized problems. One implication of this finding is that context-based problems may be a useful instructional strategy for all students, regardless of differences in demographic variables. Implications of this effect suggest that context may be a favored instructional practice for educators for diverse populations of students.

At the topic level, a topic-specific effect of contextualization on learning could be observed. The extent to which this effect was visible depended on the topic. A clear example was seen in the topics of the Astronomy and Energy, as its relevance was applied relatively more often to the final product. These subjects also appeared to be more amenable to contextualization and more consistent with students' prior experiences. Weaker and negative effects were observed in Thermodynamics and Electromagnetism where the more abstract connections, and less intuitive physical phenomena, may have made contextualization more difficult or put a higher cognitive load on the students. This suggests that the effectiveness of contextualization is likely influenced by the degree to which the subject matter can be naturally linked to the physical world.

The Likert-scale data provide additional evidence for the students' attitudes towards contextualization, with a mean on the scale above its middle point, indicating positive attitudes. The high internal consistency of the questionnaire indicates that these attitudes are stable and accurately measured. The students interviewed suggested that contextual problems improve learning, engagement and relevance of physics. This reaffirms the quantitative result that better performance is correlated with a better experience of learning the material.

These findings are supported by other multiple-choice and open-ended questions. Students reported increases in real-world relating, physical thinking, and understanding physics in real-world terms, suggesting that the contextualization may have helped students move from procedural problem solving to physical understanding. However, some students had some problems with longer problem statements, and finding the most relevant information in the more complex context of the problem statements, highlighting that contextualization might increase meaning and motivation, but also increases the cognitive load a student must manage.

The collective results suggest that by embedding physics concepts in familiar real-world situations, contextualized physics problems act as a bridge between physics theory and practice, and encourage students to explain and justify their thought processes as compared to merely recalling methods of analytical problem solving. This approach encourages higher-order analysis and interpretation, and problem-solving skills in realistic contexts, but the research also shows that care needs to be taken in creating the context. However, the usefulness of tasks may decrease if they become unnecessarily complicated or detailed, especially in more abstract branches of physics.

Ultimately, the consensus appears to be that making physics instruction contextualized is a constructive approach for improving student performance and student perception, making physics more meaningful and more intuitive for students and improving their learning. In the same breath, the variability in findings and the reported challenges underscore the argument for careful and judicious application. This suggests that integrating real-world context in physics courses is likely helpful and points to further refinements of instructional strategies using such context.

5.2 Comparison with Previous Findings

The student perception results were also consistent with the previous finding that context-based teaching increases motivation, engagement and perceived relevance. The Likert scale results overall showed a positive perception, with a mean above the mid-point. In addition, the multiple choice results showed that an important number of students felt that real-life context helped them to understand physical laws, made physics more motivating and improved their attitude toward physics. These results are in accordance with Musa et al. who found that context-based learning increased achievement, interest and retention rates. These results are also in accordance with Affriyenni et al., Assefa, and Eshetu et al. who also found positive educational effects of applying real-world contexts to the teaching of scientific concepts. Furthermore, the results also suggest that the use of context-based physics problems may have both cognitive and affective effects on students, encouraging them to think about the concepts and providing a feeling of meaning.

The current research findings also agree with Tural's study in terms of students' attitude scores. Students who had context-based teaching had a more positive attitude, curiosity, and awareness of the relevance of physics in daily life. However, context-based teaching was not able to increase students' achievement scores in other aspects of the study. Even though the students who participated in the present study displayed an important improvement in achievement, the results of the attitude study are similar to Tural: students found context-based problems more motivating and better for understanding the purpose of teaching physics. Thus, the value of the contextualization of physics teaching should not be evaluated solely based on test scores. Cutrera stated that contextualization is a way to connect abstract knowledge with concrete meaningful situations and support meaning-making and transfer.

The open and multiple-choice data indicated that students believed that contextualized problems helped their physical reasoning and understanding of real processes more than their mathematical reasoning. This is echoing findings by Heck et al., Jochen et al., Echiburu et al., Hyde, Montecinos et al., and Wee et al. that real-life physics contexts can shift students' engagement from routine calculation to interpretation, evidence-based reasoning, data analysis, and scientific reasoning. Students' responses in the present study also support the contention that solving real-world problems helped the class realize that physics is a way of knowing the world and not just a collection of equations, further strengthening the idea that contextualized physics can contribute to functional scientific literacy.

This confirms the reservations of Ültay, Tuveri et al., Ayvaci et al., Pozas et al., and Wei et al. regarding the disadvantages of adding context: students may find contextualized problems more difficult to solve, because they have to deal with the additional contextual information and with deciding how to use it. Mixed topic-based studies show that realism should not be a goal for all physics problems, but that each problem should be considered with respect to the clarity, cognitive load and conceptual issues.

The study's findings are similar to those previously published, but provide more detail. The introduction of real-life-based physics problems was associated with overall improved performance, and was viewed positively by students with respect to motivations, engagement, relevance and understanding of real-life processes. The effectiveness of context depended on the subject of physics as well as the structure of the problem task. Therefore, while the study supports the use of real-life context in physics education and the design of contextualized problems, the importance of balancing realism and clarity should be stressed.

5.3 Limitations

While the results of this dissertation are meaningful, there are several limitations to these findings.

However, although the sample size would be statistically adequate, the study is limited to only 84 participants in one single educational institution so findings may not generalize well to other student populations; furthermore, since the students had the same educational background, the findings may not generalize well to students with different educational backgrounds or in different educational settings.

Second, the same group of students completed the customary and contextual problem sets on two consecutive days. While this accounted for interstudent variability in performance, it may have contributed to potential testing effects and fatigue. Besides, students in the first and the second test have already experienced administering these types of questions, which might have affected the results of the second test (in case of confounding variables, fatigue, motivation and order effects).

Another limitation is the nature of contextual questions: although they were intended to be similar to standard questions in terms of the physics concepts, they tended to consist of longer scenarios and sometimes required more interpretation from participants. If this is in fact true for some students, it would be unclear whether it is due to poor conceptual understanding, or the problem format.

A limitation to the questionnaire results may also be that Likert-scale items are self-perceptions that may be subject to biases in interpreting the response alternatives. The validity of multiple-choice response scales that have no correct alternative is also based on preference. Thus, one should not read the data as the strongest possible evidence, but as supportive evidence.

The analysis of the open-ended comments was qualitative and thematic in nature. While this technique identifies themes and patterns, it cannot capture the full scope of participant responses and requires researcher interpretation.

In addition, time and task limitations were present. The experiment was only concerned with a small number of contextual problems, and data was gathered for a relatively short period of time. On a larger set of problems, and considering a longer time horizon, better results might be possible.

These limitations do not minimize the importance of the findings described here but provide considerations for interpretation and areas of future research.

5.4 Implications for Teaching

These findings may have a positive impact on the teaching of physics as well. Real-life context within problem-solving tasks may improve students' performance and lead to a more positive view of physics. These results suggest that contextualization may be helpful in promoting understanding by making physics topics more relatable and explicit.

One means of improving on this trend might be the use of contextualized problems, where physical principles are contextualized with more familiar or concrete real-world contexts. Contextualized problems may be able to better promote students' descriptions and applications of their understanding, instead of repetitive applications of memorized laws or formulas, thus improving students' problem solving skills and conceptual understanding.

Second, the problems presented in context appear to be more engaging and motivating for students. The study also indicates that many students find real-world application more interesting and relevant to their lives. Practically, this means context-based tasks may be useful in engaging students who have difficulty relating to abstractions present in most physics problems.

In addition, though the context was generally well-received, some participants reported task statements and supplementary information as longer and more difficult in the contextualized version, highlighting the importance of careful task design. So, contextual problems need both to be authentic representations of real-world problems and to be structured so that students can understand and solve them without overloading their working memory with irrelevant information.

The second finding is that contextualization does not work equally well for all subjects: Within the experiments run, effects were strongest in Astronomy and Energy, and weakest when it came to more abstract subjects such as Thermodynamics and Electromagnetism. This suggests that teachers will need to choose when and how to use contextual approaches for each topic depending on the abstraction involved.

Finally that there were no gender differences in attainment gains suggests that the use of context-sensitive problem solving is appropriate for all students and that context-based teaching, as an inclusive educational approach, can be used to aid the learning of many different students without concern about any negative impact.

These findings indicate that using context in physics problems can improve learning and motivation, but careful consideration should be given to matching context and difficulty of the task used to achieve the desired learning outcomes.

6. Conclusion

The aim of this thesis was to investigate the effect of using contextualized physics problems on students' learning outcomes and their perception of physics. The results of this thesis indicated that the use of context in a problem is helpful for students' learning outcomes and perceptions. Analysis of the data quantitatively found that students performed considerably better on problems that required contextual reasoning than on problems that required abstract reasoning, with a moderate to large effect size, indicating the improvement was not only statistically important. Furthermore, the effect was found to hold across the majority of students, rather than only the high achieving students or those that were likely to be successful, indicating all students benefitted from the treatment.

Furthermore, the absence of such differences strengthens the case for the applicability of contextualized problem solving to all students. It suggests that the use of real-world contexts may be helpful for all students, regardless of gender, in their mathematics classes. Importantly then, the implication for educational practice is that contextualization does not need to result in unequal outcomes for subgroups of students.

At the same time the analysis showed an uneven effect of the different domains of physics on the learning effects of contextual problems. Astronomy and Energy for example seemed to profit most from the use of contextual problem because theory and application are more closely linked. For the more abstract topics like Thermodynamics and Electromagnetism the found effects were weak or even negative. This suggests that there are factors about the mathematical content itself and how well it fits into authentic contexts that affect the potential effectiveness of contextualization. In this regard, it is important for problems using this type of contextualization to be similar to the characteristics of these mathematical topic areas.

Beyond the survey data, both the Likert-scale data and the qualitative data supported the value of contextualized education. Student responses generally revealed that students found contextual problems to be more engaging, relevant, and helpful in learning physics. The fact that the ratings have been consistently reliable is evidence that these perceptions have validity. Evidence also exists from qualitative data collected on the multiple-choice and open-response items to suggest that students believe that tasks in context help them understand the learning goals and the applicability of theory. In addition, there is a suggestion that contextualization has a positive effect on students' attitudes.

Another finding was that contextualized problem solving was more difficult for some students due to the longer problem statement and comprehension of additional information, which means that other studies show there is a risk of cognitive overload for contextualized problems. Thus, this theory suggests that the success of contextualization as an instructional strategy is further dependent upon the clarity, structure, and balance of the task that is contextualized.

Overall, this dissertation has demonstrated that connecting physics problems to a context enables a bridging of the gap between knowledge of physics concepts, and the application of that knowledge. Connecting physics concepts with the real world enables the students to better learn physics and also comprehend its relevance for their everyday lives. The study also suggests that the design of the tasks and their alignment to other content is important for deriving the greatest benefits from this approach.

Ultimately, the present study adds to the growing body of evidence as to the efficacy of context in science education by showing the impact of context on student performance and perception, and the factors underlining this impact. Perhaps of greatest interest for teachers is the important role of real-life context in making physics more accessible to students, as well as more meaningful and interesting.

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8. Appendices

Appendix A: Set of contextual problems used for this research

Conservation of Energy

A Option: ☑

Sayano-Shushenskaya Hydroelectric Power Station:

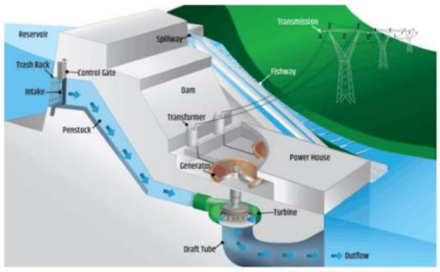
At the Sayano-Shushenskaya Hydroelectric Power Station in Russia — one of the largest in the world — the energy of falling water is converted into electricity through a multi-stage process. Water stored at a height gains potential energy, which transforms into kinetic energy as it falls. This kinetic energy rotates a massive Francis turbine runner, producing rotational energy, which is then converted into electrical energy by a generator. At each stage, some energy is lost due to mechanical and thermal inefficiencies.

Formulas:

$$\eta = \frac{E(output)}{E(input)} * 100\%$$ *- Efficiency*

$$I = \frac{m*R^2}{2}$$ *- Moment of Inertia*

$$E(r) = \frac{I*w^2}{2}$$ *- Rotational Kinetic Energy*



Problem Statement:

At this facility, water falls from a height of approximately 194 meters. Every second, about 376,000 kg of water strikes the turbine blades. The efficiency of the water intake system is 95%, the turbine operates at 96% efficiency, and the generator at 98% efficiency. The turbine runner can be modeled as a solid disk with a mass of 145,000 kg and a diameter of 6.84 meters. Assume gravitational acceleration is 9.81 m/s².

Calculate:

1. ***The linear velocity of water just before it reaches the turbine.***
2. ***The moment of inertia of the turbine runner.***
3. ***The angular velocity of the turbine shaft.***
4. ***The electrical power output generated per second.***

Electromagnetism

A Option: ☑

How Do Wind Turbines Turn Wind into Electricity? [1]

On the coast of Denmark, in the city of Esbjerg, stands the giant wind turbine Siemens Gamesa SG 14-222 DD. Its blades sweep through the air, spinning the rotor—an enormous part of the system that transfers motion to the generator. But how does this movement turn into electricity?

The principle behind it is electromagnetic induction - a phenomenon that allows mechanical energy to be converted into electrical energy. Inside the generator, there are powerful permanent magnets that create a magnetic field. Thousands of copper wire coils are placed within this field. As the rotor spins, the magnetic field cuts through these coils, inducing an electric current. The faster the rotation and the stronger the magnetic field, the more electricity is generated.

But how much exactly?

Problem Statement:

The rotor, with a diameter of 222 meters, spins due to wind at a speed of 12 rotations per minute (0.2 Hz). Inside the generator, each coil unit consists of 300 turns, and the area of each turn is 0.5 m^2. The magnetic field, created by permanent magnets, has an induction of 0.9 T. Each coil unit is connected to an external load with a resistance of 0.5 Ω. The generator contains 500 such identical coil units arranged in a balanced three-phase system. Assume that the magnetic flux through each coil varies sinusoidally and that all coil units operate identically and synchronously.

Formulas:

$$\varepsilon_{max} = NBA * \omega \text{ – Electro-Motive Force}$$

$$\varepsilon_{rms} = \frac{\varepsilon_{max}}{\sqrt{2}} \text{ – Root Mean Square value of EMF}$$

Calculate:

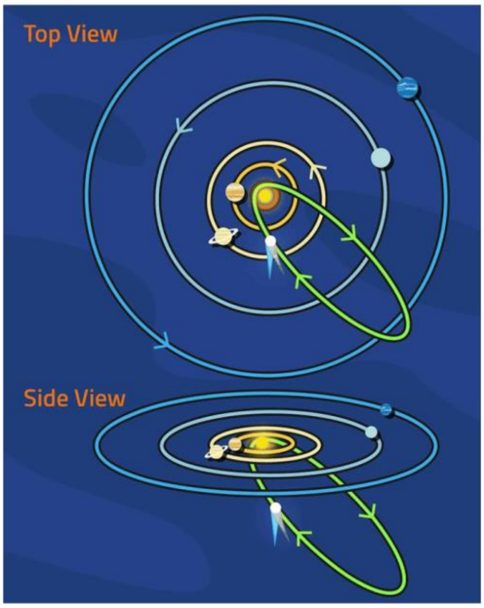
1. ***Determine the maximum induced EMF in the generator (per coil unit).***
2. ***Find the root mean square (RMS) value of the EMF.***
3. ***Calculate the average power dissipated in the load per unit.***
4. ***Calculate the total power.***
5. ***Determine the amount of electrical energy generated by the turbine in 1 hour of operation.***

Astronomy

B Option: ☑

Orbital Period of the Comet:

Comets are icy bodies that travel in highly elongated orbits around the Sun. Some of them return after hundreds or thousands of years, while others may never return at all. One such comet is Hyakutake (C/1996 B2), which passed close to Earth in 1996 and attracted great interest from astronomers. However, its orbital period is so long that humanity is unlikely to see it again in the near future.



Formulas:

$$F = G\frac{M * m}{r^2}$$ – *Newton's Universal Law*

$$T = 2\pi\sqrt{\frac{a^3}{GM}}$$ – *Kepler's Law*

- T – orbital period (s)
- a – semi-major axis (m)
- G - gravitational constant ($m^3/kg \cdot s^2$)
- M – mass of the center body (kg)

Problem Statement:

Comet Hyakutake moves in an elliptical orbit around the Sun. The mass of the Sun is 1.989×10^{30} kg. At its closest approach to the Sun, the distance from the comet to the center of the star is 3.44×10^{10} m. The semi-major axis of its orbit is approximately 0.9×10^{14} m. The gravitational constant is given as 6.674×10^{-11} $m^3/(kg \cdot s^2)$.

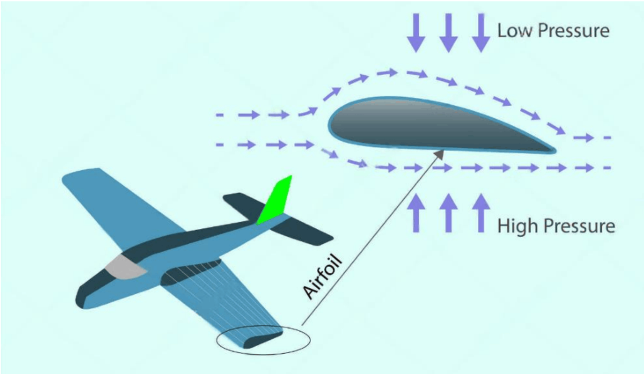
Calculate:

1. ***Determine the speed of the comet at this point in its orbit.***
   Hint: Use Newton's universal law of gravitation and 2nd law of motion.
2. ***Find its orbital period around the Sun.***

Thermodynamics

A Option: ☑

The Boeing 787 Dreamliner – Lift Generation:



The Boeing 787 Dreamliner is a modern passenger aircraft designed for high fuel efficiency and aerodynamic optimization. One of its key features is its curved wing design, which allows it to generate the necessary lift even at high altitudes. During flight, air flows around the wing at different speeds: the air above the wing moves faster, while the air below moves relatively slower. This difference in velocity creates a pressure difference, which in turn generates the lift force needed to keep the aircraft airborne. While real-world aerodynamics involves numerous complex factors such as turbulence, viscosity, and compressibility, this problem considers a simplified model based on fundamental aerodynamic principles for clarity and educational purposes.

Formulas:

$$P + \frac{\rho V^2}{2} + \rho g h = const$$ – ***Bernoulli's Equation***

$$\rho = \frac{P}{RT}$$ – ***Air Density***

- R – Specific gas constant (J/kg·K)

Problem Statement:

The aircraft is flying at an altitude of 10,000 m with an airspeed of 254 m/s. The atmospheric pressure at this altitude is 26,500 Pa, and the temperature is 223 K. The specific gas constant for air is 287 J/(kg·K). The airflow above the wing is 16 m/s faster than the aircraft's speed, while the airflow below the wing is 4 m/s slower. The surface area of the wing is 325 m².

Calculate:

1. ***The air density.***
2. ***The pressure difference between upper and lower sides of the wings.***
3. ***The lift force acting on the wings.***

Waves and Oscillations

A Option: ☑

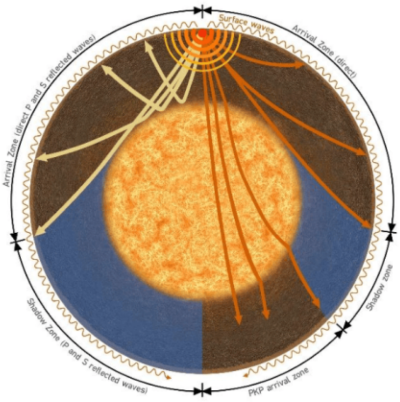
How is distance of earthquake epicentre calculated?

On January 23, 2024, an earthquake occurred in the Almaty region. The ground tremors were felt throughout the city. Seismologists reported that the earthquake originated deep underground, likely in the lower part of the Earth's crust. The exact distance to the epicenter was determined using the time delay between the arrival of primary (P) and secondary (S) seismic waves at a seismic station in Almaty.

It is known that:

- P-waves (primary waves) are longitudinal and travel faster.
- S-waves (secondary waves) are transverse and arrive later because they travel more slowly.

The speeds of these waves depend on the elastic properties of the material they pass through and are given by the following formulas:



$$\boldsymbol{V(p)} = \sqrt{\frac{K + \frac{4}{3}\mu}{\rho}}$$ ***- Speed of P-waves***

$$\boldsymbol{V(s)} = \sqrt{\frac{\mu}{\rho}}$$ ***- Speed of S-waves***

K - bulk modulus (Pa)
μ - shear modulus (Pa)
ρ - density of the material (kg/m³)

Problem Statement:

The rock through which the seismic waves travel has a shear modulus of 3.3×10^{10} pascals and a bulk modulus of 5.0×10^{10} pascals. Its density is given as 2700 kg/m³. At the seismic station, the recorded time difference between the arrivals of the secondary (S) wave and the primary (P) wave is 31 seconds.

Calculate:

1. ***The speeds of P-waves and S-waves using new formulas.***
2. ***The distance of the point of rupture (the epicentre).***