PROJECT BASED PHYSICS TEACHING IN DEVELOPING AWARENESS ON SUSTAINABLE DEVELOPMENT GOALS AMONG 8TH STANDARD STUDENTS

RENITTA.S

24PED011

UNDER THE GUIDANCE OF

Dr. H. INDU

A THESIS SUMBITTED TO

AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND

HIGHER EDUCATION FOR WOMEN

COIMBATORE-641043

In Partial Fulfilment of the Requirements for the Degree of

MASTER OF EDUCATION

APRIL 2026

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CERTIFIED AS BONAFIDE RESEARCH WORK

17/4/26
Signature of the Guide

17/4/2026
Signature of the Head of Department

17/4/26
Signature of the Dean

Declaration

DECLARATION

I, **RENITTA S**, hereby declare that the thesis entitled " **Project based Physics teaching in developing awareness on Sustainable Development Goals among 8th standard students**" submitted to Avinashilingam Institute for Home Science and a Higher Education for Women, Coimbatore, in partial fulfillment of the requirements for the award of the Degree of Master of Education, is a record of original and independent research work done by me during the period under the supervision and guidance of **Dr. H. INDU**, Assistant Professor (SG), Department of Education Professor, Department of Education, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, and it has not formed the basis for the award of any Degree/ Diploma/ Associateship/ Fellowship or other similar title to any candidate of this or any other University.

17/4/26

Signature of the Student

17/4/26

Signature of the Guide

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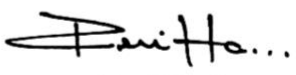

Renitta. S

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Introduction

Chapter 1

Introduction

Sustainable development is one of the foremost global priorities in the twenty-first century. Education plays a vital role in achieving these global objectives. Integrating the sustainability concepts such as Sustainable Development Goals (SDG) among the school students can help them develop knowledge, attitudes and skills related to sustainability. Among various scientific disciplines, physics education connects fundamental concepts with the real environmental and technological issues. Because of the rapid industrialization, population growth and unsustainable usage of resource have caused various damage to the Mother Earth. Switching over to sustainability is only possible way to protect the Mother Earth. In the recent decade there has been some interest towards the sustainability like, the Sustainable Development Goals, proposed by the United Nations which seek to ensure environmental sustainability while advancing social and economic welfare. Objectives such as climate action, life below water and life on land directly embody humanities' duty to protect Mother Earth. Protecting Mother Earth demands collective effort as individual, community, national and global scale. Education, policy reform, technological advancement and community engagement are essential in promoting environmental stewardship. To attain these, education can be used as a key driver focusing the school students especially the middle school students. Integration of sustainability concept into the school subjects is necessary to create the awareness among the students. Among the subjects it is very much easier to integrate the sustainability concept with science, and that too in physics. The concepts like energy, electricity, sound helps with the energy resource management, environmental protection and sustainable technological development. Many sustainability problems are directly linked to physics concepts like renewable energy, energy efficiency, noise pollution and the like. Physics helps the student to understand real world technological and environmental problems. Teaching physics concepts through Project-based Learning could be an effective way for implementation of sustainability concepts. Project-based Learning is a learner centered approach. Project-based Learning encourages active learning, inquiry, collaboration, and students learn by investigating the real world problems and by creating practical solution.

The present generation is navigating a world that is progressively becoming complex. The recent decades made the mankind to look for what they have done the Mother Earth. Mother Earth symbolises the interconnected system of land, water, air, biodiversity and human

existence that supports all living beings. Through various cultures and civilisations, Earth has been perceived not just a physical planet but as a life-sustaining entity that nurtures and upholds ecological equilibrium. Nevertheless, rapid industrialisation, urban expansion, excessive resource consumption and environmental deterioration have increasingly disturbed this balance. Sustainability arises as a solution to this ecological emergency. It focuses on the fulfilling current needs without compromising the capacity of the future generations to satisfy their own requirements. This concept combines Environmental Protection, social justice and economic growth as interdependent foundations. Therefore, safeguarding Mother Earth necessitates responsible resource management, pollution reduction, biodiversity conservation and the promotion of sustainable living practices. In recent years, the global acknowledgements of environmental issues such as climate change, deforestation, biodiversity decline and water scarcity has grown stronger. International initiatives spearheaded by **United Nations** have led to global frameworks like **Sustainable Development Goals**, which seek to ensure environmental sustainability while advancing social and economic welfare. Objectives such as climate action, life below water and life on land directly embody humanities's duty to protect Mother Earth. Protecting Mother Earth demands collective effort as individual, community, national and global scale. Education, policy reform, technological advancement and community engagement are essential in promoting environmental stewardship.

1.1 Sustainable Development Goals:

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. The 17 SDGs are integrated—they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability (Sustainable Development Goals, n.d.) The world is now past the halfway point to achieving the Sustainable Development Goals (SDGs), the world's 17-point plan to radically improve the lives of people and the planet by 2030. But with just six years to go and only 15 per cent of the SDGs on track to be achieved, there is much that remains to be done for children. Climate change, poverty, deepening inequalities and intensifying conflict are cutting children off from their chance to thrive. If the actions are not taken now, there are risk of losing millions of lives to easily preventable causes like disease, poor nutrition and unsafe environments (UNICEF, 2023). The 17 goals quoted by United Nations are SDG 1 : No Poverty, SDG 2: Zero hunger, SDG 3: Good health and well being, SDG 4: Quality education, SDG 5: Gender equality, SDG 6: Clean water and sanitation,

SDG 7: Affordable and clean energy , SDG 8: Decent work and economic growth , SDG 9: Industry, innovation and infrastructure , ,SDG 10: Reduced inequalities, SDG 11: Sustainable cities and communities ,SDG 12: Responsible consumption and production , SDG 13: Climate action, SDG 14: Life below water, SDG 15: Life on land, SDG 16: Peace, justice, and strong institutions, and SDG 17: Partnerships for the goal

SDG 1: No poverty

Global efforts to eradicate extreme poverty have faced significant setbacks by the COVID-19 pandemic and a series of major shocks during 2020-22. The pandemic caused extreme poverty to increase in 2020 for the first time in decades, reversing global progress by three years. Recovery has been uneven, with low-income countries lagging behind. With the ongoing poly-crisis, ending poverty by 2030 appears increasingly out of reach, particularly in regions that lack the fiscal capacity to cope with economic stresses.

SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year Round. By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.

SDG 3: Ensure healthy lives and promote well-being for all at all ages

Sustainable Development Goal 3 (SDG 3) aims to ensure healthy lives and promote well-being for all at all ages. It focuses on reducing global maternal mortality, ending epidemics of communicable diseases (like AIDS, tuberculosis, and malaria), reducing non-communicable diseases, promoting mental health, and ensuring universal access to healthcare services, including reproductive, maternal, and child health. SDG 3 also emphasizes the importance of universal health coverage, access to safe and affordable medicines and vaccines, and strengthening health systems and emergency preparedness.

SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Sustainable Development Goal 4 (SDG 4) aims to ensure inclusive, equitable, and quality education for all by 2030. It focuses on providing free primary and secondary education, equal

access to early childhood and higher education, improving skills for employment, eliminating discrimination, and promoting lifelong learning. Despite progress, challenges like poor learning outcomes, teacher shortages, and inequalities remain, worsened by the COVID-19 pandemic. Achieving SDG 4 is vital for overall sustainable development and requires increased investment, better data, and targeted support for vulnerable groups.

SDG 5: Achieve gender equality and empower all women and girls

Sustainable Development Goal 5 (SDG 5) aims to achieve gender equality and empower all women and girls by 2030. It focuses on ending all forms of discrimination and violence against women and girls, eliminating harmful practices like child marriage and female genital mutilation, recognizing and valuing unpaid care work, ensuring women's full participation in leadership and decision-making, and guaranteeing access to reproductive rights and health. The goal also promotes women's equal rights to economic resources, technology, and legal protections. Despite progress, challenges remain, including increased domestic violence and economic impacts exacerbated by the COVID-19 pandemic. SDG 5 is essential for social justice and sustainable development worldwide.

SDG 6: Ensure availability and sustainable management of water and sanitation for all

Sustainable Development Goal 6 (SDG 6) aims to ensure availability and sustainable management of water and sanitation for all by 2030. It focuses on universal access to safe and affordable drinking water, adequate sanitation and hygiene, and ending open defecation, with special attention to women, girls, and vulnerable groups. SDG 6 also targets improving water quality by reducing pollution and untreated wastewater, increasing water-use efficiency, protecting and restoring water-related ecosystems, and implementing integrated water resources management. Achieving these targets is critical for human health, economic development, and ecosystem sustainability, especially as water scarcity and pollution threaten billions globally. Progress is measured through 11 indicators covering access, quality, efficiency, and ecosystem health.

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

SDG 7 aims to ensure universal access to affordable, reliable, and modern energy services by 2030. It emphasizes increasing the share of renewable energy sources like solar, wind, and hydropower to reduce carbon emissions. Improving energy efficiency in industries, buildings, and transportation is a key target. Expanding infrastructure and technology for clean energy in

developing countries is critical. Access to electricity supports education, healthcare, and economic development. Despite progress, around 770 million people still lack electricity, mostly in sub-Saharan Africa and South Asia. The goal also promotes research and investment in clean energy technologies. Achieving SDG 7 helps combat climate change and fosters sustainable growth. Partnerships between governments, private sector, and communities are essential. Monitoring progress involves tracking energy access, renewable energy use, and efficiency improvements.

SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

SDG 8 promotes sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all. It targets increasing economic productivity through diversification and innovation. The goal stresses reducing youth unemployment and ensuring safe working environments. Promoting entrepreneurship and supporting small and medium enterprises (SMEs) are vital. It also calls for the eradication of forced labour, child labour, and human trafficking. Economic growth should be inclusive, benefiting all segments of society and reducing inequalities.

SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

SDG 9 focuses on building resilient infrastructure, promoting sustainable industrialization, and fostering innovation. The goal encourages upgrading industries to be more sustainable and resource-efficient. Innovation and technology development drive productivity and competitiveness. Investments in infrastructure include transportation, energy, and digital connectivity. The goal also promotes research and development (R&D) and technological capabilities in developing countries. Strengthening infrastructure and innovation creates jobs and improves quality of life. Monitoring includes industrial value added, R&D spending, and infrastructure access.

SDG 10: Reduce inequality within and among countries

SDG 10 aims to reduce inequality within and among countries by promoting social, economic, and political inclusion. It targets empowering marginalized and vulnerable groups, including migrants, refugees, persons with disabilities, and minorities. It supports social protection systems to lift people out of poverty. International cooperation is encouraged to facilitate safe

migration and remittances. Reducing discrimination based on age, gender, ethnicity, or disability is essential.

SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable

SDG 11 seeks to make cities and human settlements inclusive, safe, resilient, and sustainable. It addresses urban challenges like housing shortages, slums, and inadequate infrastructure. The goal promotes affordable and adequate housing for all, especially vulnerable populations. Sustainable transport systems, including public transit, reduce pollution and traffic congestion. Cities should improve air quality and reduce waste generation. Disaster risk reduction and resilience-building are key to protecting urban populations. Green public spaces and cultural heritage preservation enhance quality of life. Rapid urbanization requires integrated urban planning and management. The goal supports access to safe and inclusive public spaces for all ages and genders. Progress is measured by access to housing, transport, air quality, and disaster resilience.

SDG 12: Ensure sustainable consumption and production patterns

SDG 12 promotes sustainable consumption and production patterns to reduce environmental impact. It encourages efficient use of natural resources and energy across supply chains. Reducing waste generation through prevention, recycling, and reuse is a priority. The goal supports sustainable business practices and corporate responsibility. It aims to reduce food loss and waste at production and consumer levels. Governments are encouraged to implement policies that promote sustainable procurement. The goal also targets reducing harmful chemicals and waste discharge. Sustainable consumption helps conserve biodiversity and reduce pollution. Progress is monitored through resource efficiency, waste generation, and sustainable procurement indicators.

SDG 13: Take urgent action to combat climate change and its impacts

SDG 13 calls for urgent action to combat climate change and its impacts. It emphasizes strengthening resilience and adaptive capacity to climate-related hazards and natural disasters. Reducing greenhouse gas emissions through clean energy and sustainable practices is critical. It supports climate finance to help developing countries mitigate and adapt. Enhancing education, awareness, and institutional capacity on climate issues is necessary. The goal encourages international cooperation for technology transfer and capacity-building. Climate

change threatens ecosystems, food security, and human health globally. Progress is tracked by emission levels, adaptation measures, and climate finance flows.

SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

SDG 14 aims to conserve and sustainably use the oceans, seas, and marine resources. It targets reducing marine pollution, especially from land-based activities like plastics and chemicals. Sustainable management of fisheries is essential to prevent overfishing and protect marine biodiversity. The goal supports protecting marine ecosystems such as coral reefs and mangroves. It calls for regulating harvesting and ending subsidies that contribute to overcapacity. Enhancing scientific knowledge and research on oceans helps improve conservation efforts. The goal promotes international laws and agreements for ocean governance. Healthy oceans contribute to climate regulation and livelihoods for millions. SDG 14 also encourages sustainable tourism and marine resource use. Progress is monitored through marine protected areas, pollution levels, and fish stock status.

SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

SDG 15 focuses on protecting, restoring, and promoting sustainable use of terrestrial ecosystems. It targets halting deforestation, land degradation, and biodiversity loss. Sustainable forest management supports livelihoods and combats climate change. The goal calls for combating desertification and restoring degraded land and soil. Protecting endangered species and conserving biodiversity hotspots is vital. It promotes integrating ecosystem and biodiversity values into national planning. The goal supports reducing poaching and trafficking of protected species. Sustainable agriculture practices help maintain soil health and biodiversity. Community participation and indigenous knowledge are important for conservation. Progress is tracked by forest area, species extinction rates, and land degradation indicators.

SDG 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

SDG 16 aims to promote peaceful, just, and inclusive societies free from violence and

corruption. It supports access to justice for all and building accountable, transparent institutions. The goal targets reducing all forms of violence, including crime, trafficking, and abuse. It encourages inclusive decision-making and participation in governance. The goal promotes reducing corruption and bribery in public institutions. Access to legal identity and birth registration is also a target. Peaceful societies enable sustainable development and economic growth. Progress is measured by violence rates, justice access, and governance indicators.

SDG 17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development Finance

SDG 17 focuses on strengthening global partnerships to achieve all SDGs. It promotes mobilizing financial resources, including official development assistance and private investment. The goal encourages technology transfer, innovation, and capacity-building in developing countries. The goal supports policy coherence and international cooperation. Strengthening global macroeconomic stability benefits all countries. SDG 17 recognizes that achieving the SDGs requires collective action and shared responsibility. Progress is tracked through finance flows, technology access, trade, and data availability.

The SDGs selected in this investigation are SDG 3,7,9,11, and 13 as these SDGs are connected more to the physics content at middle school level.

1.2 Project-Based Learning:

Project-based learning (also known as PBL) is a teaching strategy that focuses on real-world problems and challenges using problem-solving, decision-making and investigative skills. It is increasingly being used across disciplines because of its capacity to engage students in developing self-directed learning skills. Projects range in scale and type. It can be focused on academic, personal or industry problems and involve external stakeholders such as clients or partners (Thomas, 2000). Project-based learning is a student-cantered methodology that engages students in developing critical thinking through undertaking authentic, meaningful projects (The University of Queensland, 2021). Project-Based Learning adopts the basic principles of constructivism. Specifically, students are encouraged to investigate real-world problems by setting goals, conducting research and working collaboratively. Unlike traditional learning methods, project-based learning emphasizes the active learning through investigation, collaboration and reflection. This, goal setting, active learning, communication and

collaboration, sharing of knowledge and reflection are the basics elements of project-based learning (Chiou, 2025).

1.3 SDG and Project-Based Learning:

The United Nations Sustainable Development Goals are designed to address global challenges, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. The Goals interconnect and leave no one behind. The world in which students live is ever more globally connected. These goals can help students relate to their world thinking locally, nationally, and globally. It is important for the students to understand what is happening around them before they can think bigger in terms of national and global connections. Using the Gold Standard PROJECT-BASED LEARNING model from the Buck Institute as a framework for pedagogical consideration of the UN Sustainability Goals.

Connecting the UN Sustainability Goals and Gold Standard PROJECT-BASED LEARNING:

- *Authenticity:* The sustainability goals connect to every student's future. Depending on age and experience, these goals can connect to a student's personal life and/or be adapted to national and global ideas encouraging students to apply knowledge and skills to extend their thinking.
- *Challenging Problem:* The U.N Sustainability Goals provide challenging issues that the people of the world will need to deal with in the coming decade. These problems cut across a variety of academic disciplines with areas of concern including Earth Systems, Human Activities, and the Earth, Poverty, Health, Equality, Economics, and Food Security.
- *Sustained Inquiry:* Regardless of the sustainability goal addressed, students will need to engage in the asking of questions and the defining of problems. This activity will require students to conduct research in a variety of ways which will lead to more questions. The information gathered will help to decide on potential solutions to problems and the application of knowledge and information.
- *Critique and Revision:* As part of the potential solution process, students will give and receive feedback to/from peers, group members, and teachers. They will apply these ideas to improve processes and products.
- *Reflection:* Throughout all aspects of the learning experiences students will need to reflect on their audience, the problem/project, processes, potential solutions, and the strategies and potential issues throughout the experience.

- *Student Voice and Choice:* As the students work through a performance task associated with a sustainability goal the students may be given choices related to the project, processes, solution, and how they create the solution. The teacher determines which choices to provide for the students and how much voice they have in the decision-making process. This may be determined based on student experience and knowledge.
- *Public Product*: The importance of the student's work for their own learning and for the many benefits beyond the classroom, students should have the opportunity to share their work with a public audience. This audience may be in the form of local, national, or international stakeholders. If this is not possible, other students and/or classrooms may serve as the public helping to provide meaning and appreciation for what the students have accomplished. Educators and educational leaders can connect the U.N Sustainability Goals to the classroom curriculum through the determination of the *Key Knowledge* that students will need to begin solving the challenge associated with the goal. Providing authentic learning experiences through the sustainability goals gives students opportunities for the transfer of knowledge and application of content and skills (*PROJECT-BASED LEARNING and the U.N. Sustainable Development Goals*, 2025).

1.4 Statement of the problem:

It is necessary for everyone to understand how to protect the environment and these practices should be cultivated from the young age. Hence the middle school students are an apt age group who can easily grasp the significance of sustainability. This sustainability concept related to Sustainable Development Goals can be taught through interactive activities. Here comes the importance of project-based learning, which could serve as an effective pedagogical approach to help the middle school students understand SDGs through physics. This idea led the investigator to choose a topic related to SDGs. Hence there is a need to access the awareness level of the middle school students on SDG and for these appropriate tools need to be constructed. Thus, the problem statement is "Project-based Physics teaching in developing awareness on Sustainable Development Goals among 8th standard students".

1.5 Operational definition of terms

Project-based learning:

Project-based Learning is a dynamic educational strategy which is student-centred. This pedagogical approach prioritizes the student, allowing individuals to acquire knowledge

and skills through prolonged engagement in the exploration and resolution of authentic problems, inquiries, or challenges. In this study simple physics projects were done in the class to make the middle school students develop awareness on Sustainable Development Goals and apply it in real life situation.

Awareness

Awareness refers to the condition of being knowledgeable and cognizant of a particular subject. Here it refers to knowledge about SDG.

Sustainable Development Goals (SDG):

Sustainable Development Goals are the goals framed by the UNESCO focusing on sustainability. Sustainable Development Goals selected in this study are (SDG3), Affordable and clean energy (SDF7), (SDG9), (SDG11) and Climate action (SDG13).

8^{th} standard students

8^{th} standard students are the students who pursue education after completion of seventh standard in the middle school. In the present study, the 8^{th} standard students are the students who are studying in two private schools in grade 8.

1.6 Need and importance of the study

Sustainability Awareness is an awareness of sustainable phenomena covering environment, social, and economic perspective. Sustainability awareness refers to experience and perception related to faith and action in the sustainable development context (Marcos-Merino et al., 2020). Three indicators of sustainability awareness i.e., sustainability knowingness, attitudes, and behaviour (Gericke et al., 2018).

The middle school phase is a pivotal time in a students' educational journey during which they gain foundational intellectual knowledge, develop personal values, form world views and enhance their critical thinking capabilities. At this stage, students possess the ability to engage in abstract reasoning, make connections between different disciplines and engage with real world problems. This is the right time for the educator to introduce complex global challenges in a meaningful and relevant manner.

Incorporating SDGs into the middle school curriculum, particularly within the physics subject enables students to relate the theoretical knowledge they acquire to global issues such as clean energy (SDG 7), sustainable cities and communities (SDG 11), climate action 2.1.2(SDG13). However, merely presenting and teaching the content once or twice through

lecture method is not sufficient; the choice of teaching methodologies is crucial for fostering a deep understanding of these concepts.

Project-based Learning which is student centered is an emerging powerful pedagogical approach. Engaging in the real-world projects, students simultaneously learn, explore the scientific principles, apply them to solve problems related to sustainable development. In the context of physics education, students can participate in the creative process of designing energy efficient models and investigating renewable energy sources. These hands-on activities not only enhance subject-specific understanding but also develops essential skills such as collaboration and communication.

Integrating SDGs through Project-Based learning in science education, especially at the middle school level can positively influence the connection between physics concepts and sustainability. This integration helps students to develop a genuine understanding of these complex issues and illustrates how well they support student learning.

1.7 Objectives of the study

- To create awareness among the 8th standard students on Sustainable Development Goals through Physics teaching.
- To develop and validate a Project-based Module in Physics on Sustainable Development Goals.
- To construct and validate an awareness scale on Sustainable Development Goals.
- To find out the effectiveness of Project-based Module in physics in enhancing the awareness of the 8th standard students on Sustainable Development Goals.
- To find out if there is any difference in the awareness level of students before and after intervention.
- To compare the awareness of 8th standard students on Sustainable Development Goals based on their gender, educational attainment of parents, interest in subject and access to mobile phone at home.

1.8 Hypotheses formulated for the study

- There is no significant difference in the levels of awareness on SDG among school students before and after intervention.
- There is no significant difference in the scores of pre-test and post-test of the 8th standard students after intervention

- There is no significant difference between the girls and boys in the pre-test and post-test awareness scores on SDG.
- There is no significant difference between the pre awareness and post awareness scores of the 8th standard students with respect to fathers' educational attainment.
- There is no significant difference between the pre awareness and post awareness scores of the 8th standard students on SDG with respect to mothers' educational attainment.
- There is no significant difference between the pre awareness and post awareness scores of the 8th standard students on SDG with respect to interest in science or language subject.
- There is no significant difference between the pre awareness and post awareness scores of the 8th standard students on SDG based on their access to mobile phone at home.

1.9 Limitation of the study:

- The study considered only the Physics content of middle school level 0f Samacheer kalvi text books.
- The study has concentrated only on five SDGs out of the seventeen SDGs.
- The sample has been taken from two schools only and that too private schoos.
- The study focuses only on the middle school students

1.10 Organization of the thesis

The thesis has been organized under five chapters.

Chapter 1: It deals with the introduction of the study, background and rationale of the study, need and importance, problem statement and operational definition of the key terms used in the study, objectives, hypothesis and limitations of the study.

Chapter 2 : Explains the theoretical background of the study and the review of related literature including the studies related to different variables used in the present study.

Chapter 3 : Includes the detailed presentation of the methodology used in the study and the preparation and validation of the tools and conduct of the study.

Chapter 4 : Deals with the statistical analysis and interpretation of the results.

Chapter 5: It clearly explains the major findings of the study, recommendations, educational implications of the study and suggestions for further research. Chapter five is followed by references and appendices.

Review of Related Literature

Chapter 2

Review of Related Literature

Introduction

A literature review is a review of the writings related to a specific topic, theory or research question. The word "literature" refers to "source of information". Review means to make a revision or "look" or "refer again"(Agarwal, A. 1998). They provide insights into the research that has been previously conducted in relation to the concerned topic. This helps to avoid the duplication or repeat the study that already exits, unless there is a reason to carry out.

Among other methods, literature reviews are essential for: (a) identifying what has been written on a subject or topic; (b) determining the extent to which a specific research area reveals any interpretable trends or patterns; (c) aggregating empirical findings related to a narrow research question to support evidence-based practice; (d) generating new frameworks and theories; and (e) identifying topics or questions requiring more investigation (Paré, Trudel, Jaana, & Kitsiou, 2015).

2.1 Theoretical background:

2.1.1 SDG:

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.

2015 Sustainable Development Goals*:*

In 2015, the need for a new agenda (Agenda 2030 for Sustainable Development) was formulated and it was the integration of the Sustainable Development Goals (SDGs), which unite and link goals in the economic, ecological, and social fields. Following consultation processes at national, regional, and global level, the working group finally proposed 17 Sustainable Development Goals in July 2014. The new development goals encompass all aspects of sustainable development and thus place greater emphasis on the ecological component of sustainable development. In addition to 17 Sustainable Development Goals, the

Agenda adopted in 2015 contains 169 sub-goals as well as indicators and reference data (Lazarus Union International, 2022).

The SDGs build on decades of work by countries and the UN, including the UN Department of Economic and Social Affairs

- In June 1992, at the Earth Summit in Rio de Janeiro, Brazil, more than 178 countries adopted Agenda 21, a comprehensive plan of action to build a global partnership for sustainable development to improve human lives and protect the environment.
- Member States unanimously adopted the Millennium Declaration at the Millennium Summit in September 2000 at UN Headquarters in New York. The Summit led to the elaboration of eight Millennium Development Goals (MDGs) to reduce extreme poverty by 2015.
- The Johannesburg Declaration on Sustainable Development and the Plan of Implementation, adopted at the World Summit on Sustainable Development in South Africa in 2002, reaffirmed the global community's commitments to poverty eradication and the environment, and built on Agenda 21 and the Millennium Declaration by including more emphasis on multilateral partnerships.
- At the United Nations Conference on Sustainable Development (Rio+20) in Rio de Janeiro, Brazil, in June 2012, Member States adopted the outcome document "The Future We Want" in which they decided, inter alia, to launch a process to develop a set of SDGs to build upon the MDGs and to establish the UN High-level Political Forum on Sustainable Development. The Rio +20 outcome also contained other measures for implementing sustainable development, including mandates for future programmes of work in development financing, small island developing states and more.
- In 2013, the General Assembly set up a 30-member Open Working Group to develop a proposal on the SDGs.
- In January 2015, the General Assembly began the negotiation process on the post-2015 development agenda. The process culminated in the subsequent adoption of the 2030 Agenda for Sustainable Development, with 17 SDGs at its core, at the UN Sustainable Development Summit in September 2015.
- 2015 was a landmark year for multilateralism and international policy shaping, with the adoption of several major agreements:
    - Sendai Framework for Disaster Risk Reduction (March 2015)
    - Addis Ababa Action Agenda on Financing for Development (July 2015)

- Transforming our world: the 2030 Agenda for Sustainable Development with its 17 SDGs was adopted at the UN Sustainable Development Summit in New York in September 2015. Paris Agreement on Climate Change (December 2015)

Now, the annual High-level Political Forum on Sustainable Development serves as the central UN platform for the follow-up and review of the SDGs.

Today, the Division for Sustainable Development Goals (DSDG) in the United Nations Department of Economic and Social Affairs (UNDESA) provides substantive support and capacity-building for the SDGs and their related thematic issues, including water, energy, climate, oceans, urbanization, transport, science and technology, the Global Sustainable Development Report (GSDR), partnerships and Small Island Developing States. DSDG plays a key role in the evaluation of UN system wide implementation of the 2030 Agenda and on advocacy and outreach activities relating to the SDGs. In order to make the 2030 Agenda a reality, broad ownership of the SDGs must translate into a strong commitment by all stakeholders to implement the global goals. DSDG aims to help facilitate this engagement (United Nations, 2015a).

India and the SDGs:

The Government of India is strongly committed to Agenda 2030, including the Sustainable Development Goals. The prime minister of India in his statement at the Sustainable Development Summit in New York on 25 September 2015 strongly affirmed India's commitment to Agenda 2030 and the SDGs. He drew attention to the fact that we live in "an age of unprecedented prosperity, but also unspeakable deprivation around the world" and pointed out that "much of India's development agenda is mirrored in the Sustainable Development Goals". Further, he has reiterated the importance of the SDGs at Global level, such as at G-20 meetings. The Parliament of India has taken exemplary initiatives to propel the SDG agenda forward. The Speaker of the Lok Sabha, the Lower House of the Parliament of India, has organized briefing sessions on the SDGs for the Members of Parliament, including bringing together legislators from South Asia and other BRICS nations to collectively work towards the realization of these goals. India has provided strong endorsement to the SDGs, giving a considerable fillip to Agenda 2030.

It is widely agreed that India will play a leading role in determining the relative success or failure of the SDGs, as it is the second most populous country in the world. India is already taking significant strides towards the attainment of SDGs. India's National Development

Agenda outlines the measures the Government is taking on issues like poverty, sustainable growth, health, nutrition, gender equality and quality education, among several others.

The key actions undertaken so far by key entities responsible for spearheading the work on SDGs include:

NITI Aayog: NITI Aayog is mandated with the task of coordinating work on SDGs by adopting a synergistic approach, involving central ministers, States unions territories (UTs), civil society organizations, academia and business sector to achieve India's SDG targets. A comprehensive mapping of SDG targets with schemes and programms has been developed. This suggests an approach to sustainable development that brings together economic, social and environmental pillars, with a focus on their interlinkages. A series of consultations have been conducted by NITI Aayog with all stakeholders focusing on different goals, capacity building, evaluation framework, sharing of new knowledge and best practices, and progress mapping. So far, 22 such national and regional consultations have happened.

Ministry of Statistics and Programme Implementation (MoSPI): The Ministry has drafted the National Indicator Framework (NIF) in consultation with Ministries and State/UTs. MoSPI has also been leading discussions at the global level on the indicator framework for the SDGs.

States/UTs: Several States/UTs have mapped State and centrally sponsored schemes vis-a-vis the SDG; and undertaken long term (visioning), medium term (strategy development) and short term (action pan) exercises (NITI Aayog, 2018).

2.1.2 Project-based learning:

Origin and early advancements

The origin of Project-based Learning can be traced as far back as 551 BC. Notably used first in Chinese and Greek philosophy, it was not until 1592 when Project-based Learning was officially documented in the early modern age of education (CODE, 2024). John Amos Comenius, a Czech philosopher and theologian (also referred to as the 'father of modern education'), was a proponent of project-based learning. His belief was that education should be centred around the student, not the teacher and the student should learn through a combination of curiosity, questioning, and active participation.

Following the establishment of Project-based Learning in mainstream education, the contributions of Johann Heinrich Pestalozzi, Friedrich Fröbel, and Henriette Goldschmidt

emerged. Johann Heinrich Pestalozzi, a Swiss educator, advocated for students to confront unfamiliar challenges in their learning processes, thereby fostering a wave of project-based learning environments across Europe and beyond. As a German educator, Friedrich Frobel introduced the term 'kindergarten' to signify that children are unique individuals with varying needs, talents, and learning styles. Henriette Goldschmidt, a German Jewish educator, transformed women's education in Germany and was a passionate supporter of Frobel's educational principles. Shortly thereafter, the pace of new discoveries and theories in project-based learning accelerated significantly. John Dewey posited that active learning would yield superior outcomes for students, not only in terms of learning but also concerning retention and practical application. William Heard Kilpatrick, a protégé of Dewey, formulated the project model in the early 1900s, formally asserting that educators should act more as facilitators than authoritative figures to cultivate a more comprehensive learning atmosphere.

Support for Project-based Learning

Many advocates of Project-based Learning believe that this mode of teaching is a high-engagement method that improves student learning (Krajcik & Blumenfeld, 2006) although research supporting this position is not highly conclusive. The discussion of the effectiveness of Project-based Learning is limited by an inability of practitioners of instructional design to agree on what constitutes evidence of student learning when Project-based Learning is implemented. This problem of defining evidence becomes increasingly difficult when Project-based Learning is implemented outside of math and laboratory sciences where learning is less easy to measure (Thomas, 2000).

Many practitioners of science, technology, engineering, and math (STEM) education are especially enthusiastic supporters of Project-based Learning, where funding grants for Project-based Learning are abundant. Hundreds of grants for secondary STEM classrooms are available to educators (stemgrants.com). The popularity of advocating for funding for STEM classrooms is so high that United States President Barack Obama recently discussed the need to fund STEM in the 2011 State of the Union Address (Obama 2011).

Support for Project-based Learning in STEM fields has led to the coining of the term Project-based Science (PBS). PBS is simply the application of Project-based Learning in a science classroom. In 2006, Krajcik and Blumenfeld conducted a study in which students in urban Detroit and Chicago public middle schools learned science using curriculum that included one or multiple PBS units during the course of study. Pre- and post-tests as well as performance on the Michigan state standardized assessment showed significant improvement in scores by

students who engaged in one PBS unit over students who did not engage in a PBS unit. Students who engaged in multiple PBS units showed significantly better performance than students who engaged in only one PBS unit (Krajcik & Blumenfeld, 2006). Findings like those of Krajcik and Blumenfeld may contribute to the rise in popularity of Project-based Learning in STEM classrooms. However, Project-based Learning should not be considered as a STEM-centric approach to instruction. Project-based Learning can be adapted to fit a variety of curricula due to its ability to holistically address the real-world nature of most projects (Perry, 2020).

A characteristic of Project-based Learning is that it integrates real-world situations into the learning experience. This means that instructors should seek to create an experience that is as authentic as possible for students. For example, an activity that requires students to formulate a business plan for a restaurant should include the requirement to comply with health, fire, and building codes. Some advocates in K-12 education might suggest that the real-world nature of Project-based Learning enhances career readiness in students, but research findings do not strongly support this position. This may be in part due to the difficulty of defining career readiness (Jollands, Jolly, & Molyneaux 153).

2.2 Review of related studies:

2.2.1 Studies on SDG

Jonsson's 2022 article, "The Sustainable Development Goals: A Universalist Promise for the Future," critically examines the United Nations' Sustainable Development Goals (SDGs) through a postcolonial and feminist lens. Published in *Futures*, the paper argues that the SDGs, while presented as a universal framework, are deeply influenced by Global North priorities and neoliberal ideologies. The article highlights the tension between the SDGs' universal aspirations and the realities of their implementation, suggesting that without a more inclusive and context sensitive approach, the SDGs risk reinforcing existing power imbalances and failing to address the unique challenges faced by different communities.

Halkos and Gkampoura's 2021 article, *Where Do We Stand on the 17 Sustainable Development Goals? An Overview on Progress*, published in *Economic Analysis and Policy*, offers a comprehensive literature review and trend analysis of each of the 17 Sustainable Development Goals (SDGs). The authors examine the specific challenges each goal addresses and assess global and regional progress using United Nations data. Their findings indicate that

while some SDGs have seen notable advancements, others lag significantly, particularly in areas such as inequality (SDG 10), climate action (SDG 13), and life on land (SDG 15). The study highlights the uneven progress across different regions and underscores the need for targeted policy interventions to address these disparities. They argue that achieving the 2030 Agenda requires not only tracking progress through robust indicators but also fostering synergies between goals to maximize their collective impact. This analysis provides valuable insights for policymakers and stakeholders aiming to accelerate progress toward sustainable development by identifying priority areas and promoting coordinated efforts across sectors.

Moyer and Hedden's 2020 study, *Are We on the Right Path to Achieve the Sustainable Development Goals?*, published in *World Development*, critically assesses global progress toward the United Nations' Sustainable Development Goals (SDGs) using the International Futures (IFs) integrated assessment model. The authors simulate a "middle-of-the-road" scenario (SSP2) to project outcomes for 186 countries across nine human development-related indicators by 2030. Their findings indicate that, under current policy trajectories, only 53% of the country-indicator combinations are projected to meet SDG targets by 2030, a modest increase from 43% in 2015.

Da Silva-Oliveira, and da Silva Pereira's 2019 article, *"Education for Advancing the Implementation of the Sustainable Development Goals: A Systematic Approach,"* published in *The International Journal of Management Education*, explores the critical role of education in supporting the implementation of the United Nations' Sustainable Development Goals (SDGs). Through a systematic review of 193 academic articles, the authors identify four key thematic areas: indicators, the educational environment, policies related to sustainable education, and the Principles for Responsible Management Education (PRME). The study emphasizes the importance of integrating sustainability into higher education institutions (HEIs), particularly within management education, to prepare future leaders who are capable of addressing global sustainability challenges. By embedding ethics and sustainability principles into curricula, education becomes a transformative force in advancing the SDGs. The authors argue that a structured and strategic approach to education can foster critical thinking, promote responsible decision-making, and significantly contribute to the realization of the 2030 Agenda for Sustainable Development.

Leal Filho et al.'s 2018 paper, "Using the Sustainable Development Goals Towards a Better Understanding of Sustainability Challenges," published in the *International Journal of*

Sustainable Development & World Ecology, offers a comprehensive analysis of the United Nations' 2030 Agenda for Sustainable Development. The authors examine each of the 17 Sustainable Development Goals (SDGs), assessing their potential to address pressing global sustainability challenges. Through three case studies, the paper illustrates practical applications of the SDGs, demonstrating how their implementation can advance equal opportunities and foster economic empowerment. The study concludes that effectively implementing the SDGs can significantly contribute to promoting sustainable development across various regions.

David Le Blanc's 2015 working paper, *Towards Integration at Last? The Sustainable Development Goals as a Network of Targets*, published by the UN Department of Economic and Social Affairs, employs network analysis to assess the interconnectedness of the proposed Sustainable Development Goals (SDGs). Le Blanc's analysis reveals that while certain thematic areas within the SDGs exhibit strong interconnections, others remain more isolated. This structure suggests that the SDGs are more integrated than their predecessors, the Millennium Development Goals (MDGs), potentially facilitating policy coherence across sectors. However, the paper also highlights that many links among goals, particularly those documented in biophysical, economic, and social dimensions, are not explicitly reflected in the SDGs. Le Blanc concludes that achieving effective policy integration will require comprehensive studies of the underlying biophysical, social, and economic systems.

Kates, Parris, and Leiserowitz's seminal 2005 paper, "What is Sustainable Development? Goals, Indicators, Values, and Practice," offers a comprehensive exploration of sustainable development (SD). The authors begin by acknowledging the term's widespread adoption and its inherent ambiguity, noting that SD serves as a flexible framework onto which various institutions and initiatives project their aspirations. They delve into the evolution of SD, tracing its roots from the 1987 Brundtland Commission report, which defined it as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." This definition underscores the intergenerational equity central to SD. The paper further examines the development of SD goals and indicators, highlighting the challenges in creating universally accepted metrics that balance environmental, economic, and social dimensions. The authors emphasize the importance of values such as equity, participation, and justice in guiding SD practices. They also discuss the practical application of SD, noting that while the

concept is widely endorsed, its implementation often encounters difficulties due to varying interpretations and priorities across different contexts. In conclusion, Kates, Parris, and Leiserowitz provide an understanding of sustainable development, emphasizing its complexity and the need for a balanced approach that integrates diverse goals, indicators, and values in practice.

2.2.2 Studies related to Project-based Learning

Desca Saurina, et al. (2025) conducted classroom action research at SDN Palumbosari II to address inadequate student participation and suboptimal learning outcomes in fourth-grade science classes. The study implemented the Project-Based Learning model, which engages students in exploring, interpreting, and evaluating information through hands-on projects. Over two learning cycles, the Project-based Learning model led to notable improvements in both student and teacher activities, with students becoming more active and directly involved in the learning process. The research found that the application of Project-based Learning significantly improved science learning outcomes for class IV A students.

A study by Harahap, Hasibuan, et al. (2025) examined the impact of Project-based Learning on science learning outcomes at Bhayangkari 3 Rantauprapat, a private junior high school. Using an experimental one-group pretest-post test design, the researchers first assessed students' baseline understanding, then implemented Project-based Learning as the primary instructional strategy. Results showed a marked improvement: students' average posttest score rose to 75.00 compared to a pretest average of 67.41, a statistically significant increase confirmed by t-test analysis ($t = 4.216$, $p < 0.05$). The study found that Project-based Learning made students more active and engaged, enabling them to construct understanding collaboratively and individually.

Almulla (2020) investigated the effectiveness Project-based Learning in engaging students in learning. The study addresses concerns that Project-based Learning might promote a technocratic approach to education, rather than being responsive to students' ideas. Data was collected via questionnaires from 124 teachers using Project-based Learning, and analyzed through structural equation modelling (SEM). The findings demonstrate a significant positive relationship between Project-based Learning and collaborative learning, disciplinary subject learning, iterative learning, and authentic learning—all of which contribute to increased student engagement. Almulla concluded that Project-based Learning enhances student

engagement by facilitating knowledge sharing and discussion, recommending its widespread use in educational settings and universities.

Du and Han (2016) provide a literature review on the definition and process of Project-Based Learning, highlighting its growing popularity, especially in second language education. The review outlines that Project-based Learning involves students working over an extended period to investigate and respond to complex questions or challenges, culminating in a public product or presentation. This process not only deepens content knowledge but also develops essential 21st-century skills such as critical thinking, creativity, communication, and collaboration. Teachers act as facilitators, guiding students rather than directly instructing, which encourages autonomy and lifelong learning. Du and Han also discuss the positive influence of Project-based Learning on educational practices, noting that it makes learning more relevant, engaging, and memorable for students. The review aims to support teachers in effectively employing Project-based Learning by summarizing research on its definition, process, and benefits, thus offering practical insights for classroom implementation.

Michael M. Grant (2011) presents a qualitative case study exploring eighth-grade students' perspectives on Project-Based Learning (PBL). The study identifies five key themes: internal and external influences, beliefs about projects, use of technology, and learning outcomes/products. These elements collectively shape students' learning experiences and the quality of their project outcomes. Students reported that PBL increased their engagement, autonomy, and ownership of learning. They valued the authenticity of tasks and connections to personal interests, which boosted motivation and relevance. PBL also enhanced collaboration, communication, and self-efficacy. Students appreciated creating meaningful products that reflected real-world skills. However, some noted less content coverage. Technology and thoughtful project design supported positive experiences. Overall, students saw PBL as building both academic and social-emotional skills.

Blumenfeld, Soloway, et al. (1991) argue that Project-Based Learning is a powerful classroom approach that engages students through the investigation of authentic, real-world problems. The authors highlight that Project-Based Learning sustains motivation and supports learning by placing students in active roles, allowing them to explore problems of personal interest without predefined solutions. Key factors influencing motivation in Project-Based Learning include the authenticity and complexity of tasks, opportunities for student choice and agency, collaboration, and the presence of clear project closure. The article also notes that while Project-Based Learning can foster deep engagement, students and teachers may face challenges

such as managing open-ended tasks and maintaining sustained effort. The role of technology is emphasized as a support for both students and teachers, helping to organize, communicate, and reflect throughout the project process. Ultimately, the authors conclude that well-designed projects, supported by thoughtful scaffolding and relevant technology, can maintain student motivation and promote meaningful learning outcomes

2.2.3 Related studies on SDG awareness:

Padilla, et al., (2025) investigated the awareness and integration of Sustainable Development Goals (SDGs) among senior high school students in a Philippine STEM school using a quantitative descriptive survey. The study assessed students' self-reported SDG knowledge, sources of information, subject-specific SDG coverage, and the impact of SDGs on students' personal lives and career planning. Results show that formal education is the primary source of SDG awareness, but students' understanding of the SDGs' broader temporal and geographic contexts is limited. Subjects such as STEM Research, Social Science, Science Elective, and Science Core demonstrate strong SDG integration, largely due to project-based and inquiry-driven pedagogical approaches, while Mathematics and some language courses show significant gaps in SDG coverage. Path analysis revealed that both students' self-reported knowledge and their information sources significantly influence learning outcomes, engagement, and future career choices. The study found minimal sex-based differences in SDG awareness, likely due to standardized curricular structures ensuring equal access to sustainability education. The authors conclude that to deepen students' understanding and engagement, innovative cross-curricular strategies and enhanced career guidance are needed. They recommend expanding project-based learning and integrating SDGs across all subjects to better align sustainability education with national development frameworks and prepare students for sustainability-oriented careers.

Sharma et al., (2024) conducted an empirical study to assess the level of awareness regarding the Sustainable Development Goals (SDGs) among university students in Northern India. Using a two-stage cluster sampling method, the researchers surveyed 335 participants from four cities, employing a questionnaire that covered all 17 SDGs. The findings revealed that Indian youth had moderate awareness of SDG5 (Gender Equality), SDG6 (Clean Water and Sanitation), SDG7 (Affordable and Clean Energy), SDG9 (Industry, Innovation and Infrastructure), SDG13 (Climate Action), and SDG15 (Life on Land), with mean scores ranging from 3.27 to 3.80. However, awareness was low for SDG10 (Reduced Inequalities),

SDG11 (Sustainable Cities and Communities), SDG16 (Peace, Justice and Strong Institutions), and SDG17 (Partnerships for the Goals), with mean scores below 3.0. The study also found significant gender differences in SDG awareness. Males showed higher awareness for SDG2 (Zero Hunger), SDG3 (Good Health and Well-being), SDG4 (Quality Education), SDG9, SDG14 (Life Below Water), SDG15, and SDG17, while females demonstrated greater awareness for SDG5, SDG6, SDG7, SDG10, SDG11, SDG12 (Responsible Consumption and Production), SDG13, and SDG16. These differences suggest that social structure and gender roles influence SDG awareness among youth. The authors highlight that, despite government initiatives and youth-led programs, there remains a need for targeted educational interventions to raise awareness and promote discussion of SDGs in academic settings. The study underscores the importance of integrating SDG education into curricula to empower youth as active contributors to sustainable development in India.

Yuan, Yu, and Wu (2021) conducted a questionnaire-based study among students at Beijing No. 35 High School to assess their awareness and understanding of the Sustainable Development Goals (SDGs). A study on SDG knowledge among senior high school students in China (n=328) shows limited understanding, with formal education being the primary source, no gender disparities, but differences noted across grades, particularly in Grade 11 where students performed best. There is a strong integration of SDGs in the subjects of biology, geography, and physics, with a focus on priorities such as gender equality, quality education, and health; career aspirations tend to lean towards economic growth and innovation.

Das et al., (2014) study published in the *International Journal of Informative & Futuristic Research* explores the awareness of sustainable development among secondary school students. The research, focusing on 322 students from Bengali medium schools, aimed to determine the extent of their understanding and whether differences existed based on gender or location (urban vs. rural). The study found that there were no significant differences in awareness of sustainable development between boys and girls, or between urban and rural students, as indicated by t-values of 1.043 and 0.927 for gender comparisons in urban and rural areas, respectively, and a t-value of 1.029 for the urban-rural comparison. The authors emphasize the importance of sustainable development awareness due to increasing population density, deforestation, declining social values, unscientific resource use, and a lack of recycling, which collectively threaten ecological balance. These challenges highlight the need

for greater understanding and action to ensure a safe, secure, and sustainable world. However, this study's findings suggest that, at least within the surveyed population, awareness levels are consistent across demographic groups.

2.2.4 Related studies on SDG and Project-based Learning:

Bindu et al., (2024) emphasized that sustainable development is essential for preserving resources for future generations and maintaining ecosystem balance. The authors analyzed the Sustainable Development Goals (SDGs) as a critical global framework for addressing environmental and socioeconomic challenges, detailing both the progress and obstacles in SDG implementation. Key challenges include data deprivation, governance issues, resource constraints, and the complexity of monitoring progress, all of which hinder effective SDG achievement. The authors stress the need for educators to stay updated on industry trends and pedagogical strategies through ongoing professional development. Effective SDG implementation also requires continuous monitoring, baseline assessments, supportive energy policies, investment analysis, regulatory frameworks, and robust public-private partnerships. The study concludes that integrating project-based learning approaches can help achieve interdisciplinary learning goals, foster student engagement, and support the attainment of SDGs by Development (ESD). The study used a one-shot case study design with 37 high school students in East Java, Indonesia, who were divided into five groups to design and implement renewable energy projects focused on solar and wind energy. The RELP was structured over four sessions, beginning with an introduction to renewable energy, its types, and its significance for sustainable development and the Sustainable Development Goals (SDGs). Students then worked collaboratively to conceptualize, design, and build renewable energy projects, receiving guidance from teachers throughout the process. The projects culminated in written reports and group presentations, fostering both communication and critical thinking skills. he study highlights that integrating project-based renewable energy activities in physics not only supports the development of 21stcentury skills but also meaningfully contributes to ESD by providing real-world, STEAM-oriented learning experiences.

Koculu and Topcu (2024) address the gap in curriculum materials for teaching Sustainable Development Goals (SDGs) at the K-12 level by developing and implementing an SDG-focused unit for middle school students. Using a design-based research approach, they created an 8-week "learn–think–act" SDG unit for 20 seventh-grade students enrolled in an

environmental education and climate change elective at a public school in Turkey. The unit aimed to enhance students' understanding of the importance of global resources, the need for their protection, and the students' potential roles in shaping a sustainable future. To evaluate the unit's effectiveness, the researchers conducted semi-structured interviews before and after the intervention, analyzing the data with deductive content analysis. Results demonstrated that the "learn–think–act" approach significantly improved students' SDG knowledge, indicating that structured, action-oriented SDG education can effectively build awareness and understanding among middle schoolers.

Thea Suaco (2024) investigated the integration of Sustainable Development Goals (SDGs) in the secondary science curriculum within the Cordillera Administrative Region in the Philippines. The study employed a concurrent triangulation mixed-method design to assess the extent of SDG incorporation in the curriculum, as well as science teachers' knowledge and attitudes towards SDGs. The research revealed that the Junior High School science curriculum includes SDG-related competencies, with 51.61% focusing on knowledge, 21.29% on values, and 21.19% on skills. The curriculum incorporates social (14 competencies), environmental (25 competencies), and economic (23 competencies) dimensions, indicating an integrated approach to these issues. Additionally, science teachers demonstrated a high level of knowledge (M = 3.10, SD = 0.15) and a very positive attitude (M = 3.46, SD = 0.09) toward SDGs. A weak positive correlation was found between teachers' knowledge and attitude (r =. 37), with a regression test showing a significant correlation (r =. 37, p = 0.03). The study concludes that SDGs serve as a valuable tool for enriching the science curriculum by providing real-world scenarios and life skills, and by offering depth and perspective to scientific lessons.

In their study, Widya Eko Nurazizah et al., (2024) investigated the impact of integrating Sustainable Development Goals (SDGs) into project-based learning (PjBL) on students' sustainability awareness. The research was conducted with 66 senior high school students in Indonesia, divided into control and experimental groups. The intervention centered on biotechnology material and used a quasi-experimental design with pre and post-tests, questionnaires, and classroom observations to assess changes in sustainability knowingness, attitudes, and behaviour, based on the Sustainability Consciousness Questionnaire Short (SCQ-S). Results showed that while pretest differences between groups were not significant, posttest results indicated a significant improvement in the experimental group's sustainability awareness, with an N-Gain score of 0.4869, categorized as medium. Both teachers (93.03%)

and students (90.96%) rated the SDGs-integrated PjBL implementation as excellent. Notably, the greatest gains were observed in the social dimension of sustainability attitudes.

Costa et al. (2023) introduces an interdisciplinary approach rooted in STEM, utilizing hands-on activities related to the physics of sound to enhance awareness of the health impacts of noise pollution among elementary and secondary students. Workshops organized through collaborations between higher education institutions and schools feature experiments on sound intensity and frequency, which bolster teachers' confidence and enhance students' grasp of preventive measures, as indicated by pre- and post-surveys. The results indicate increased motivation, knowledge, and community influence, addressing a gap in the existing literature concerning the connection between sound physics and the Sustainable Development Goals (SDGs). Higher education institutions are pivotal in promoting sustainable practices through continuous partnerships. Looking ahead, there are plans for expanded workshops, partnerships under Erasmus+, and the implementation of noise monitoring policies.

Maria Cristina Costa, et al., (2023) present an interdisciplinary educational approach using the physics of sound to raise awareness for the Sustainable Development Goals (SDGs) through STEM hands-on activities for elementary and secondary students. Their project specifically addresses noise pollution, highlighting its impact on health, well-being, and productivity, and aligns with SDG 3 (good health and well-being) and SDG 4 (quality education)2. The initiative involved workshops and professional development programs for teachers, who then facilitated classroom experiments and sensory activities related to sound phenomena—such as visualizing sound waves with Chladni plates and exploring frequency and hearing limits. The study used a mixed-methods approach, including pre- and post-workshop questionnaires and participant observation, to assess changes in awareness and understanding. Results showed that both teachers and students gained a deeper understanding of the dangers of noise pollution and the importance of preventive measures. The authors emphasize the crucial role of higher education institutions in supporting community engagement, teacher training, and the dissemination of sustainable development practices. The project demonstrates that integrating sound physics into STEM education not only enhances scientific literacy but also promotes active citizenship and sustainable behaviours in the community.

2.2.5 Discussion

The review of related literature was helpful for the investigator for collecting evidences on the past researches done in the field of Sustainable Development Goals, Sustainable Development Goals awareness, project-based learning, Sustainable Development Goals and project-based learning. Regarding the field of Sustainable Development Goals, it was found that many researches has been done on integration and implementation. They highlight the complexity of transformation of global aspirations into outcomes. They speak about the gaps in implementing the Sustainable Development Goals and the need for strong legal framework, integrated policy mechanisms that align with both global ambitions and local realities.

Regarding the field of Project-based learning; it was found that numerous studies highlighted the effectiveness of project-based learning on various educational contexts. It fosters deeper student engagement enhancing educational achievement on various aspects, developing skills like critical thinking, problem solving, creativity, collaboration. It also has various challenges but the evidences shows that project-based learning has the potential for improving science education with thoughtful implementation.

Regarding the field of Sustainable development goal awareness, the evidences shows that there are varied level of understanding of the SDGs among the students at various educational levels and geographical areas. However there are gaps in students comprehension, where they tend to associate SDGs primarily with environmental issues. The evidences shows that there is a need to strengthen education for Sustainable Development Goals, which can be done through integration of curriculum, pedagogies that connects knowledge with real life applications.

2.3 Conclusion

When analysing the studies on SDGs and project-based learning, it was evident that there were minimal number of researches done on integration of SDGs and project-based learning, and even the available studies are done abroad. From the collected evidences it is promising that, to teach Sustainable Development Goals to the middle school students project-based learning strategy could be an effective method. Hence the investigator felt a great need to integrate Sustainable Development Goals with the project-based learning in physics curricula of the middle school students to bridge the gap on the awareness of Sustainable Development Goals among the middle school students.

Methodology

Chapter 3

Methodology

INTRODUCTION:

This chapter outlines the research design, sample, data collection method and data analysis procedures used to explore the integration of Sustainable Development Goals with the educational strategies through Project-based Learning.

3.1 Conceptual Framework of the Study

A well-planned methodology is that it offers the investigator with a scientifically valid and an economically justifiable, acceptable plan for testing the hypothesis and arriving at conclusions. A conceptual framework is a pictorial presentation of the relationship between the variables that was chosen for the study. This conceptual framework gives the relationship and the linkage between the variables used in the study. It shows the diagrammatic representation of the procedure by which the study is progressing (Kumar, 2022).

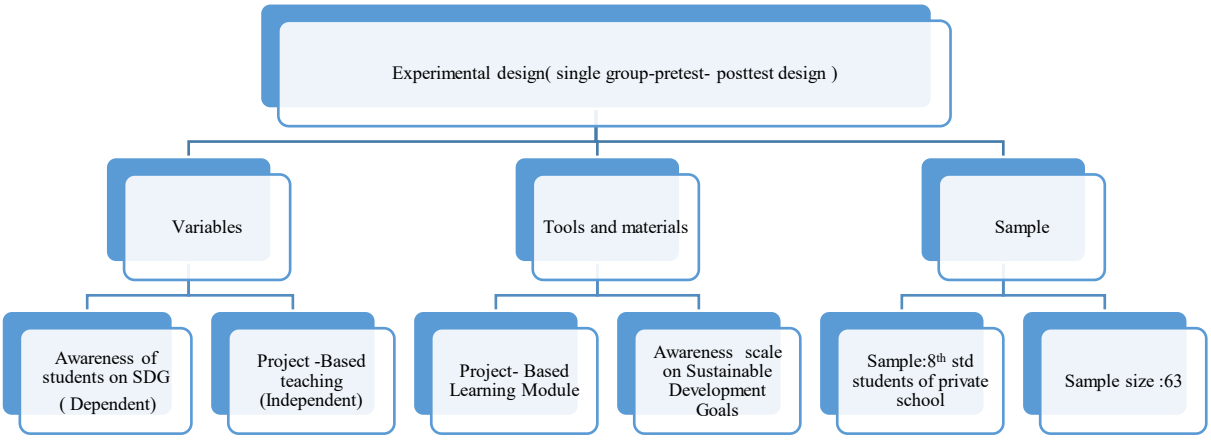
3.1.a. Background of the study

The study tries to analyse the awareness of the 8^{th} standard students on Sustainable Development Goals. The sample for the study was selected from two private schools in Palani namely St. Peters Matriculation School and Sankar Ponnar Higher Secondary School. The teaching methodology selected by the investigator was the project-based learning.

3.1.b. Framing of research questions

The study is intended to develop awareness on Sustainable Development Goals connecting it with physics through project-based learning. Hence the general research question framed was *"Will the project-based physics teaching methodology help to develop better awareness on Sustainable Development Goals among the 8^{th} standard students?"*

3.1.c. Creation of conceptual framework



The methodology of the present study is discussed under the following headings:

3.2 Design adopted for the study

3.3 Variables for the study

3.4 Population of the study

3.5 Sample of the study

3.6 Tools used for the study

3.7 Conduct of the study

3.8 Data analysis procedure

3.9 Conclusion

3.2 Method adopted for the study

The method used in this study is experimental method. The experimental method gives a plan for adopting different process in investigating the underlying relationships behind a cause and to derive them under controlled and set conditions. The process helps to identify the conditions behind the occurrence of a given phenomenon. The investigators involved in the experimental research manipulate certain specific stimuli, certain treatments or approaches, some specified conditions or some methods in order to observe and analyse the effect that occurs because of the changes made. It must be noted that such changes are purposeful, systematic and

deliberately done by the investigators. It should also be taken into consideration about the intervening factors that may or may not affect the progress of the research in any manner because that may influence the final result of the research. Hence, they should be taken care of by the investigator either by controlling them or by removing them and thus help in ensuring a logical relationship between the manipulated variables and the observed variables (Kumar, 2022).

Experimental Design: "Single-group pre-test post-test design" is used in this study. The dependent variable measurement is carried out only for a single time in the sample before the administration of the experimental treatment in a "single-group pre- test post-test design" and the post test is administered after the implementation of the experiment in this particular design.

3.3 Variables for the study

Variables play a crucial role in all types of research. In the present study 'Project-based Physics teaching in developing awareness on Sustainable Development Goals among 8th standard students' the variables involved are:

- Testing variable or Dependent variable- Awareness of the students on Sustainable Development Goals
- Experimental variable or Independent variable - Project-based learning

3.4 Population of the study:

Population refers to the set or group of all the units on which the findings of the research are to be applied. In other words, population is a set of all the units which possess variable characteristic under study and for which findings of research can be generalized (Shukla, 2020). The population of this study is the 8th standard school students from Palani.

3.5 Sample of the study

The sample for the present study consists of 63 students. To obtain sample representatives of the population, the investigator followed purposive sampling technique on St. Peters Matriculation School and Sankar Ponnar Higher Secondary School in Palani.

3.6 Tools and Materials used for the study

3.6.1 Awareness scale on Sustainable Development Goals

3.6.2. SDG incorporated Project-based Learning module

3.6.1 Awareness scale on Sustainable Development Goals

The Awareness scale on Sustainable Development Goals is developed in such way that it can be used to find out the SDG awareness among the middle school students. The Awareness scale on Sustainable Development Goals was developed with both open-ended and closed-end questions.

- **Planning of the inventory**

The SDG awareness inventory consists of 4 sections, namely general awareness, awareness created by school, awareness created by family and open-ended section; general means awareness of students in general on Sustainable Development Goals.

- **Validity of the Awareness scale on Sustainable Development Goals**

Various validities like face validity and content validity were established for the Awareness scale on Sustainable Development Goals. Content validity determines the content of the scale and checks whether it actually measures the SDG awareness among the middle school students. The tool possesses face validity, as the items were selected after the judgment made by the subject specialists. The tool was given to one expert from the field of teacher education and five teachers from school. Out of 100 items, 10 items were deleted and 15 items were modified based on the expert opinion and the final tool consisted of 90 items.

- **Pilot study and Item analysis**

Pilot study was conducted on 25 eighth standard students in a private school in Palani. The draft tool consisted of 90 items with 60 items in the general scale, 20 in school related items and 10 items in family related statements. After their completion, the response sheets were collected and scored separately. Each individual score was calculated and tabulated.

Thus, it is concluded that the scale constructed by the investigator to measure the SDG awareness of the middle school students is an effective one for assessing the same. Analysis was done using item discrimination and item difficulty, in order to select the most appropriate statements for the inclusion in the final copy of the tool. The final SDG awareness inventory with the 4 sections, namely general, school, family and open-ended section; consisted of Sustainable Development Goals with 42 statements, section on school includes 14 statements related to how school is enhancing or creating awareness on Sustainable Development Goals,section on family with 7 statements is related to how family is enhancing or creating awareness on Sustainable Development Goals and the open ended section has 12 questions.

- **Reliability of the Awareness scale on Sustainable Development Goals**

The reliability of the 63 items in the Awareness scale on Sustainable Development Goals was determined using Cronbach alpha and the value of the reliability coefficient was found to be 0.72

- **Mode of responding and scoring**

The final SDG awareness scale consisted of 75 items, with 63 closed ended questions and 12 open ended questions. For the closed end questions, 4-point scale for general awareness, 5-point Likert scale type questions for school related and 3-point scale for family related questions. The respondents are asked to put a tick mark (√) in any one of the appropriate option.

- **Scoring procedure**

The scoring procedure for the positive statement ranged between 4 and 1, 5 and 1, 3 and 1 respectively for the general awareness, for the school related statements and for the family related statements. A score of 1 denote the lowest and 4 denote the highest for the general awareness, 1 denotes the lowest and 5 denotes the highest for the school related items and 1 denotes the lowest and 3 denotes the highest for the family related statements. For the negative statements the scoring procedure is reversed. Thus the maximum possible score of the statements for the general awareness would be maximum of 168 and minimum of 42; for awareness created by school would be maximum of 70 and minimum of 14, for awareness created by family would be maximum of 21 and minimum of 3.

3.6.2 SDG incorporated project-based learning module:

The SDG incorporated project-based learning module was constructed with the help of the results of the SDG awareness inventory and content analysis of the Tamil Nadu state board Samacheer Kalvi science books of 6^{th}, 7^{th} and 8^{th} grade.

Content analysis:

Content analysis is a research technique used to determine the patterns and themes from qualitative data. Holisti (1969) define content analysis as “any technique for making inferences by objectively and systematically identifying specified characteristics of message”. To conduct content analysis, the text was divided into small categories on variety of levels under the name units, those units can be name, place, themes, pictures, paragraphs etc., then examined using conceptual analysis or relational analysis. The results from the analysis are used to interpret the message from the text.

Types of content analysis:

There are two types of content analysis, they are conceptual analysis and relational analysis. Conceptual analysis is mostly preferred when doing content analysis, where a concept is chosen and analysis is done to quantifying and counting its presence. The main purpose is to examine the occurrence of the selected text in the selected data. The text must be coded into manageable content categories. This helps the investigators to focus on specific code or pattern easier. It is also called as thematic analysis.

In relational analysis, the concepts alone hold no inherent meaning; they are like the "ideational kernels"(Carley 1992) or symbols that acquire meaning through their connections to other symbols. A concept's meaning is assigned by its relationship to other concepts. Relational analysis is also called as sematic analysis.

In content analysis, the research conclusion is drawn from the examination of the specific units. Therefore, it is essential to quantify the content unit related to SDG present in the Tamil Nadu state board middle school science books.

In the present study, the investigator used conceptual content analysis as the aim of the investigator is to identify the contents related to SDG and based on the nature of the content, the investigator has used only two units of analysis (paragraphs, concepts) in order to find out to what extent the science textbook for middle school of Tamil Nadu State Board Education has incorporated SDG.

Sustainable Development Goals:

Five goals of SDG have been identified in the Science textbook based on review of related literature by the investigator for content analysis of science textbook. They are SDG 3: Good health and wellbeing, SDG7: Affordable and clean energy, SDG 9: Industry, innovation and infrastructure, SDG11: Sustainable cities and communities, SDG 13: Climate action.

Table 3.1

An overview of the SDGs and units adopted for the study

S.No	SDG goals	Class	Unit
1.	SDG 3: Good health and well-being	6	TERM 2: UNIT 2- Electricity
		6	TERM 3: UNIT 4- Our Environment
		7	TERM 2: UNIT 2- Electricity

		8	UNIT 6-Sound
2.	SDG 7: Affordable and clean energy	6	TERM 2:UNIT 2- Electricity
		7	TERM 2: UNIT 2- Electricity
		8	UNIT 5- Electricity
3.	SDG 9: Industry, innovation and infrastructure	6	TERM 2: UNIT 2- Electricity
		6	TERM 3:UNIT 1- Magnetism
		7	TERM 2: UNIT 2- Electricity
		8	UNIT 5: Electricity
		8	UNIT 6: Sound
4.	SDG 11: Sustainable cities and communities	6	TERM 3: UNIT 1- Magnetism
		7	TERM 2: UNIT 2- Electricity
		8	UNIT 8: Water
5.	SDG 13 : Climate action	6	TERM 3: UNIT 4- Our Environment
		7	TERM 2: UNIT 2- Electricity
		8	UNIT 11: Air

Structure of SDG incorporated project-based learning module:

In total 5 modules covering 8 units from the Samacheer Kalvi science textbook of middle school students was included in the SDG incorporated project-based learning module. The eight chapters selected for the module from the 6^{th} grade, 7^{th} grade and 8^{th} standard science textbook are depicted in Table 3.2. It consists of activities and experiments from the day to day life and is easy for the students to comprehend and develop an understanding on the SDGs.

Procedure for the development of the SDG incorporated project-based learning module:

The SDG incorporated project-based learning module is designed based on a specific framework which has been exclusively designed for the purpose of teaching and learning.

Each module has a particular framework that consists of the below mentioned sub heading.

- Module Title
- Module Duration
- Learning Outcome
- Content
- Activity

- Feedback

Table 3.2

An overview of 5 modules in SDG incorporated project-based learning module

Module Title	SDG 3: Good health and well-being	SDG7: Affordable and clean energy	SDG 9: Industry, innovation and infrastructure	SDG11: Sustainable cities and communities	SDG 13: Climate action
Module Duration	3hrs	2hrs	3hrs	3hrs	3hrs
Learning Outcomes	To understand the correlation of sound to noise pollution and its consequences	To understand energy transformation and to create awareness on renewable energy resources	To understand the technological innovation using the physics concepts	To understand the concept of sustainability in the cities and communities	To understand the impact of greenhouse gases, climate change, carbon footprint
Content	Electricity, Our Environment, Sound	Electricity	Electricity, Magnetism, Sound	Magnetism, Electricity, Water	Our Environment, Electricity, Air
Activity	1.Sound: production of vibration and sound wave propagation 2.Visualizing frequencies	1.Box type solar cooker 2.Hydraulic lift Model 3.Hand crank Generator	1.Construction of electric vehicle powered by solar power 2. Simple touch sensor	1.Maglev train model 2.Water filtration 3.Construction of wind	1.Observing greenhouse effect in a jar 2.Designing a radioactive cooling roof for hot cities model

	3.Measuring sound intensity with sound level meter		3.Electromagnetic train	powered house model	3.Thermal Insulation challenge: keeping ice from melting
Feedback	The activities are easy to carry out	The model could entertain and engage the students at the same time	The models can give great insights about the innovation by physics concepts	The activities can help the students to use sustainability concepts in their homes	The activities are very easy that can bring awareness on the climate actions

Discussion with experts

During the process of developing module on SDG incorporated project-based learning, the investigator consulted with a number of experts in the field of Project based learning for taking their expertise opinion. They gave essential suggestions to the development of the SDG incorporated Project-based learning module. Some of the experts consulted are listed out in Table 3.3.

Table 3.3

Name of the experts and designation

S.No	Name of the expert	Designation
1.	Dr. H. Indu	Professor of Education, Avinashilingam Institute, Coimbatore
2.	Biji Cherian C	Head Mistress, St. Peter's Matriculation school, Palani
3.	Devapriya Kribakiri R	Science teacher, St. Peter's Matriculation school, Palani
4.	Revathi G	BRTE, Thoppampathy
5.	Jayanthi A	B.T. Assistant in Science, Govt. Hr. Sec.school Thoppampathy
6.	Chitra J	Science teacher, Govt. Hr. Sec. school, Thoppampathy

SDG incorporated project-based learning module

Module 1: SDG 3: Good health and well-being

Sustainable Development Goal 3(Good health and well-being) highlights the importance of ensuring healthy lives by mitigating environmental risks, including noise pollution, which is frequently and underestimated danger to both physical and mental health. In context of school physics, the topic of sound serves as a significant framework to foster this awareness among students in class 6 to 8. At the introductory level learners are familiarized with concepts such as vibrations, wave propagation and energy transfer through subject related to electricity and environmental studies, progressively connecting these concepts to real world challenges like noise pollution. By the time students reach class 8, a more profound scientific comprehension of sound allows them to understand how excessive sound levels and exposure to high frequencies can result in health issues such as stress, sleep disturbance and hearing impairment.

The activities that are incorporated are:

1. Sound: production of vibration and wave propagation
2. Visualizing frequencies
3. Measuring sound intensity with sound level meter

One of the activities is explained in brief which is included in the module

Activity 2: Visualizing frequencies

This activity illustrates how sound waves differ with frequency and how these differences affect the patterns created by vibrating materials. Sound is generated when an object vibrates, producing waves that propagate through a medium. These waves processes varying frequency [the number of vibrations per second], which dictate the pitch of their sound. Higher frequencies yield higher - pitched sound, whereas lower frequencies result in lower- pitched sound.

When sound waves emitted from the speaker strikes the plastic sheet or the balloon, they induce vibration in it. The salt or sand particles resting on top react to these vibrations by shifting and creating discernible patterns vary according to the frequencies, rendering invisible sound waves visible.

Objectives of this activity:

- Understanding frequency patterns: Students examine how various frequencies generate distinct vibration patterns, adding them in visualizing abstract sound concept
- Connecting to SDG 3: Elevated frequencies and loud noises can impact human health, leading to stress, sleep disturbances or hearing impairment. This exercise enables students to connect scientific principles to their real life health.

Materials and their purposes

- Bowl: Acts as a container to hold and amplify vibration
- Speaker: Produces sound waves of varying frequencies
- Thin plastic sheet /balloon: Serves as a vibrating surface [like a drum membrane].
- Rubber band : Secures the vibrating surface tightly to ensure proper vibration
- Salt or sand: Makes the vibration visible by foaming patterns

Steps

1. Take the bowl and place the speaker inside the bowl
2. Then close the bowl with the thin plastic sheet or balloon tightly with rubber band.
3. Now sprinkle some salt or sand on top
4. Now connect the speaker to the phone or audio source and play sound at different frequencies
5. Observe the different waveforms at a different frequencies

Scientific explanation of observation

- At a lower frequencies, vibrations are slower, so particles move gently and form simple platforms.
- At higher frequencies vibrations are rapid, causing particles to jump and arrange into more complex shapes
- The patterns occurs because particles move away from areas of strong vibration and settle in areas of less movements.

Expected learning outcomes

Students clearly understand that sound waves with different frequency affect materials differently

- They visualize how sound energy travels and interact with matter
- They relate these concepts to real life situations like noise pollution

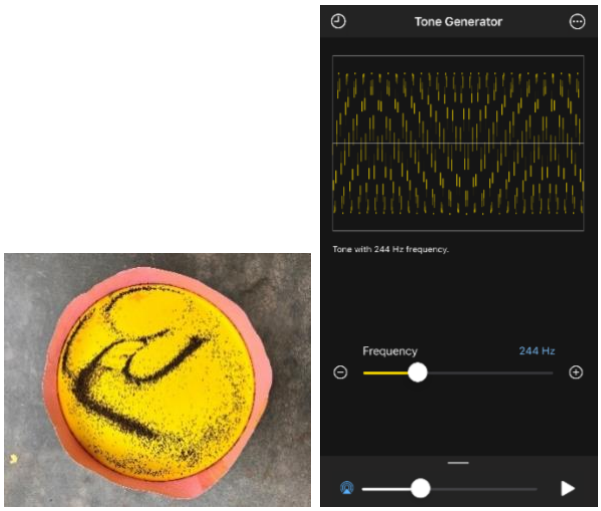


Figure 3.1(a) pattern formed at 244Hz

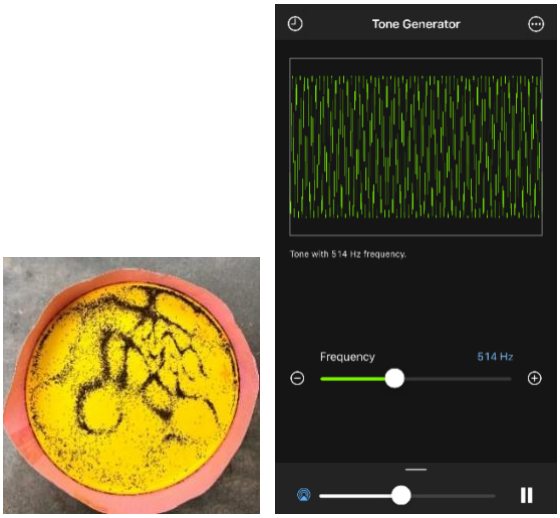


Figure 3.1(b) pattern formed at 514Hz

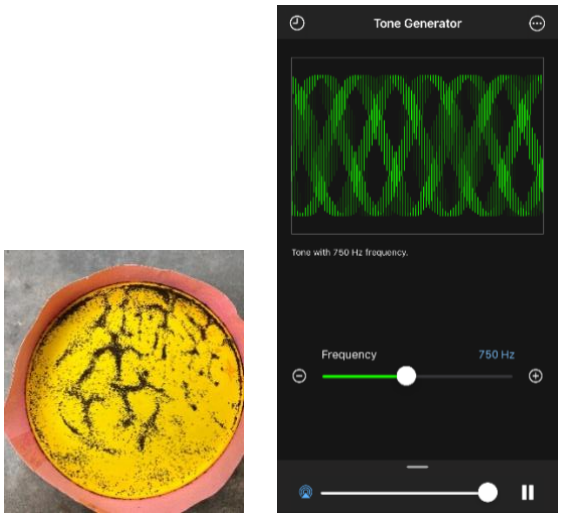


Figure 3.1(c) pattern formed at 750Hz

Module 2: SDG7: Affordable and clean energy

Sustainable Development Goal 7 [affordable and clean energy] aims to guarantee access to reliable, sustainable and modern energy for everyone. School level physics serves as an effective platform to cultivate this awareness through the concept of energy transformation. From class 6 to class 8, students progressively enhance their understanding of electricity and energy sources, starting with fundamental concepts of electrical energy and its origins, including renewable forms and advancing towards broader notions of energy generation and sustainable practices.

Through experimental learning activities such as building a box type solar cooker, students investigate how sunlight can be focused, transformed into heat and retained for cooking, showcasing solar energy as a clean alternative to fossil fuels. The hydraulic lift model

introduces the principle of water pressure and indirectly relates to hydropower generation aiding students in comprehending how renewable water resources can be utilized for energy. Likewise, the hand crank generator illustrates the transformation of mechanical energy into electrical energy, highlighting sustainable and accessible power generation through human effort.

The activities that are incorporated are

1. Box type solar Cooker
2. Hydraulic lift model
3. Hand crank generator

One of the activities is explained in brief which is included in the module

Activity 2: Hydraulic lift model

This activity illustrates the operational principle of hydraulic lift which operates on the basis of fluid pressure [Pascal's law] and find extensive use in practical applications such as car lifts, elevators and construction equipment. Hydropower systems similarly depend on fluid principles, utilizing water pressure to produce and convey energy. When pressure is exerted on a liquid within a closed system (such as a syringe and tube), the pressure is uniformly transmitted throughout the liquid. This characteristics enables a minor force applied at one location to elevate heavier objects at another location, rendering it effective mechanism for lifting.

Objective for this activity

- Understanding hydropower mechanism: Students gain insights into how water pressure can be harnessed to accomplish work, linking this concept to renewable energy systems such as hydropower facilities.
- Exploring lift mechanism: The zig zag (scissor) configuration illustrates the interaction between mechanical design and fluid pressure to generate upward movement.
- Promoting sustainable awareness: Students recognize the efficient use of renewable resources like water in place of fossil fuels for mechanical tasks.

Materials and their purposes

- Ice cream sticks: Form the structure of the scissor lift mechanism
- Bamboo sticks: Act as a joints or pivots allowing movement
- Straw pieces: Provide smooth rotation at joints, reducing frictions

- Cardboard base: Supports and stabilizes the model
- Syringe and tubes: Create a closed hydraulic system to transfer pressure using water
- Coloured water: Helps visualize the movement of the fluid clearly

Steps

1. Prepare the sticks with hole: Holes allows the stick to be connected and move freely like joints in a real lift
2. Cut bamboo sticks and assemble zigzag structure: This creates a scissor mechanism, which expands and contracts to lift or lower the platform.
3. Use straws at joints: Straws act as sleeves, allowing smooth movement and preventing wear and tear.
4. Fix these structure on a cardboard base: Ensures stability so that the lift can move vertically without collapsing
5. Prepare the hydraulic system: Fill one syringe with coloured water and connect it to another syringe using a tube. This forms a closed fluid system
6. Attach these string to the lift: When the syringe is pushed, it extends force on this structure, causing it to expand upwards
7. Operate this system
    a. Pushing one syringe → water moves → lift rises
    b. Pulling back → water returns → lift lowers

Scientific explanation of observation

- The activity is based on Pascal's law, which states that pressure applied to confined fluid is transmitted equally in all directions. When force is applied to once syringe, pressure increases in the liquid, pushing the piston of the other syringe. This movement is transferred to the scissor structure, converting fluid energy into mechanical motion. The design allows a small input force to lift a relatively large load efficiently.

Expected learning outcomes

- Students understand that hydropower uses water as a renewable, non-polluting energy source and can perform useful work through water pressure.
- Students develop the ability to think critically about sustainable infrastructure and future clean energy solutions.

Figure 3.2 Hydraulic lift

Module 3: SDG 9: Industry, innovation and infrastructure

Sustainable development goal 9 [Industry innovation and infrastructure] focuses on creation of resilient infrastructure, the promotion of sustainable industrialization, and the encouragement of innovation, all of which can be effectively integrated through the concepts taught in school level physics period . From class 6 to class 8, students progressively acquired foundational knowledge regarding electricity magnetism and sound, which are essential to modern technological advancement and infrastructure systems. Early engagement with electrical circuits, conductors and insulators enables students to grasp the functioning of basic technology, while the study of magnetism introduces innovations such as electromagnetic transportation. As student advances in their studies, they investigate the applications of electricity within urban infrastructure, which includes lighting systems, electric vehicles and smart cities technologies as well as communication system based on sound principles. Through practical activities, such as constructing a solar powered electric vehicle student gained insights into energy transfer, storage and the photovoltaic effect thereby connecting clean energy with sustainable transport innovation. The simple touch sensor activity serves to introduce foundational electronics and the interaction of humans with circuits, mirroring real world application into automated and smart infrastructure. Moreover, electromagnetic train experiment illustrates the principle of electromagnetism and motion, aiding students in visualizing advanced transportation technologies like high speed trains. These hands on learning experience not only enhances conceptual understanding but also fosters creativity, problem solving and innovation skills, prompting students to critically consider sustainable industrial development and resilient infrastructure in accordance to SDG 9.

The activities that are incorporated are

1. Construction of electric vehicle powered by solar power
2. Simple touch sensor
3. Electromagnetic train

One of the activities is explained in brief which is included in the module

Activity 1: Construction of electric vehicle powered by solar power

This activity illustrates the process of converting solar energy into electrical energy through photovoltaic effect, as well as how this energy is stored and utilized to perform mechanical work. Solar panels capture sunlight and transform it into electricity which can be used immediately or stored on battery for future use. In this model the electrical energy produced from sunlight is stored in a battery wire at charging module [TP4056] and subsequently employed to operate a DC motor, which transforms electrical energy into mechanical energy. This exemplifies a complete cycle of energy transfer, storage and application.

Objectives for this activity

- Understanding photovoltaic energy conversion: Students gain insight into the process by which sunlight is transformed into electricity through the use of solar panels
- Learning energy storage: The battery retains energy for future utilization, even in absence of sunlight
- Connecting to SDG 9: The model exemplifies practical innovations such as solar powered vehicles fostering sustainable and emission free transportation system

Materials and their purpose

- Solar panel: Converts sunlight into electrical energy.
- TP4056 module: Safely charges the battery from the solar panel
- Lithium battery: Stores electrical energy.
- DC motor: Converts electrical energy into motion.
- Switch: Controls the flow of electricity to the motor.
- Wooden sticks or dummy car: Forms the structure of the vehicle.
- Wires and glues: Helps in correction and assembly

Steps

1. Build the car base: Using ice cream sticks, creating a lightweight structure to support the components.

2. Attach the DC motor: The motor will drive the wheels, converting electrical energy into motion.
3. Connect solar panel to TP4056 module: This step allows solar energy to charge the battery safely.
4. Connect battery to TP4056: The battery storage stores the energy generated by the solar panel.
5. Connect TP4056 output to DC motor: The stored energy is supplied to the motor to run the vehicle.
6. Add a switch: Enables control over when the motor operates.
7. Complete the circuit

   The system works as solar panel → charging module → battery → switch → motor → movement

Scientific explanation of observation

- The photovoltaic effect converts sunlight into electrical energy.
- The battery stores energy, ensuring continuous operation even without sunlight.
- The DC motor converts electrical energy into mechanical energy, causing the wheels to rotate.
- This demonstrates energy conservation, where energy changes form but it is not lost.

Expected learning outcome

- Students understand how innovation and sustainable transport system, such as electric vehicle, supports modern infrastructure.
- Students recognize the renewable energy can power infrastructure without causing pollution.
- Student develop awareness of the importance of clean, efficient and resilient technologies.
- Student understand the role of engineering and innovation in the development of modern industries.

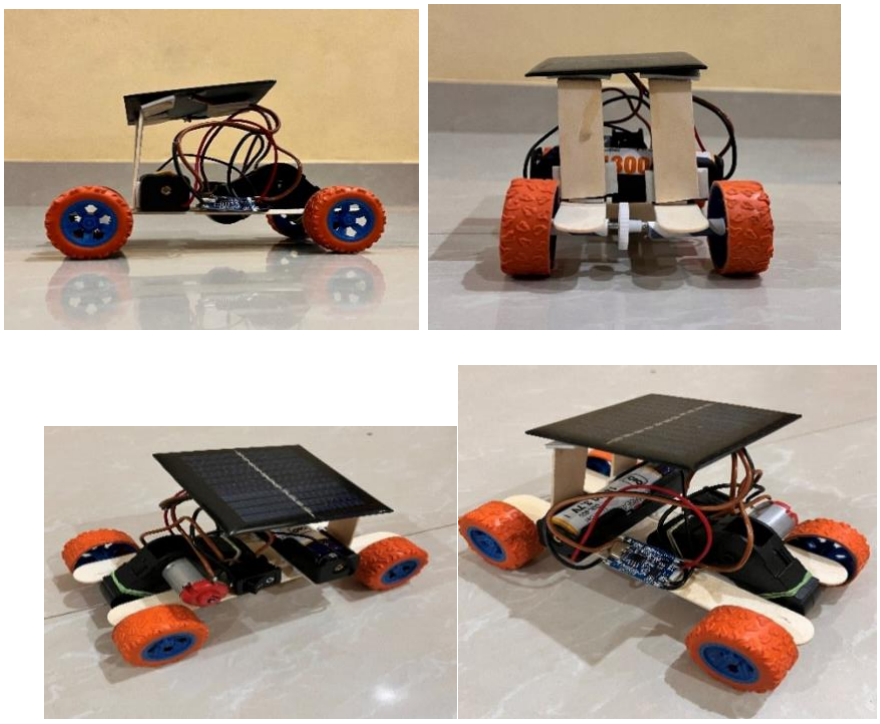


Figure 3.3 Solar powered electric car

Module 4: SDG11: Sustainable cities and communities

Sustainable development goal 11 [Sustainable cities and communities] aims to establish urban environments that are inclusive, safe, resilient and environmentally sustainable. School level physics serves as a strong foundation for comprehending these principles through practical applications. In class 6 to 8 students are introduced to essential scientific concepts such as magnetism, electricity and water management, all of which are intricately connected to sustainable Urban Development. In class 6, the exploration of magnetism allows students to investigate innovative transportation systems, such as maglev trains, which minimize frictions, reduce energy consumption and lower urban pollution. Class 7 focuses on fundamental principles of electricity and its sources, which aids in understanding sustainable infrastructure, including energy efficient system within cities. By class 8, the curriculum emphasis water-related concepts, highlighting the significance of access to clean water and pollution management, both of which are vital for healthy communities. Through interactive activities, students engage with these concepts the maglev train model exemplifies magnetic limitations such as clean transportation alternative, water filtration experiment demonstrates how natural processes can yield safe drinking water in urban settings, and the wind powered model illustrates the conservation of energy renewable wind energy into electricity for sustainable living. These hands on learning experiences allows students to link physics concepts with real

world urban issues, enhancing their awareness, problem solving abilities ultimately equipping them to contribute to creation of sustainable and resilient communities in accordance with the SDG 11.

The activities that are incorporated are

- Maglev train model
- Water filtration
- The construction of wind powered house model

One of the activities is explained in brief which is included in the module.

Activity 1: Maglev train model

This activity illustrates the concept of magnetic levitation [maglev], wherein an object hover above a surface without any direct contact, owing a magnetic repulsion. Magnets possesses two poles North Pole and South Pole and when like poles [North-North, South- South] are positioned in proximity to one another, they exert a repulsive force. In this model, the arrangement of magnets on the track and the train generates a repulsive force that elevates the train slightly above the surface, thereby minimizing friction. This principle is applied in actual maglev trains, which operates at high velocities with negligible energy loss due to the lack of friction between the train and the track.

Objectives for this activity

- Understanding magnetic levitation: Students gain insights how magnetic forces can be utilized to elevate objects without physical contact.
- Connecting to sustainable transport: Maglev technology diminishes friction, energy usage and pollution, thereby promoting environmentally friendly urban transportation.
- Promoting innovation awareness: It encourages the students to contemplate advanced transportation systems in contemporary cities

Materials and their purposes

- Cardboard: Forms the base and the structure of the track and the train.
- Magnets: Provide the repulsive force needed for levitation.
- Glue: Secures materials in place
- Ruler and cutter: Helps in accurate measurement and construction

Steps

- Prepare the base: Cut the cardboard and cover it with black paper to create neat track surface.
- Arrange magnets on the tracks: Place magnets with the same poles facing upwards on the track, this create a repelling magnetic field
- Create side walls: Attach cardboard strips on both sides to guide the train and keep it aligned on the track
- Build the train model: Attach the magnets with the same pole orientation as the track magnets underneath the train model
- Place the train on the track: The repulsion between similar poles causes the train to lift slightly and float, reducing contact with the track

Scientific explanation of observation

- Magnets exert non-contact forces that can either attach or repel. When like poles face each other, repulsive forces pushes the train upwards, causing levitation. Reduced contact means less friction, allowing smoother and faster movement.
- This demonstrates how magnetic energy can be used for motion and transport systems.

Expected learning outcomes

- Students understand the concept of magnetic forces and levitation.
- They learn how friction can be reduced using innovative technology.
- They gain insight into modern transportation system and their scientific principles

Figure 3.4 (a) Maglev train model

Figure 3.4 (b) Maglev train track

Module 5: SDG 13: Climate Action

Sustainable Development Goal 13 [climate action] highlights the critical necessity to address climate change and its effects. School level sciences, practically physics and environmental studies, lay a significant group work to for fostering this awareness among students period from class 6 to class 8, learners gradually comprehend ecosystems, pollution, atmospheric composition and their scientific underpinnings of climate change, including greenhouse effects and the global warming. In classics, students investigate environmental element and of pollutions on ecosystems, while class 7 emphasis their significance of energy efficient technologies that indirectly mitigate carbon emission. By class 8, students acquire a more profound understanding of air composition and the function of gases such as carbon dioxide and climate change. Through the activities like stimulating the greenhouse effect with the jar, students witness how elevated CO2 level trap heat, establishing a direct connection to global warming. The radiative cooling roof experiment aids them in grasping how reflective materials can minimize heat observation, thereby encouraging energy efficient architectural design in warm urban settings. Thermal insulation challenge illustrates how various materials influence heat transfer, underscoring the necessity of energy conservation and residential spaces. These interactive learning experiences empower students to relate scientific principles to real world climate issues, nurturing critical thinking, environmental stewardship and innovative problem solving abilities. Thus equipping them to undertake informed actions in alignment with SDG 13 for sustainable future.

The activity is incorporated are

- Absorbing greenhouse effect in a jar
- Designing a radioactive cooled roofing for hot city model
- Thermal insulation challenge: keeping ice from melting

One of the activities is explained in brief which is included in the module

Activity 3 Thermal insulation challenge keeping ice from melting

This activity illustrates the principle of heat transfer and the role of various materials as insulators that impede the flow of heat. Heat inherently moved from a hotter area to cooler ones in this instance, from environment to the ice cube, resulting in its melting.

Insulating material diminish this heat transfer by trapping air or impending heat movement, which is a crucial concept in designing energy-efficient buildings. Residences with effective insulation require less energy for heating or cooling, thereby enhancing sustainability and being more environmentally conscious.

Objectives for the activity

- Understanding heat transfer: Students gain insight into the movement of heat and how different materials influence the melting rate
- Comparing insulation efficiency: Through the observation of melting rates, students discern which material serves as a superior insulator
- Connecting to SDG 13: This activity underscores the significance of adequate insulation in lowering energy usage and aiding in the fight against climate change

Material and their purpose

- Ice cubes: Act as the object affected by heat transfer.
- Insulation material [cotton, aluminium foil, cardboard]: Used to compare how different materials resist heat flow
- Stopwatch: Helps measure the time taken for the ice to melt, allowing comparison.

Steps

- Wrap ice cubes with different materials: Each material acts as a barrier to heat, affecting how quickly the ice melts.
- Observe the melting process: Place all the samples in the same environment and monitor them over time.
- Compare results: Identify which material slows down melting the most, indicating better insulation.

Scientific explanation of observation

- Cotton traps air, which is poor conductor of heat, making it a good insulator.
- Aluminium foil reflects heat but can also conduct heat if in direct contact
- Cardboard provides moderate insulation due to trapped air pockets.
- The materials that slows melting the most is the best insulator, as it reduces heat transfer effectively.

Expected learning outcomes

- Students understand how heat transfer affect materials and are able to identify effective insulating material for reducing heat flow in real life situation.
- Students relate insulation concept to energy-efficient buildings, recognizing how reduced use of heating and cooling systems lowers overall energy consumption.
- Students develop awareness of climate action SDG 13 by understanding how insulation helps reduce greenhouse gas emission and promote sustainable home design and energy conservation.

Figure 3.5 (a) ice cube is being placed in the insulation material at the initial time

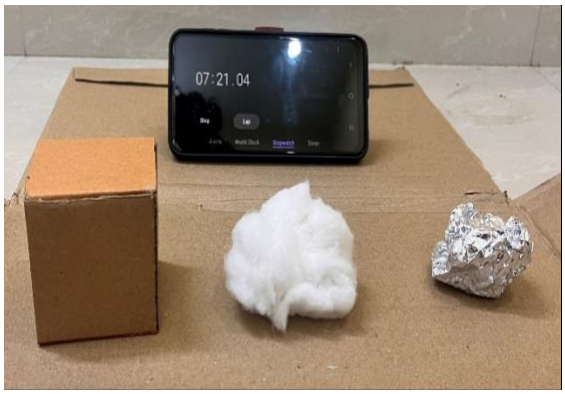


Figure 3.5 (b) condition of the ice cube after 7 minutes

Figure 3.5 (c) After 30 mins the condition of the ice cube in different insulation materials

Figure 3.5 (d) ice cube is slighly melted in cotton, partially melted in cardboard and completely meltaed in aluminium foil

3.7 Conduct of the study

After the preparation of the module and finalisation of the tools, the study was conducted. The study was conducted during the month of February. For administering the tools, the investigator first met the head of the institution of the schools and sought permission for the conduct of the study. The investigator met the concerned school teachers for help and cooperation in the study and testing the pervious knowledge of the students to test their entry behaviour. The investigator met the concerned students, established a rapport and administered the tools, providing clear general instructions and addressing all their queries. The investigator was fortunate to receive sincere cooperation from all the teachers of St. Peters Matriculation School (Palani) and Sankar Ponnar Higher Secondary School (Palani). The details of the sample drawn are given in the Table 3.4

Table 3.4

Details of the sample involved in intervention

Sl.No	Variable	N	Percentage (%)
1	St. Peters matriculation School	24	38
2	Sankar Ponnar Higher Secandary School	39	62
3	Boys	21	33
4	Girls	42	67
5	Father's education level- Completed schooling	32	51
6	Father's education level- Pursued Higher education	31	49
7	Mother's education level- Completed schooling	40	63
8	Mother's education level- Pursued Higher education	23	37
9	Interested in science	30	48
10	Interested in language	33	52
11	Have access to phones at home	12	19
12	Don't have access to phones at home	51	81

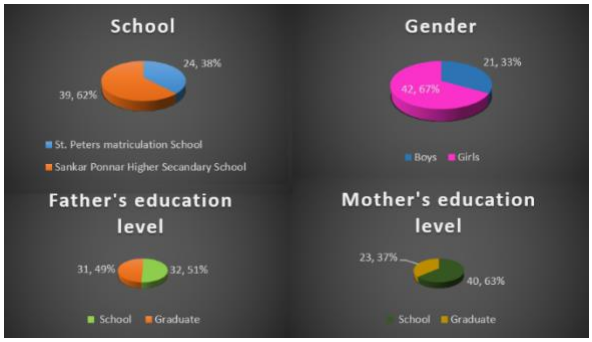


Figure 3.6 (a) percentage of students from different schools, gender, father's education level and mother's education level.

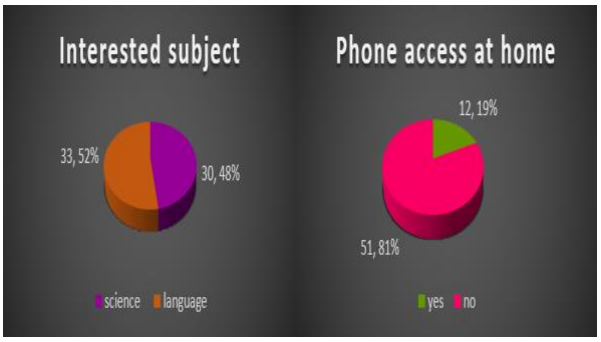


Figure 3.6 (b) Percentage of student's interest of subject and access to phone at home

The intervention was personally done by the investigator in St. Peters Matriculation School and Sankar Ponnar Higher Secondary School located in Palani, Dindigul district. The intervention was planned to conduct in two session. The intervention required 15 days to get completed. The head of both the schools gave permission for conducting the study for the

investigator for a minimum period of 15 days and maximum of 20 days. So, the conduct of the study cannot be completed in two different schools on different dates. Hence the investigator divided the day as two session, during the morning session the investigator went to Sankar Ponnar Higher Secondary School and afternoon session to St. Peters Matriculation School.

The investigator was given permission for the data collection during the month of February in the year 2026. The previous knowledge testing was done during the first week of February which was then followed by the intervention for a period of three weeks and finally the post test was administered by the end of third week of February.

3.8 Data Analysis Procedure

The following statistical techniques are to be used for analysing the data quantitatively. To test the data,

- Mean and standard deviation
- Paired sample t-test
- Independent sample t test

3.9 Conclusion:

The investigator constructed and validated the tool for assessing the Awareness of the middle school students on Sustainable Development Goals and developed and validated a five module package with different activities for developing awareness and hence create a better awareness on Sustainable Development Goals among 8^{th} standard students. The tools and materials developed were used for the intervention and scores obtained are used for further statistical analysis which is presented in Chapter 4.

RESULTS AND DISCUSSIONS

Chapter 4

Results and discussions

The obtained data was analysed statistically after the intervention. The researcher used descriptive statistics such as mean, median, mode, standard deviation, and inferential statistics such as student's *t*- test for statistically analysing the data. The present study is aimed at finding out the effect of "Project based Physics teaching in developing awareness on Sustainable Development Goals among 8th standard students". This chapter deals with the details of statistical findings and discussions.

The details of the statistical analysis are presented under the following headings.

- **Preliminary Analysis**
- **Major Analysis of the Data**
- **Conclusion**

4.1 Preliminary Analysis

As a preliminary step in the data analysis, the statistical characteristics of the variables which were selected for the study were analysed in detail and concluded after discussions. The mean, median, and standard deviation worked out for the variables are evaluated under descriptive statistics such as N (Total Number), M (Mean) , Md (Median), and SD (Standard Deviation). Summary of the statistical details are presented in Table 4.1

Table 4.1

Data and Results of the Preliminary Analysis of awareness of middle school students on Sustainable Development Goals

Variable	Pre-Test				Post- Test		
	N	Mean	Median	SD	Mean	Median	SD
Awareness on SDG in General	63	131	134	11.7	153	152	2.52
Awareness created by School	63	40	41	3.30	51.6	52	1.70

Awareness created by Family	63	11.2	11.0	0.97	18	18	0.750

Table 4.1 shows the preliminary analysis of the measures of central tendency of the scores of Awareness on SDG in General, Awareness created by Family, Awareness created by School of the eighth standard students. From Table 4.1 it is clear that all the variables, Awareness on SDG in General, Awareness created by School, Awareness created by Family have higher Post-test score value in comparison with the Pre-test scores value of the variables. The Pre-test scores of Awareness on SDG in General has 131 as mean value, 134 as median and 11.7 as SD value whereas Post-test scores had 153 as mean value, 152 as median and 2.52 as SD value. The Pre-test scores Awareness created by School has 40 as mean value, 41 as median and 3.30 as SD value whereas Post-test scores had 51.6 as mean value, 52 as median and 1.70 as SD value. The Pre-test scores of the variable Awareness created by Family has 11.2 as mean value, 11.0 as median and 0.97 as SD value whereas Post-test scores had 18 as mean and median and 0.750 as SD value.

4.2 Major Analysis of the Data

4.2.1 To determine the levels of awareness on SDG of middle school students of *th standard

The different levels of awareness on SDG of middle school students of 8th standard are discussed below. The results are recorded in Tables 4.2, 4.3 and 4.4.

Table 4.2

General awareness on SDG of middle school students

TEST	High	Average	Low
Pre test	7	48	8
Post Test	18	37	8

Table 4.2 shows the different levels of the scores of General awareness on SDG of middle school students. The scores have been categorised into different levels namely, high, average and low after calculating the (M+SD) and (M-SD) in the sample. The high group students were recorded under (M+SD) and the low group students were recorded under (M-SD) and finally the average group students were found out as those coming in between (M+SD) and (M-SD). This calculation was carried out in the sample and it was found out that the pre-test scores has a group of 7 students in high, 48 students in average and 8 students in low group. After the

intervention, post-test has been conducted and is also categorised into three different groups as, 18 in the high group, 37 in the average group and 8 in the low group. It has been recorded that the data corresponds to a sample population wherein majority of the students fall under average group. The results are diagrammatically represented in the form of a pie diagram as in Figure 4.1

Figure 4.1

Different levels in Pre-test and Post-test of General awareness on SDG of middle school students

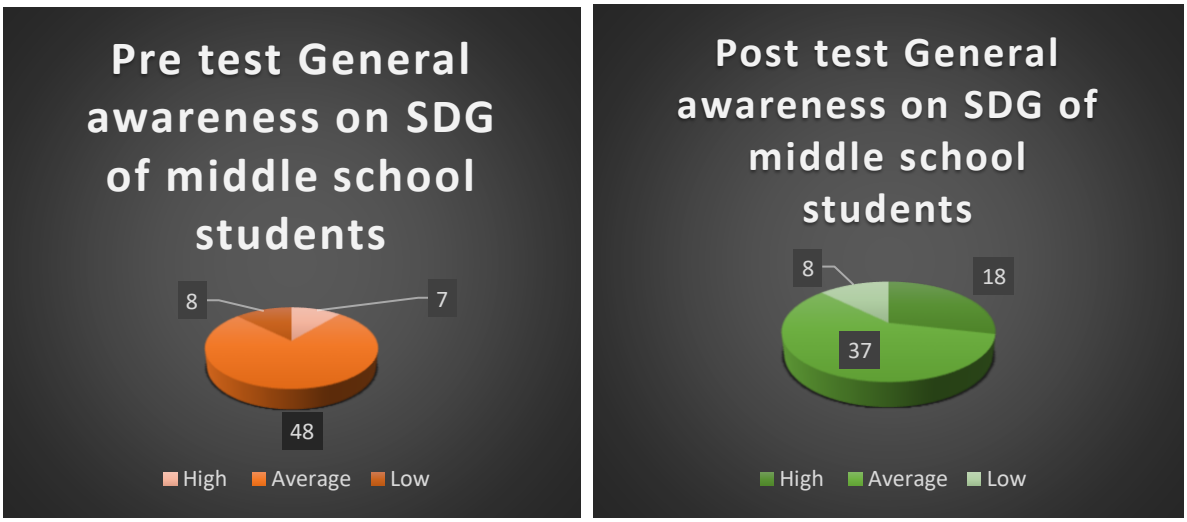


Table 4.3

Awareness created by school on SDG

TEST	High	Average	Low
Pre test	12	43	8
Post Test	26	29	8

Table 4.4 shows the different Awareness level on SDG of middle school students developed by School studying in St. Peters Matriculation School and Sankar Ponnar Higher Secondary School. The scores have been categorised into different levels. It was found out that the pre-test scores has a group of 12 students in high, 43 students in average and 8 students in low group. After the administration of the module, post-test has been conducted and is also categorised into three different groups as, 26 in the high group, 29 in the average group and 8 in the low group. It has been recorded that the data corresponds to a sample population wherein majority of the students fall under average group. The results are presented in Figure 4.3

Figure 4.2

Different levels in Pre-test and Post-test of Awareness on SDG of middle school students developed by School

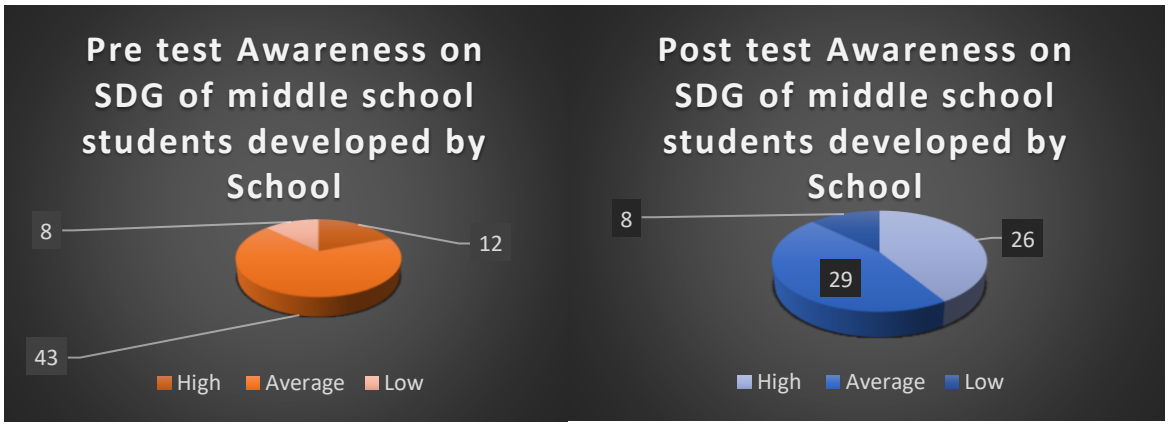


Table 4.4

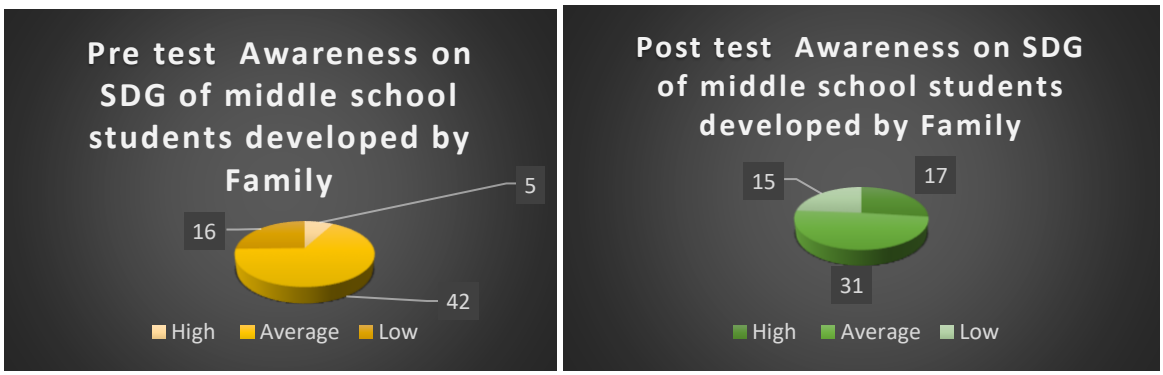
Awareness developed by family on SDG

TEST	High	Average	Low
Pre test	5	42	16
Post Test	17	31	15

Table 4.3 shows the different levels of the scores of Awareness on SDG of middle school students developed by Family. The scores have been categorised into different levels namely, high, average and low and it was found out that the pre-test scores has a group of 5 students in high, 42 students in average and 16 students in low group. After the administration of the module, post-test has been conducted and is also categorised in to three different groups as, 17 in the high group, 31 in the average group and 15 in the low group. The results discussed above can be diagrammatically represented in the form of a pie diagram in Figure 4.4

Figure 4.3

Different levels in Pre-test and Post-test of Awareness on SDG of middle school students developed by Family



4.2.2 Significance of difference in the mean pre-test scores and mean post-scores

The significance of the difference in the mean pre-test scores and mean post-test scores of General awareness, Awareness created by School and Awareness created by family of the eighth standard school students on SDG was statistically analysed by employing the paired sample *t*-test. The result of the *t* test is presented in Table 4.5

Table 4.5

Results of paired sample t test for the scores obtained in Pre-test and Post-test

Variables	Test	N	M	SD	r	T	p
Awareness on SDG in General	Pre test	63	131	2.52	0.632*	14.6**	<.001
	Post test		153	11.74			
Awareness created by School	Pre test	63	40	3.3	0678*	22.8**	<.001
	Post test		51	1.7			
Awareness created by Family	Pre test	63	11.2	0.965	0.789*	41.3**	<.001
	Post test		18	0.75			

*Note . **p<.01 N=number of students, M-Mean, SD= Standard deviation*

Table 4.5 describes the significance of difference in the mean pre-test and the post-test scores of students before and after intervention. For the variable Awareness on SDG in General, the mean value of the Pre-testis found to be 131 and SD value is 2.52, while the mean value of the Post-test is found to be 153 and SD value is 11.74. The obtained t-value (t=14.6) is found to be significant at the level 0.01 level. The correlation value (r=0.632) indicates a moderate positive relationship between pre-test and post-test scores, suggesting significant improvement in the students' general awareness of SDG after the intervention.

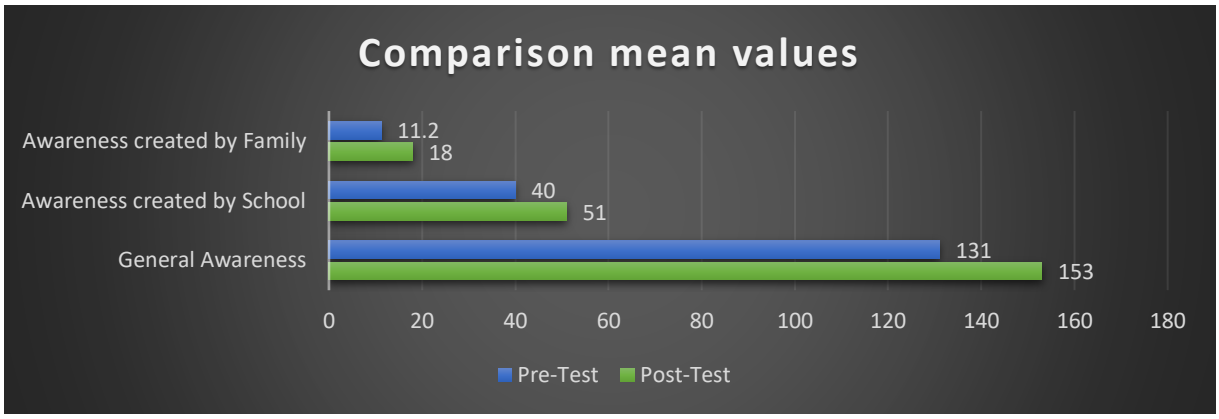
For the variable Awareness created by School, the mean value of the Pre-test was found to be 40 and SD value is 3.3, while the mean value of the Post-test is found to be 51 and SD value is 1.7. The obtained t-value (t=22.8) is found to be significant at the 0.01level. The correlation value (r=0.678) indicates a moderate positive relationship between pre-test and post-test scores, suggesting significant improvement in the students' awareness after the intervention.

For the variable Awareness created by Family, the mean value of the Pre-test was found to be 11.2 and SD value is 0.965, while the mean value of the Post-test is found to be 18 and SD value is 0.75. The obtained t-value (t=41.3) is found to be highly significant at the level 0.01

level. The correlation value (r=0.789) indicates a strong positive relationship between pre-test and post-test scores, suggesting significant improvement in the students' awareness after the intervention. The interpretation can be diagrammatically represented in the form of bar diagram as shown in Figure 4.5

Figure 4.4

Comparison of mean values of Awareness on SDG in General, Awareness created by School, Awareness created by Family



4.2.3 Significance of difference in the mean pre-test scores on awareness of girls and boys of the experimental group

The effectiveness of Project based learning in Physics in creating awareness among boys and girls was compared using independent t-test. The results are given in Table 4.6

Table 4.6

Data and results of independent sample t test for the scores obtained in Pre-test on awareness of girls and boys of the experimental group

Variables	Gender	N	M	SD	df	t	p
Awareness on SDG in General	Boys	21	130.1	12.76	61	0.407	.685
	Girls	42	131.4	11.33			
Awareness created by School	Boys	21	41.1	2.23	61	1.990	.051*
	Girls	42	39.4	3.61			
Awareness created by Family	Boys	21	11.0	1.12	61	1.396	0.168
	Girls	42	11.3	0.87			

*Note . **p<.05 N=number of students, M-Mean, SD= Standard deviation*

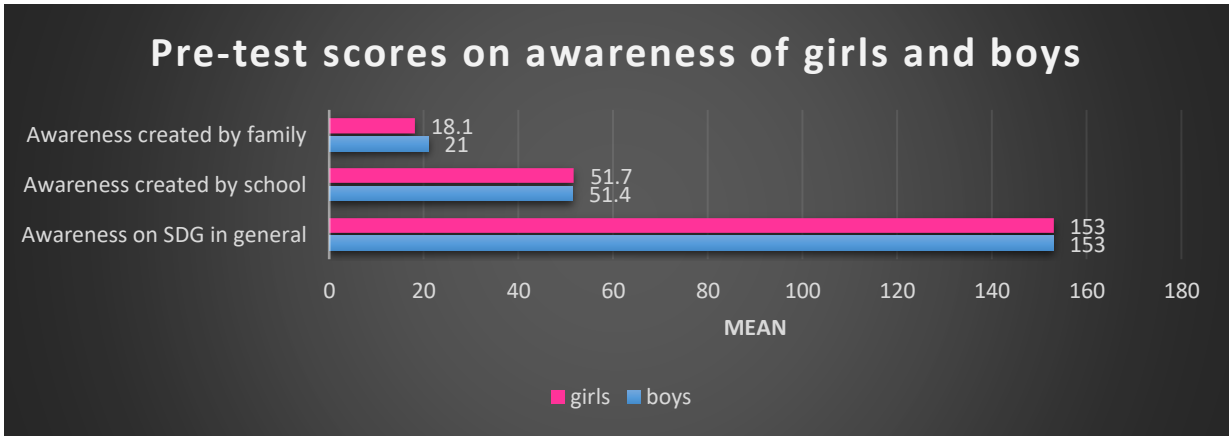
Table 4.6 describes the significance of difference in the mean Pre-test scores of girls and boys. For the variable Awareness on SDG in General, the mean value of the Pre-test scores for boys was found to be 130.1 and SD value is 12.76, while the mean value of the Pre-test scored by girls was found to be 131.4 and SD value is 11.33. The obtained t-value (t=0.407) is found to be not significant (p=0.685). This indicates that there is no significant difference between boys and girls in terms of awareness on SDG in General.

For the variable Awareness created by School, the mean value of the Pre-test scores of boys was found to be 41.1 and SD value is 2.23, while the mean value of the Pre-test scored by girls was found to be 39.4 and SD value is 3.61. The obtained t-value (t=1.990) is found to be marginally significant (p=0.051), which is very close to the 0.05 level of significance. This indicates that there is a significant difference between boys and girls in terms of Awareness created by School. The mean value indicates that boys have better awareness than girls when it is created by the school.

For the variable Awareness created by Family, the mean value of the Pre-test scored by boys was found to be 11.0 and SD value is 1.12, while the mean value of the Pre-test scored by girls was found to be 11.3 and SD value is 0.87. The obtained t-value (t=1.396) is found to be not significant (p=0.168). This indicates that there is no significant difference between boys and girls in terms of Awareness created by Family. The interpretation is diagrammatically represented in the form of bar diagram as shown in Figure 4.6.

Figure 4.5

Comparison of mean values of pre-test scores of Awareness on SDG in General, Awareness created by School, Awareness created by Family among girls and boys



4.2.4 Significance of difference in the mean post-test scores on awareness of girls and boys of the experimental group

The effectiveness of Project based learning in Physics in creating awareness on SDGs among boys and girls was compared using independent t-test. The results are given in Table 4.7

Table 4.7

Data and results of independent sample t test for the scores obtained in Post-test on awareness of girls and boys of the experimental group

Variables	Gender	N	M	SD	df	t	p
Awareness on SDG in General	Boys	21	153	2.55	61	0.147	.889
	Girls	42	153	2.53			
Awareness created by School	Boys	21	51.4	1.83	61	0.678	.500
	Girls	42	51.7	1.65			
Awareness created by Family	Boys	21	18.1	0.768	61	0.354	.725
	Girls	42	18.0	0.749			

Note. N=number of students, M-Mean, SD= Standard deviation

Table 4.7 shows that there is no significant difference among Boys (N=21) and Girls (N=42) on awareness on SDG after the implementation of Project based teaching. For the variable Awareness on SDG in General, the mean post test score of both groups are identical (Mean=153) indicating similar overall performance. The median scores are also very similar with 153 and 152 as scores, the standard deviation values indicates low variability within each group.

For the variable Awareness created by School, the mean value scored for post test by boys was found to be 51.4 and by girls was found to be 51.7 and 18.1 for boys and 18.0 for girls for Awareness created by Family. The obtained t-values (t=0.678) and (t=0.354) respectively for awareness created by School and awareness created by Family was found to be not significant (p=0.051) indicating that there is no significant difference between boys and girls in terms of Awareness created by School on SDG.

4.2.5 Significance of difference in the mean pre-test scores on awareness of students on SDG based on Father's educational attainment

The efficacy of Project based learning in Physics in creating awareness among the 8th standard students was compared with respect to educational attainment of their father, specifically those who have completed schooling versus those who have pursued higher education. The results are given in Table 4.8

Table 4.8

Data and results of independent sample t test for the scores obtained in Pre-test on awareness of students with based on educational attainment of their father

Variables	Educational attainment	N	Mean	SD	df	t	p
Awareness on SDG in General	Completed schooling	32	131.3	12.63	61	0.267	0.791
	Pursued Higher education	31	130.5	10.939			
Awareness created by School	Completed schooling	32	41.5	1.87	61	4.167**	<.001
	Pursued Higher education	31	38.4	3.730			
Awareness created by Family	Completed schooling	32	11.2	1.10	61	0.235	0.815
	Pursued Higher education	31	11.2	0.820			

*Note. **p<.01 N=number of students, M-Mean, SD= Standard deviation*

Table 4.8 shows the difference in the mean pre-test scores on awareness of girls and boys

For Awareness on SDG in General, the mean score of students whose father's educational attainment is at school level is 131.3 and SD value is 12.63, while the mean score of students whose father's educational attainment is at higher education is 130.5 and SD value is 10.939. The obtained t-value (t = 0.267) was not statistically significant (p = 0.791). This indicates that there is no significant difference between the two groups in general awareness at the pre-test level based on the father's education level.

For awareness created by school, the mean score of students whose father's educational attainment is at school level is 41.5 and SD value is 1.87, whereas the mean score of students whose father's educational attainment is at higher education is 3.730. The calculated t-value (t

= 4.167) was found to be statistically significant at the 0.001 level ($p < 0.001$). This indicates that there is a significant difference between the groups in school-based awareness before the intervention.

For awareness created by family, the mean scores of both groups were identical Mean is 11.2, with slight variation in SD values of 1.10 and 0.820. The obtained t-value ($t = 0.235$) was not statistically significant ($p = 0.815$). This indicates that there is no significant difference between the groups in family-based awareness at the pre-test level. Then the Standard error values SE= 0.194 and 0.147 is low, reflecting reliable estimate of the sample mean.

4.2.6 Significance of difference in the mean post-test scores on awareness of students on SDG based on Father's educational attainment

The effectiveness of Project based learning in Physics in creating awareness among students on SDG based on father's educational attainment was compared and the results are given in Table 4.9

Table 4.9

Data and results of independent sample t test for the scores obtained in Post-test on awareness SDG of students based on the educational attainment of their fathers.

Variables	Group	N	Mean	SD	df	t	p
Awareness on SDG in General	Completed schooling	32	152.9	2.595	61	0.817	0.417
	Pursued Higher education	31	152.4	2.445			
Awareness created by School	Completed schooling	32	51.6	1.794	61	0.030	0.976
	Pursued Higher education	31	51.6	1.628			
Awareness created by Family	Completed schooling	32	18.2	0.808	61	1.172	0.246
	Pursued Higher education	31	17.9	0.680			

Note. N=number of students, M-Mean, SD= Standard deviation

Table 4.9 show the difference in the mean post-test scores on awareness of students based on the educational attainment of their father and the results indicate that there is no significant difference in the post awareness scores on SDG in Awareness on SDG in General, Awareness

created by school and Awareness created by family. This brings out the fact that educational attainment of father is not contributing to the difference in the awareness of students whose father has completed school or higher education.

4.2.7 Significance of difference in the mean pre-test scores on awareness of students on SDG based on their Mother's educational attainment

The efficacy of Project based learning in Physics in creating awareness among the 8th standard students was compared with respect to educational attainment of their mother, specifically those who have completed schooling versus those who have pursued higher education. The results are given in Table 4.10

Table 4.10

Data and results of independent sample t test for the scores obtained in Pre-test on awareness SDG of students based on the educational attainment of their mothers.

Variables	Educational attainment of mother	N	Mean	SD	df	t	p
Awareness on SDG in General	Completed schooling	23	132.4	9.834	61	0.735	0.465
	Pursued Higher education	40	130.1	12.754			
Awareness created by School	Completed schooling	23	39.0	3.873	61	1.767	0.082
	Pursued Higher education	40	40.5	2.828			
Awareness created by Family	Completed schooling	23	11.4	0.941	61	1.259	0.213
	Pursued Higher education	40	11.1	0.971			

Note. N=number of students, M-Mean, SD= Standard deviation

Table 4.10 show the difference in the mean pre-test scores on awareness of students based on the educational attainment of their mother and the results indicate that there is no significant difference in the pre awareness scores on SDG in Awareness on SDG in General, Awareness created by school and Awareness created by family. This brings out the fact that educational attainment of mother is not contributing to the difference in the awareness of students whose mother has completed school or higher education.

4.2.8 Significance of difference in the mean post-test scores on awareness on SDG of students was compared with respect to educational attainment of their mother

The efficacy of Project based learning in Physics in creating awareness among the 8th standard students was compared with respect to educational attainment of their mother, specifically those who have completed schooling versus those who have pursued higher education. The results are given in Table 4.11

Table 4.11

Data and results of independent sample t test for the scores obtained in Post-test on awareness SDG of students based on the educational attainment of their mothers.

Variables	Educational attainment of mother	N	Mean	SD	df	t	p
Awareness on SDG in General	Completed schooling	23	152.3	2.367	61	0.722	0.473
	Pursued Higher education	40	152.8	2.611			
Awareness created by School	Completed schooling	23	51.9	1.687	61	0.999	0.322
	Pursued Higher education	40	51.4	1.708			
Awareness created by Family	Completed schooling	23	18.1	0.757	61	0.662	0.511
	Pursued Higher education	40	18.0	0.751			

Note. N=number of students, M-Mean, SD= Standard deviation

Table 4.11 show the difference in the mean post-test scores on awareness of students based on the educational attainment of their mother and the results indicate that there is no significant difference in the post awareness scores on SDG namely, Awareness on SDG in General, Awareness created by school and Awareness created by family. This brings out the fact that educational attainment of mother is not contributing to the difference in the awareness of students whose mother has completed school or higher education.

4.2.9 Significance of difference in the mean pre-test scores on awareness of students based on their interest in science or language

The effectiveness of Project based learning in Physics in creating awareness among students based on their interest in science or language was compared and the results are given in Table 4.12

Table 4.12

Results of independent sample t test for the scores obtained in Pre-test on awareness of students on SDG based on their interest in science or language

Variables	Interest in subject	N	Mean	SD	df	t	p
Awareness on SDG in General	Science	33	130.0	12.586	61	0.694	0.490
	Language	30	132.0	10.850			
Awareness created by School	Science	33	39.8	3.597	61	0.489	0.627
	Language	30	40.2	2.980			
Awareness created by Family	Science	33	11.1	0.879	61	0.857	0.395
	Language	30	11.3	1.060			

Note. N=number of students, M-Mean, SD= Standard deviation

Table 4.12 values shows the difference in the mean pre-test scores on awareness of students based on their interest in subject and the results indicate that the interest in science or language is not contributing towards awareness in general, awareness created by school and awareness created by family on SDG. The t values indicate it clearly.

4.2.10 Significance of difference in the mean post-test scores on awareness of SDG of students based on their interest in subject.

The effectiveness of Project based learning in Physics in creating awareness of SDG of students based on their interest in subject especially science and language. The results are given in Table 4.13.

Table 4.13

Results of independent sample t test for the scores obtained in Post-test on awareness of students on SDG based on their interest in science or language

Variables	Subject	N	Mean	SD	df	t	p
Awareness on SDG in General	Science	33	152.4	2.693	61	0.747	0.458
	Language	30	152.9	2.325			
Awareness created by School	Science	33	52.1	1.576	61	2.749**	<.001
	Language	30	51.0	1.661			
Awareness created by Family	Science	33	18.4	0.653	61	3.887**	< .001
	Language	30	17.7	0.702			

*Note . **p<.01 N=number of students, M-Mean, SD= Standard deviation*

It is interesting to note from Table 4.13 that the awareness created by school and family shows statistically significant difference in the mean post-test scores on awareness of SDG after intervention using project based learning. The mean value shows that students who is interested in learning science was having more awareness on SDG when compared to the students who had interest in language.

For Awareness on SDG in General, the mean score of science is 152.4 and value of SD is 2.693, while language had a mean score of 152.9 and value of SD is 2.325. The obtained t-value ($t = -0.747$) was not statistically significant ($p = 0.458$). This indicates that there is no significant difference between the groups in awareness on SDG in General after the intervention with respect to interest in science or language subject.

4.2.11 Significance of difference in the mean pre-test scores on awareness on SDG of students who have access to mobile phones at home

The effectiveness of Project based learning in Physics in creating awareness on SDG of students who have access to mobile phones at home were compared to those who do not have access and the results are given in Table 4.14

Table 4.14

Results of t test for the scores obtained in Pre -test on awareness on SDG of students based on their access to mobile phones at home

Variables	Mobile phone access	N	Mean	SD	df	t	p
Awareness on SDG in General	Has access	51	130.5	11.770	61	0.559	0.578
	No Access	12	132.7	11.970			
Awareness created by School	Has access	51	39.9	3.225	61	0.442	0.660
	No Access	12	40.3	3.730			
Awareness created by Family	Has access	51	11.2	0.907	61	0.757	0.452
	No Access	12	11.0	1.210			

Note. N=number of students, M-Mean, SD= Standard deviation

Table 4.14 shows that there is no significant difference in the mean pre-test scores on awareness of students on SDG based on their access to mobile phone at home. Students who have access and who do not have access possess the same awareness on SDG.

4.2.12 Significance of difference in the mean post-test scores on awareness on SDG of students who have access to mobile phones at home

The effectiveness of Project based learning in Physics in creating awareness among boys and girls was compared with respect to access to mobile phone at home. The results are given in Table 4.15

Table 4.15

Results of t test for the scores obtained in Post -test on awareness on SDG of students based on their access to mobile phones at home

Variables	Mobile phone access	N	Mean	SD	df	t	p
Awareness on SDG in General	Has access	51	152.6	2.591	61	0.024	0.981
	No Access	12	152.7	2.270			
Awareness created by School	Has access	51	51.7	1.693	61	0.761	0.450
	No Access	12	51.3	1.765			
Awareness created by Family	Has access	51	18.0	0.707	61	0.608	0.545
	No Access	12	18.2	0.937			

Note. N=number of students, M-Mean, SD= Standard deviation

The post intervention scores also show no significant difference in the awareness on SDG of students who have access to mobile phone at home and who do not have access. This indicates that access to mobile phone has no significant impact in creating awareness on SDG.

4.2.13 Analysis of pre-test open ended question

The open ended section has 12 questions , the 12 questions were divided as 2 question for concentrated 5 SDG and 2 question on the basic knowledge of SDG. Table 4.16 shows the items and the percentage of positive response of the eight standard students

Table 4.16

Percentage of positive response to the pre-test open-ended questions

Item no	Item	Positive response (%)
1	Name at least 3 SDG's.	30
2	Name least one organization working for SDGs.	25
3	Name three physics concepts used for good health and well-being.	45
4	How does loud traffic noise (high decibels) affect our hearing health?	42
5	How managing energy resources helps our planet?	37
6	Do you think switching to clean energy like solar panels can make life better and why?	28
7	How does SDGs encourage innovation and invention?	32
8	Why do cranes use pulleys to lift construction materials?	38
9	In what ways does sustainable transport reduce pollution?	27
10	How can white roofs keep buildings cool in hot cities?	24
11	What recent climate-related disasters that you are aware of?	49
12	Why does melting ice in summer make floods worse?	35

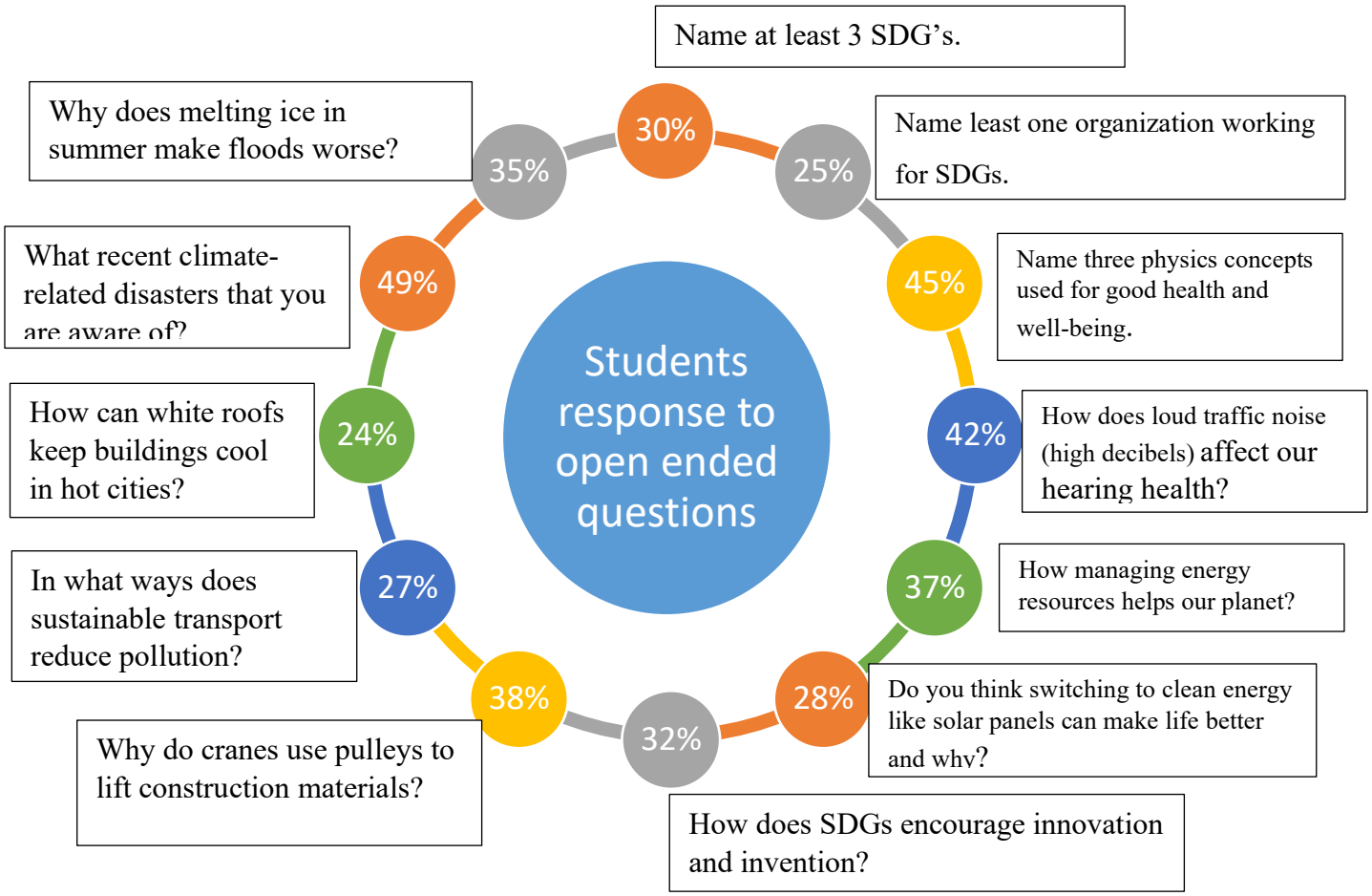


Figure 4.6 Students pre-test response to open-ended questions

The table reveals that a moderate yet inconsistent level of awareness among students concerning Sustainable Development Goals (SDGs) and their relationship with physics concepts. The basic understanding of SDGs seems to be relatively low, as only 30% of students can identify at least three SDGs, and 25% are aware of organizations that are working towards these goals, indicating a limited foundational exposure. Conversely, students demonstrate a comparatively better comprehension in areas that are directly associated with their daily experiences, such as physics concepts related to health (45%) and the impact of noise on hearing (42%). Environmental awareness shows mixed outcomes: while 37% grasp the management of energy resources, only 28% acknowledge the advantages of clean energy sources like solar power. Likewise, awareness of innovation and practical applications, including the role of SDGs in fostering invention (32%) and the application of pulleys in cranes (38%), remains moderate. Knowledge of sustainable practices is relatively low, with merely 27% understanding sustainable transportation and 24% being aware of cooling methods such as white roofs. Notably, climate-related awareness is comparatively higher, with 49%

recognizing recent climate disasters, although only 35% comprehend the scientific connection between melting ice and flooding. In summary, the findings indicate that while students possess some awareness of observable environmental issues, there is a distinct necessity for integrated teaching strategies that link SDGs with physics concepts and real-world applications to enhance their conceptual understanding.

4.2.14 Analysis of post-test open-ended question

Table 4.17

Percentage of positive response to the post-test open-ended questions

Item no	**Item**	**Percentage of students who gave Correct / Positive response (%)**	**Similar answers**
1	Name at least 3 SDG's.	96	1.Good health and well being (56%) 2. Affordable and clean energy (20%)
2	Name least one organization working for SDGs.	93	1.UN (66%) 2.WHO (25%)
3	Name three physics concepts used for good health and well-being.	82	1.Sound (55%) 2. X-ray (33%)
4	How does loud traffic noise (high decibels) affect our hearing health?	92	1.Ear drum damage (62%) 2.Sleep disturbance (23%)
5	How managing energy resources helps our planet?	87	1. Switching to renewable resources (45%) 2. Reducing fossil fuel usage (24%)

6	Do you think switching to clean energy like solar panels can make life better and why?	91	1. Reduces green house gas (53%) 2. switching to renewable energy(36%)
7	How does SDGs encourage innovation and invention?	78	1.Awareness (45%) 2. Partnership (29%)
8	Why do cranes use pulleys to lift construction materials?	95	1.Easy to lift (79%) 2. Less human work (12%)
9	In what ways does sustainable transport reduce pollution?	87	1.Reduces greenhouse effect (49%) 2. Less pollution (23%)
10	How can white roofs keep buildings cool in hot cities?	84	1. Less heat absorption(37%) 2. Reflects sunlight (32%)
11	What recent climate-related disasters that you are aware of?	89	1.Flood (57%) 2.Cyclone (24%)
12	Why does melting ice in summer make floods worse?	85	1.Water level rises(56%) 2.Excess water in lake ,river (34%)

Table 4.17 shows the positive response of the students to post-pest open ended question.

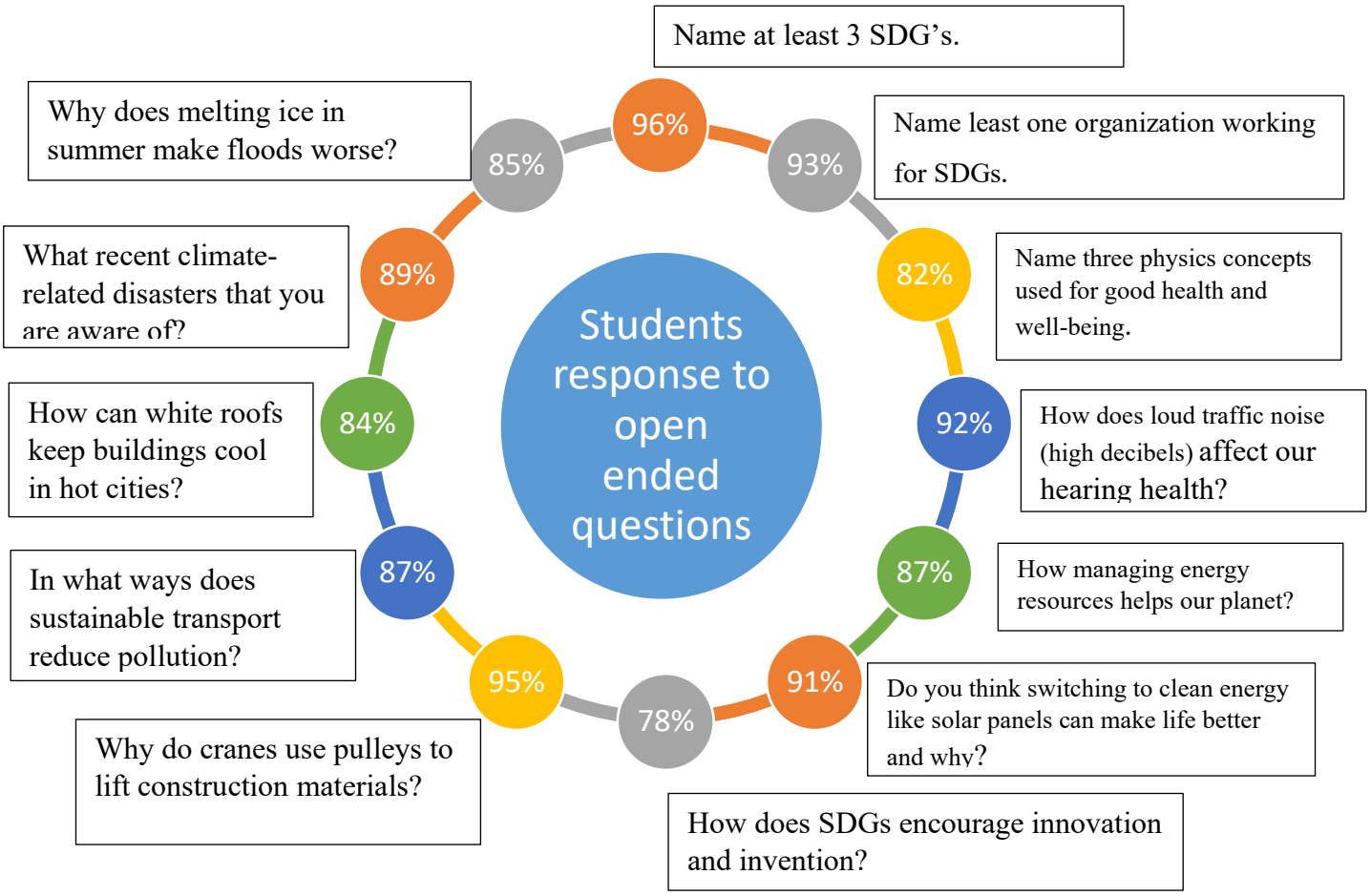


Figure 4.7 Students post-test response to open-ended questions

Table 4.17 indicates a notable enhancement and elevated awareness among students concerning Sustainable Development Goals (SDGs) and their connection to physics concepts. A substantial majority of students exhibit a robust foundational understanding, with 96% capable of naming at least three SDGs and 93% recognizing organizations that are working towards them, which signifies effective exposure and comprehension. Furthermore, students demonstrate a high degree of understanding in applying physics to practical situations, especially in areas such as the utilization of pulleys in cranes (95%) and the effects of noise on hearing health (92%). Awareness of environmental issues and sustainability is particularly strong, with 87% grasping energy resource management, 91% acknowledging the advantages of clean energy, and 87% recognizing the significance of sustainable transport in mitigating pollution. Although slightly lower, the comprehension of SDGs in fostering innovation (78%) still reflects a solid conceptual understanding. In addition, students show a strong awareness of climate issues, with 89% cognizant of recent climate-related disasters and 85% understanding the connection between melting ice and flooding. In summary, the results

clearly demonstrate that students have cultivated a thorough, well-integrated understanding of SDGs, physics concepts, and their practical applications, underscoring the effectiveness of the instructional methods employed.

4.3 Conclusion

The current study concludes that teaching physics through project- based method is an effective strategy for improving middle school student's awareness on sustainable development goals. The notable enhancements seen in pre-test and post-test scores clearly demonstrates that intervention successfully boosted students' awareness across all areas including general awareness, awareness created by school and awareness created by the family. The results also indicate that this improvement is both consistent and widespread as evidenced by decreased variability in scores and the transition of students from average to higher levels of awareness. It can be concluded that the incorporating project based learning into physics education not only enhances conceptual understanding but also significantly contributes to raising awareness on global sustainability challenges among students the method can be advocated as a valuable pedagogical approach for fostering SDG awareness in educational setting.

SUMMARY AND CONCLUSION

Chapter-5

Summary and conclusion

5.1 Introduction

This chapter presents the brief summary of the procedure, conclusion and suggestion derived from this study. This chapter includes the study in retrospect, objectives of the study, a brief methodology, major findings, educational implications, recommendations and suggestions for the further studies.

5.2 Study in Retrospect

Study in retrospect give the summary of the study by including the details of objectives, hypotheses and methodology.

Objectives of the study

- To create awareness among the 8th standard students on Sustainable Development Goals through Physics teaching.
- To develop and validate a Project-based Module in Physics on Sustainable Development Goals.
- To construct and validate an awareness scale on Sustainable Development Goals.
- To find out the effectiveness of Project-based Module in physics in enhancing the awareness of the 8th standard students on Sustainable Development Goals.
- To find out if there is any difference in the awareness level of students before and after intervention.
- To compare the awareness of 8th standard students on Sustainable Development Goals based on their gender, educational attainment of parents, interest in subject and access to mobile phone at home.

Hypotheses formulated for the study

- There is no significant difference in the levels of awareness on SDG among school students before and after intervention.
- There is no significant difference in the scores of pre-test and post-test of the 8th standard students after intervention

- There is no significant difference between the girls and boys in the pre-test and post-test awareness scores on SDG.
- There is no significant difference between the pre awareness and post awareness scores of the 8th standard students with respect to fathers' educational attainment.
- There is no significant difference between the pre awareness and post awareness scores of the 8th standard students on SDG with respect to mothers' educational attainment.
- There is no significant difference between the pre awareness and post awareness scores of the 8th standard students on SDG with respect to interest in science or language subject.
- There is no significant difference between the pre awareness and post awareness scores of the 8th standard students on SDG based on their access to mobile phone at home.

Methodology in Brief

Method

The method adopted for the study was experimental method. In the first phase a pilot study was administered on a random sample of 24 eighth standard students. This was done to validate the tools developed by the investigator. A SDG incorporated module was also constructed and expert opinions were sought in order to validate the module.

Then in the second phase the data collection was carried out in the selected sample using the validated tools. This phase included pre-test, intervention using the validated module and post-test after intervention.

Experimental design

Single group pretest-post-test design

Sample and population

The population for the study consisted of 8th standard students of Palani. The sample included 63 eighth standard students from two schools namely, St. Peters Matriculation School and Sankar Ponnar Higher Secondary School in Palani.

Variables included in the study

Dependent variable: Awareness of the students on Sustainable Development Goals

Independent Variable : Project-based Physics learning

Tools and materials used in the study

- Awareness scale on Sustainable Development Goals
- SDG incorporated Project-based Learning module

Statistical techniques used in the study

- Mean and standard deviation
- Paired t-test
- Independent sample t-test

5.3 Major findings of the study

The following were the major findings of the present investigation

1. The 8th standard textbook shows a broad and more balanced integration of SDGs across various units and scientific themes.
2. The awareness level of the SDGs among the middle school students are found to have improved after intervention as the students in the level with higher awareness increased from 7 students to 18 in general awareness, 12 students to 24 in the category where awareness was enhanced by school and 5 students to 17 in the category where awareness was enhanced by family. This indicates that project-based learning can enhance the awareness on SDG among middle school students.
3. Descriptive analysis of the scores obtained for both pre-test and post-test for both the schools respectively St. Peters Matriculation School and Sankar Ponnar Higher Secondary School, were calculated for all the dependent variables. The mean , median and standard deviation for the Awareness on SDG in general were found out as (M=131 Md=134 SD= 11.7) for pre-test and (M=153 Md=152 SD= 2.52) for post-test. For Awareness created by school (M=11.2 Md=11.0 SD=0.97) for pre-test and (M=18 Md=18 SD= 0.750) for post-test. For Awareness created by family (M=40 Md=41 SD=3.30) for pre-test and (M=51.6 Md=52 SD= 1.70) for post-test. The results showed that the data corresponds to normal distribution.
4. There is significant difference in the mean pre-test and the post-test scores on awareness on SDG of students studying in eighth standard, indicating that there is improvement in the SDG awareness after the exposure of students to project based intervention

5. There is no significant difference in the mean pre-test scores on awareness on SDG in general and on awareness by family of girls and boys. But it was seen that there is a significant difference between boys and girls in terms of scores on pretest awareness scores by School. The mean value indicates that boys have better awareness than girls when it is created by the school.
6. When the post test scores were compared for boys and girls it was found that there is no significant difference on awareness on SDG in general, awareness by family and awareness by school.
7. There is no significant difference in the mean pre-test scores on awareness of students with respect to father's educational attainment level on awareness on SDG in general, awareness by family.
8. For awareness created by school, the mean score of students whose father's educational attainment is at school level is 41.5 and SD value is 1.87, whereas the mean score of students whose father's educational attainment at higher education is 3.730. The calculated t-value ($t = 4.167$) was found to be statistically significant at the 0.001 level ($p < 0.001$). This indicates that there is a significant difference between the groups in school-based awareness before the intervention and was interesting to see that students whose father have completed school level has better awareness on SDG when compared to students whose father have completed higher education.
9. There is no significant difference in the mean post-test scores on awareness of students with respect to father's educational attainment level on awareness on SDG in general, awareness by school and awareness by family.
10. There is no significant difference in the mean pre-test scores and post test scores on awareness of students with respect to mother's educational attainment level on awareness on SDG in general, awareness by school and awareness by family.
11. There is no significant difference in the mean pre-test scores on awareness of girls and boys with respect to interest science/language subject.
12. There is no significant difference in the mean post-test scores on awareness of students in general with respect to interest science/language subject. But it was seen that that the awareness created by school and family shows statistically significant difference in the mean post-test scores on awareness of SDG after intervention using project-based learning. The mean value shows that students who is interested

in learning science was having more awareness on SDG when compared to the students who had interest in language.

13. There is no significant difference in the mean pre-test scores on awareness of students with respect to access to mobile phone at home.
14. There is no significant difference in the mean post-test scores and post test scores on awareness of students with respect to access to mobile phone at home.

5.4 Educational Implications of the study

The present study is grounded in project-based learning pedagogy, which fosters active and experiential learning by linking physics principles with real world sustainable development goals. This methodology aids students in grasping the significance of science in tackling global issues and enhances meaningful learning.

The results indicated that project-based physics learning heightens students' awareness of SDG's, and boosts student engagement and renders the learning experience more captivating and effective.

The research offers valuable insights for educators and curriculum designers advocating for the adoption of innovative, activity-oriented teaching strategies. It underscores the necessity of incorporating sustainability concepts into school curriculum to cultivate 21st-century competencies and responsible conduct among learners.

In summary, the research stresses that the integration of SDG's into education is crucial for fostering socially responsible and environmentally conscious citizens. Collaborative initiatives from educators and policymakers are essential to advance sustainable education and secure a brighter future.

5.5 Suggestion for further research:

The current research emphasizes that efficacy of project-based physics instruction in fostering awareness of sustainable development goals among these students in the eighth grade. The result indicates that similar teaching methodologies could be applied to other grades and subjects within middle and secondary education period by incorporating SDG's into various disciplines such as chemistry, biology and social studies, interdisciplinary comprehension can

be enhanced, allowing students to connect scientific knowledge with real world sustainable challenges.

It is advisable for the educators to receive training in project based and activity focused teaching strategies. Professional development initiatives and workshops can provide teachers with essential skills required to effectively design and implement learning modules centered on SDGs. This approach was facilitated as shift from conventional teaching method to more engaging, student-centered practices that are pertinent to contemporary global issues.

Moreover, the research advocates for curriculum developers and policymakers to systematically integrate SDG related content into school textbooks and educational resources. While the existing textbooks demonstrate a moderate level of integration there remains an opportunity to strengthen the link between scientific principle and sustainability topics. By incorporating more real-world examples, case studies and project-based activities, students' awareness and sense of responsibility towards sustainable developments can be significantly improved.

5.6 Conclusion

The study entitled the "Project based Physics teaching in developing awareness on Sustainable Development Goals among 8th standard students" has a significant impact in enhancing the awareness of SDGs of the students with the help of SDG incorporated Project-based Learning module. The project-based module enabled the students to connect physics concepts with real-life sustainability issues, thereby making learning more significant, pertinent and effective. This approach not only strengthen the conceptual understanding but also cultivates critical thinking, problem-solving abilities and a scientific mindset among the learners. To conclude, project-based physics instructions can be broadly implemented in schools to advocate sustainability education and comprehensive development of the students. It fosters self-directed learning, curiosity and accountability, thereby equipping students to become informed and engaged citizens. Such educational strategies can significantly contribute to aligning education with global objectives and nurturing a generation capable of contributing to sustainable development.

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Appendix

Avinashilingam Institute for Home Science and Higher Education for Women
Deemed-to-be-University Estd. u/s 3 of UGC Act 1956, Category A by MHRD (now MoE)
Re-accredited with 'A++' Grade by NAAC CGPA 3.65/4, Category I by UGC
Coimbatore-641 043, Tamil Nadu, India

Institutional Human Ethics Committee (IHEC)

Date 4/3/2026

To
Renitta S
24PED011
Department of Education
Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore 641043

Dear Ms Renitta S
Ref: Your application IHEC 2026/EDN7
Project based Physics teaching in developing awareness on Sustainable Development Goals among 8th standard submitted for approval of IHEC

The Institutional Human Ethics Committee of Avinashilingam Institute for Home Science and Higher Education for Women after careful scrutiny and review of your application, hereby grants approval to your application titled 'Project based Physics teaching in developing awareness on Sustainable Development Goals among 8th standard '. The approval number for the same is IHEC 2026/EDN7/ XMT
This certificate is issued for the study period specified in your application.

Best Wishes,

Dr. Shubashini K. Sripathi
Member Secretary

Institutional Human Ethics Committee

Appendix II

AWARENESS SCALE ON SUSTAINABLE DEVELOPMENT GOALS

GENERAL:

NO	STATEMENT	Strongly Agree	Agree	Disagree	Strongly Disagree
1.	United Nations Sustainable Development Goals (SDGs) is known to all				
2.	Ending poverty is important for everyone				
3.	Everyone deserves good health and well being				
4.	Boys and girls should not have equal opportunities				
5.	Clean water is a human right				
6.	Renewable energy is good for the environment				
7.	Using innovative technologies can help people				
8.	Reducing inequalities makes society better				
9.	Cities and town should be safe and sustainable				
10.	Climate action is necessary for our future				
11.	Oceans need not be protected				
12.	Saving forest is very important				
13.	The society should be peaceful				
14.	Working together does not help to achieve SDGs				
15.	Gender equality is important to me				
16.	People from all backgrounds need not be treated the same				
17.	Mental well-being is not a part of good health				
18.	Participating in a clean-up drive is essential				
19.	Technology helps solve environmental problems				

20.	Waste separation is not important				
21.	There are people in my neighborhood who struggle to get food				
22.	Everyone has clean water				
23.	Renewable energy can make cities cleaner				
24.	Pollution affects oceans and marine life				
25.	Forests are important for clean air				
26.	SDGs can be learned through social media and internet.				
27.	Everyone should have the right to work safely				
28.	The environment should be considered when new things are introduced				
29.	Peace and justice help build strong societies				
30.	Plastic pollutes our environment				
31.	SDGs are important for protecting people and nature.				
32.	Wildlife conservation is very much needed				
33.	It is difficult to achieve SDGs				
34.	Gender equality means equal chances for everyone				
35.	Solar and wind energy are good alternatives to save energy				
36.	Participating in tree planting is a service to our nation				
37.	War and violence must be stopped				
38.	Supporting businesses involving locally produced materials helps for Nation's economic growth				
39.	Recycling does not create jobs				
40.	The SDGs are not related to problems I see in the news				
41.	More teamwork is needed to solve global problems				
42.	Health includes eating healthy food and exercise alone.				

SCHOOL:

NO	STATEMENT	Always	Often	Sometimes	Rarely	Never
1.	My school discusses global issues like SDGs in class					

2.	My school encourages recycling					
3.	My school invites guest speakers to talk about sustainability					
4.	School projects help me learn about sustainability problems					
5.	I believe students can make a difference using sustainable ways					
6.	My teachers encourage us to participate in discussions related to sustainability.					
7.	I have participated in sapling planting activity in my school					
8.	My friends talk about social issues affecting our country.					
9.	My school encourages us to be respectful to others.					
10.	My school has rules about saving electricity.					
11.	My school uses digital tools in our classes.					
12.	Water conservation is taught in our school.					
13.	My school teaches the importance of equality					
14.	My school encourages in campus cleaning activities					

FAMILY:

NO	STATEMENT	Always	Sometimes	Never
1.	Families benefits from decent work and economic growth			
2.	I try to avoid wasting food at home			
3.	I help to save water at my home			
4.	My family teaches me about protecting the environment			
5.	My family practices reduce, reuse, and recycle at home.			

6.	My family encourages me to do community service.			
7.	My family discusses how air pollution harms our health.			

Open ended questions:

1. Name at least 3 SDG's.

   _____

   _____

2. Name least one organization working for SDGs.

   _____

   _____

3. Name three physics concepts used for good health and well-being.

   _____

   _____

4. How does loud traffic noise (high decibels) affect our hearing health?

   _____

   _____

5. How managing energy resources helps our planet?

   _____

   _____

6. Do you think switching to clean energy like solar panels can make life better and why?

   _____

   _____

7. How does SDGs encourage innovation and invention?

   _____

   _____

8. Why do cranes use pulleys to lift construction materials?

   _____

   _____

9. In what ways does sustainable transport reduce pollution?

_____

_____

10. How can white roofs keep buildings cool in hot cities?

_____

_____

11. What recent climate-related disasters that you are aware of?

_____

_____

12. Why does melting ice in summer make floods worse?

_____

_____

Appendix III

SDG incorporated Project Based Learning Module

SDG 3: Good Health and Well-being

Context of the physics of sound, namely, by warning about the dangers of noise pollution (sound) and its consequences for health and well-being.

Class -6

Term 2: Unit 2 – Electricity

Although the central concentration is on electricity, this unit educates students with fundamental concepts concerning the sound waves and vibrations phenomena as a means of grasping energy transfer.

Term 3: Unit 4 - Our environment

This unit talks about the environmental issues including the concept of pollution where noise pollution comes through which the concept of sound can be introduced.

Class- 7

Term 2: Unit 2 – Electricity

This unit talks about the fundamental of electricity and in the part of application of magnetic effect of electric current, the concept of telephone concerns the production of sound.

Class 8

Unit 6 - Sound

This unit talks about the scientific understanding of sound and its practical application including awareness about the harmful effects of noise pollution.

Activities:

1. **Sound: production of vibration and wave propagation**

   Concept:

   - Sound Vibration
   - Wave propagation

Objectives:

- ✓ Students identify how vibrations produce sound, relating uncontrolled noise to SDG 3's focus on health protection from environmental hazards.
- ✓ Demonstrate wave propagation visually, building understanding that excessive sound waves contribute to community well-being threats.

Materials needed:

- Speaker
- Spring

Steps:

1. Connect the speaker to the phone or an audio source.
2. Then placing hands on the speaker will help to feel the vibrations produced by the speaker.
3. Then hold one end of the spring and make a pushing motion on the spring can help to see to the propagation of waves.

Expected result:

To make the students to understand the vibration and propagation of waves.

Figure 1(a): Hand placed on the speaker to fee; the vibration

Figure 1 (b) **:** seeing propagation of wave in a spring

2. Visualizing frequencies:

Concept:

- Sound waves at different frequencies

Objectives:

- ✓ Observe frequency patterns in sound waves, connecting high-frequency noise exposure to SDG 3 health risks like sleep disruption.
- ✓ Differentiate safe vs. harmful frequencies, fostering skills to promote well-being through noise-conscious environments.

Materials needed:

- Bowl
- Speaker
- Thin plastic sheets / balloon
- Rubber band
- Salt or sand

Steps:

1. Take the bowl and place the speaker inside the bowl.
2. Then close the bowl with the think plastic sheet tightly with rubber band.
3. Now sprinkle some salt or sand on top.
4. Now connect the speaker to the phone or audio source and play sounds at different frequencies.
5. Observe the different wave forms at different frequencies.

Expected result:

To make the students to understand the wave forms at different frequencies.

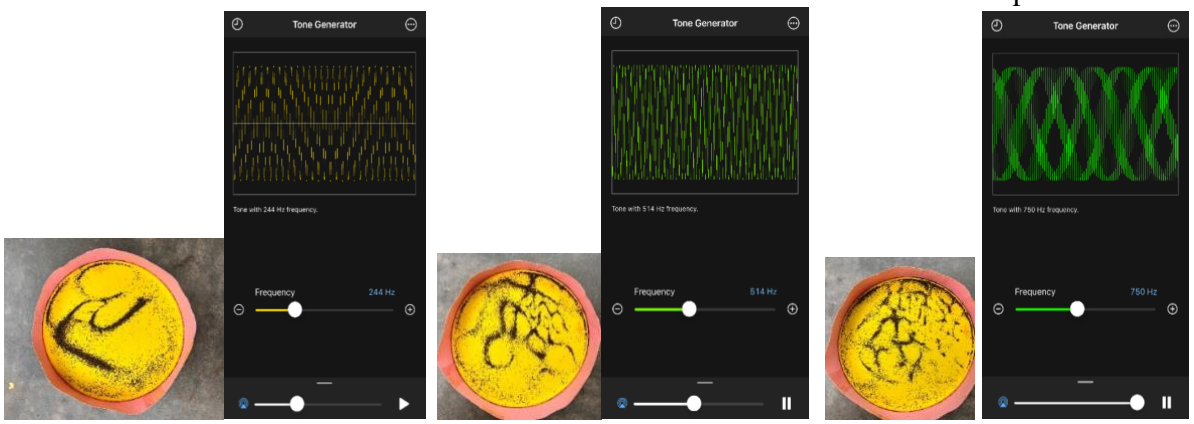


Figure 2 (a) pattern formed at 244Hz

Figure 2(b) pattern formed at 514Hz

Figure 2(c) pattern formed at 750Hz

3. **Measuring sound intensity with sound level meter**

Concept:

- Frequency
- Sound intensity

Objectives:

- ✓ Measure and analyze decibel levels across school areas, mapping high-noise zones to SDG 3 indicators on pollution-related health impacts.
- ✓ Hypothesize/strategize noise reduction (e.g., posters), empowering students to act for healthier school spaces under SDG 3.

Materials needed:

- Sound level meter (or decibel meter app on mobile)
- A notebook for data collection

Steps:

1. Understanding the concept of frequency and sound intensity.
2. Framing a hypothesis on which area of the school has the highest and lowest sound levels.
3. Then choose the areas to measure.
4. Take 3 reading at different times and calculate the average of each place.
5. Then compare the measured sound levels and discuss about the location, time.
6. Now discuss about the idea to reduce the noise pollution.
7. Then create a poster based on the understanding of the activity.

Expected result:

To make the students to understand sound intensity and how to measure them to reduce noise pollution.

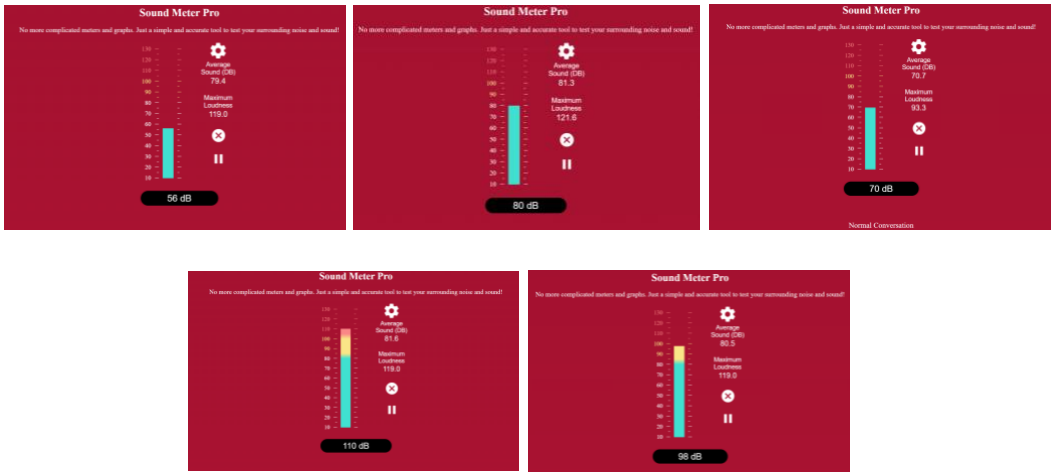


Figure 3(a) Noise measured in classroom while taking a test, during class, during lunch break, in playground and during break

SDG 7: Affordable and clean energy

Context of energy transformation and renewable energy awareness

Class 6:

Term 2: Unit 2 – Electricity

This unit talks about the foundation of electrical concepts, its application, specifically in the part of sources of electricity, renewable sources is being mentioned.

Class- 7

Term 2: Unit 2 – Electricity

This unit introduces electricity generation and its sources, it also lays groundwork for understanding different energy sources, including renewable sources.

Class 8

Unit 5 – Electricity

Although this unit does not mention the renewable sources directly, but it talks about the energy sources providing indirect link to sustainable practices, here the energy generation is being talked which leads to the clean energy technologies that are being covered in higher classes.

Activities:

1. Box type Solar

cooker Concept:

- Concentration of sunlight
- Conversion of light into heat
- Trapping heat

Objectives:

- ✓ Demonstrate sunlight concentration and light-to-heat conversion, showing solar energy reduces reliance on non-renewable cooking fuels per SDG 7 targets.
- ✓ Apply heat trapping principles, fostering skills to promote affordable solar alternatives for household energy needs.

Materials needed:

- Cardboard box
- Thermocol
- Black paper
- Aluminum foil
- Tape
- Glue
- Glass plate
- Metal wire

Steps:

1. Take the cardboard box and insulate the inner side of the box with thermocol where single is of the thermocol covered with aluminum foil.
2. Cut the excess cardboard covers on the top except the one leaving with 2 cm long.
3. Place the glass plate on the top of the box and secure it with the excess 2cm cardboard.
4. Take another sheet of cardboard to make reflector for which the single side of the cardboard sheet is covered with aluminum foil.
5. Now fold the sides of the reflector according to box and attach it to the box with tape.
6. Now use the metal wire to set the angle so that the sunlight can reflect and direct inside the box.
7. Then place the box in the sunlight with a bowl of water to heat it.

Expected result:

Using solar energy to reduce non-renewable resources used for cooking.

Figure 4: Box type solar cooker

2. Hydraulic lift

Concept:

- Hydropower
- Lift mechanism

Objectives:

- ✓ Illustrate hydropower mechanics via water pressure lift, connecting fluid dynamics to renewable energy generation for sustainable infrastructure.
- ✓ Evaluate renewable resource efficiency, empowering students to advocate clean hydropower over fossil fuels for energy security.

Materials needed:

- Cardboard
- 12 Wooden ice cream sticks

- Bamboo sticks
- Straw
- Syringes
- Tube

Steps:

1. Take the ice cream sticks and make three holes on 9 and single hole on 4 sticks.
2. Then cut the bamboo sticks into 8 pieces each of length 9cm.
3. Then connect the wooden ice cream sticks in the zic-zak way using the bamboo sticks use the straw as a cover to the bamboo sticks secure each connection with super glue.
4. Then take the cardboard sheet and attach the lift model to it with glue gun on both top and bottom.
5. Take the 2 syringes, fill one syringe with colored water and connect them both with the tube.
6. Now attach one syringe with the bottom cardboard and last bamboo stick to push the lift upwards.
7. Now when the water from one syringe is pushed out, it fills the other syringe making lift to go up and vice versa.

Expected result:

To make the students to understand the usage of renewable recourses in a sustainable way.

Figure 5 Hydraulic lift

3. Hand crank generator

Concept :

- Mechanical to electrical energy conservation
- Sustainable power generation

Objectives:

- ✓ Build belt-driven generator using DC motor and cardboard wheels, illustrating electromagnetic induction for sustainable power generation per SDG 7 targets.

- ✓ Convert hand-crank rotation to LED light via energy transfer, fostering awareness of human energy as clean, accessible alternative to fossil fuels.

Material needed

- Cardboard
- Empty pen
- Strong glue
- Old tire tube
- DC motor
- Connecting wires
- LED bulb
- Small plastic tube

Steps:

1. Take the cardboard, measures of 20x10cm for generator frame.
2. Cut 2 circle from the cardboard of 6cm radius and another one with 5.5cm as radius
3. Glue all the three circles to make a wheel with the circle of 5.5cm in center.
4. Then poke a hole at the center of the wheel with the empty pen and glue the pen acting as a shaft rod.
5. Then create a mount base of the wheel using the cardboard and mount the wheel on the generator frame.
6. Then cut the old tire type to make a belt for belt mechanism.
7. Then place the DC motor in the frame and connect the wheel with the belt.
8. Then cut a small piece plastic tube and attach it to the more as shaft rod.
9. Then connect the LED bulb to the shaft rod on the motor using connecting wires.
10. Then attach another plastic ruble to the wheel as a hand crank rod.
11. Now using the hand crank rod rotate the wheel to make the LED bulb to glow.

Expected result:

By rotating the hand crank electricity is generated and the LED bulb is expected to glow.

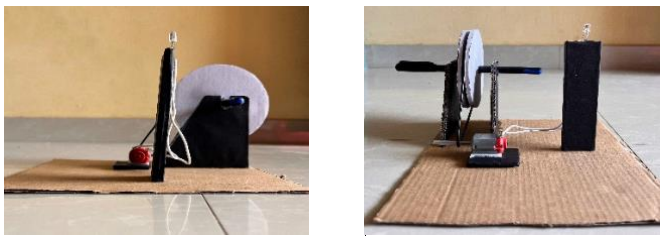


Figure 6 Hand crank generator

SDG 9: Industry, innovation, infrastructure

Class -6

Term- 2: Unit 2 – Electricity

This unit introduces the concept of electricity and its application in infrastructure, discusses about electrical circuits, conductors and insulators laying groundwork for understanding technological innovations.

Term- 3: Unit 1: Magnetism

This unit purely talks about the discovery, magnetic materials, properties of magnets, and

the usage of magnets comes the innovation of transportation: electromagnetic trains

Class- 7

Term 2: Unit 2 – Electricity

This unit introduces electrical circuits it also lays groundwork for understanding technological innovations, supports the idea of urban infrastructures like lighting, understanding of e- vehicles, and smart cities.

Class 8

Unit 5: Electricity

This unit talks about the properties of electricity, effects of electric current, different circuits, application of electricity, lays the way for innovation of technologies.

Unit 6: Sound

This unit talks about the production, propagation sound and in the part of its application comes the communication technologies which are crucial for modern infrastructure.

Activities:

1. Electric vehicle powered by solar energy

Concept:

- Energy transfer
- Energy conservation
- Energy storage
- Photovoltaic effect

Objectives:

- ✓ Demonstrate photovoltaic energy transfer/storage, linking solar power to SDG 9's resilient infrastructure for emission-free transport innovation.

- ✓ Construct/test a functional solar EV circuit, promoting skills in clean energy integration for sustainable industrial applications.

Materials needed:

- DC motor
- Wooden ice sticks
- Solar panel
- Dummy car model
- Switch
- Glue gun
- Battery holder
- Lithium battery
- 1S TP4056 1A

Steps:

1. Make a dummy car base with the ice sticks.
2. Then place the DC motor to the dummy model.
3. Now connect the solar panel to TP4056

   (Positive (+) from Solar Panel → IN+ on TP4056

   Negative (-) from Solar Panel → IN- on TP4056

   This allows the panel to charge the battery.)
4. Connect battery to TP4056

   (Positive (+) from Battery → B+ on TP4056

   Negative (-) from Battery → B- on TP4056

   This ensures safe charging.)
5. Connect TP4056 to DC motor

   (Positive (+) OUT from TP4056 → Positive of DC Motor

   Negative (-) OUT from TP4056 → Negative of DC Motor

   This powers the motor from the charged battery.)
6. Add switch to control the motor

   (Between the TP4056 OUT+ and DC motor +ve terminal)
7. The final circuit flow looks like Solar Panel → TP4056 → Battery →(Switch)

→ DC Motor → Wheels Move

Expected result:

The car powered by the solar energy is expected to move.

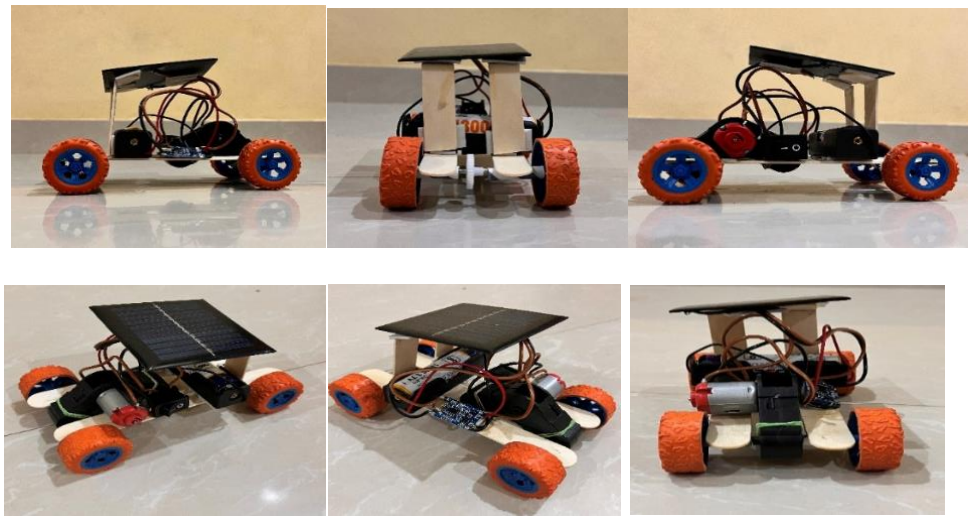


Figure 7 Solar powered electric car

2. Simple touch sensor:

Concept:

- Electricity
- Insulators and conductors
- Electrostatics

Objectives:

- ✓ Explore conductors/electrostatics in sensor circuits, connecting basic electronics to SDG 9 smart infrastructure like touch-enabled urban controls.
- ✓ Build/test LED response via human touch, building innovation competencies for inclusive, accessible technology ecosystems.

Materials needed:

- LED
- 2N 2222 Transistor
- 470 ohms resistor
- Steel wires
- Battery
- Breadboard

- Connecting wires

Steps:

1. Connect the positive terminal the LED bulb to the power rails and negative terminal to the terminal strips.
2. Then insert one leg of the resistor on the line of the terminal strip which the

–ve terminal of the LED bulb and other leg on other side of the center divider.

3. Now insert the transistor's collector leg on the terminal line where the resistor is placed, the transistor should be placed in vertical manner.
4. Then ground the emitter leg of the transistor.
5. Connect the base of the transistor in the vertical manner on the terminal strips.
6. Now place the steel wires connecting the two parts of the breadboard in the same line of the connecting wire.
7. Place another wire parallel to the previous steel wire.
8. Then ground the 2nd steel wire.
9. Now connect both power rails with source and ground.
10. Then connect the battery to the source and ground of the power trail.

Expected result:

The breadboard circuit is expected to work by touching the steel wires the LED

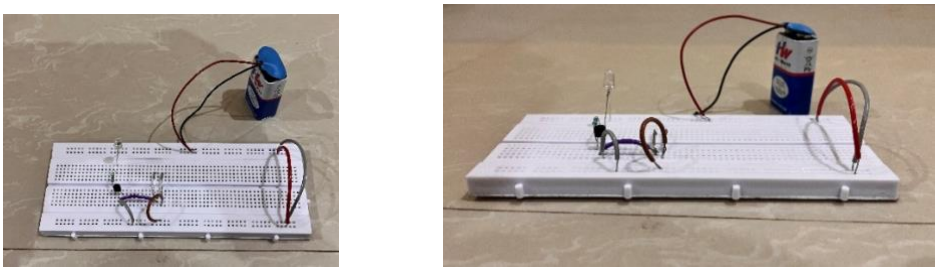


Figure 8 Simple touch sensor

3. Electromagnetic train

Concept:

- Electromagnetism
- Energy transfer

Objectives:

- ✓ Apply electromagnetism for propulsion, illustrating SDG 9 high-speed rail innovations that upgrade sustainable transport infrastructure.
- ✓ Observe energy-driven motion in coils, empowering design thinking for resilient, efficient industrial mobility systems.

Materials needed:

- Non insulated copper wire
- Neodymium magnets
- AAA battery Black paper

Steps:

1. Take a stick with a dimension that is little larger than the AAA battery and make a coil tunnel with the non-insulated copper.
2. Now take the neodymium magnets place two on the positive side and another two on the negative side of the battery, ensure both the magnets are place in the same polarity direction as north-north or south-south.
3. Insert the battery with the magnets into one end of the coil, the magnets creating the closed electrical circuit.
4. Now observe the train moves from one end to another end, this continues if the coil is connected in a circular form until the energy is depleted.

Expected result:

The electromagnetic train is expected to run with the energy created in the circuit.

Figure 9 Electromagnetic train

SDG 11: Sustainable cities and communities

Class -6

Term- 3: Unit 1 – Magnetism

This unit discusses about the discovery, magnetic materials, properties of magnets, and the usage of magnets comes the concept of maglev train as a part of sustainable transportation.

Class- 7

Term 2: Unit 2 – Electricity

This unit discusses about the foundational knowledge about electricity generation, its sources, electrical circuits it also lays groundwork for understanding technological innovations with sustainable resources.

Class 8

Unit 13: Water

This unit talks about importance, properties, usage of water, water pollution and diverse ways to control the water pollution, here to have sustainable community clean water must be attained.

Activities:

1. Maglev train

Concept:

- Magnetic levitation technology

Objectives:

- ✓ Demonstrate magnetic levitation principles, connecting repulsion technology to SDG 11's sustainable transport reducing urban emissions and congestion.
- ✓ Construct a floating track system, building awareness of innovative infrastructure for efficient, low-impact city mobility.

Materials needed:

- Cardboard
- Glue
- Black paper
- Ruler
- Cutter
- Magnets

Steps:

1. Take a cardboard piece of size 15x3 inches, cover it with black paper.
2. Arrange the magnets with the same poles placed next to each other in a straight line on each horizontal sides of the cardboard with uniform distance between them.
3. Paste the cardboards on both sides to create a wall for the magnetic track.
4. Take another piece of cardboard to make a train model and stick 2 magnets of alternative poles on the bottom of the model.
5. Then place the train model on the track, it should float due to magnetic repulsion.

Expected result:

The magnets should cause the train to levitate, stimulating the levitation technology of the maglev train.

Figure 10 (a) Maglev train model

Figure 10 (b) Maglev train track

2. Water filtration:

Concept:

- Filtration and water flow
- Gravity
- Pressure

Objectives:

- ✓ Apply gravity/pressure filtration layers, illustrating clean water systems essential for SDG 11 healthy urban communities free from pollution.
- ✓ Test dirty water purification, empowering design of accessible water solutions for sustainable city resource management.

Materials needed:

- Plastic bottle (cut in half)
- Sand, pebbles, charcoal
- Coffee filter or cloth
- Sample dirty water

Steps:

1. Layer pebbles, sand, and charcoal inside the bottle.
2. Pour dirty water through the filter.
3. Observe how different layers removes dirt and particles.

Expected result:

Understanding how natural filtration works, learning about clean water system in cities.

Figure 11 Water filtration

3. Wind powered house:

Concept:

- Energy transfer
- Wind Energy and motion
- Forces and rotation

Objectives:

- ✓ Convert wind energy to electricity via turbine rotation, linking renewable power to SDG 11 resilient buildings and energy-independent communities.
- ✓ Wire series circuits to light LEDs, promoting skills for decentralized clean energy infrastructure in sustainable urban planning.

Materials needed:

- Cardboard
- Turbine blades
- LED bulb
- DC motor
- Wires for electrical connections
- Super glue
- Wind source

Steps:

1. Prepare the 2 towers of desired length.
2. Mount the motors on the tower and secure them with super glue.
3. Attach the wind turbine blades to the motor.
4. Wire the motors in series connection (connect one wire from the first motor to one wire from the second motor and the remaining two wires of each motor are the source of output forming series connection).
5. Build a house frame with the attachment of LED bulb inside the house.
6. Now connect the LED bulb with the output wires of the tower.

Expected result:

The LED bulb is supposed to glow with the power generated from the windmill.

Figure 12 Wind powered house

SDG 13: Climate action

Class -6

Term- 3: Unit 4 – Our Environment

This unit talks about ecosystem, their components and diverse types of pollution and their effect on environment, ecosystem, climate.

Class- 7

Term 2: Unit 2 – Electricity

Though this unit talks about electricity, it has indirect addressing of need of energy efficient technologies, contributing to the lowering of carbon footprint.

Class 8

Unit 11: Air

This unit takes about know about the occurrence and composition of oxygen, nitrogen, and carbon dioxide in the atmosphere, understand the properties and uses of oxygen, nitrogen, and carbon dioxide, identify the causes of greenhouse effect, global warming, and acid rain.

Activities:

1. **The Greenhouse Effect in a jar**

Concept:

- Heat absorption and infrared radiation
- Trapping heat (greenhouse gases effect)
- Role of CO_2 in climate change

Objectives:

- ✓ Simulate CO2 heat trapping via temperature comparison, linking gas emissions to SDG 13's urgent climate regulation needs.

- ✓ Measure infrared radiation retention, fostering understanding of emission reduction strategies for global warming prevention.

Materials:

- transparent plastic bottle or glass jars
- thermometers
- Vinegar and baking soda (to produce CO2)
- Heat source

Steps:

1. Place a thermometer in each jar.
2. In one jar, create CO_2 by mixing vinegar and baking soda, then seal it.
3. Leave the other jar open to normal air.
4. Place both under a heat source and record temperature change over time.

Expected result:

The jar with more CO_2 traps more heat, simulating the greenhouse effect.

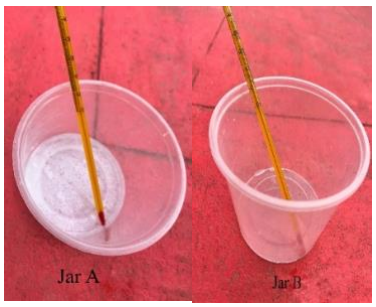


Figure 13(a) Jar A measured as 39°C and Jar B measured as 37°C

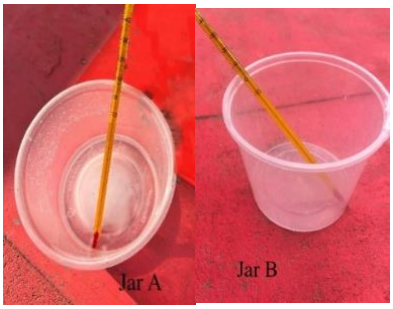
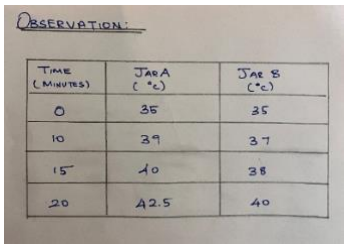


Figure 13(b) Jar A measured as 40°C and Jar B measured as 38°C

Figure 13(c) Jar A measured as 42.5°C and Jar B measured as 40°C



OBSERVATION:

TIME (MINUTES)	JAR A (°C)	JAR B (°C)
0	35	35
10	39	37
15	40	38
20	42.5	40

Figure 13(d) Observation table

2. Designing a Radiative Cooling Roof for Hot cities

Concept:

- Radiation cooling (emitting heat into space)
- Thermal conductivity

- Energy efficiency

Objectives:

- ✓ Test reflective surfaces (white paint/foil) against heat absorption, connecting cool roofs to SDG 13 resilient infrastructure in warming climates.
- ✓ Analyse thermal conductivity differences, promoting passive cooling innovations to lower urban heat islands and energy demands

Materials needed:

- small boxes or trays
- Aluminum foil, white paint black paint
- Thermometer
- Heat source

Steps:

1. Paint one box with white and line another with aluminum foil.
2. Leave the third box unpainted as a control.
3. Place them under the heat source and record temperature.
4. Compare which surface stays coolest and discuss real- world application (cool roofs, reflective coating).

Expected result:

The box painted with white is expected to stay coolest.

Figure 14 (a) Aluminum foil lined box, Control box measured as 41°C and white surface box are laid down under heat source

Figure 14 (b) Aluminum foil lined box measured as 37°C, Control box measured as 39 °C and white surface box measured as 36.5°C

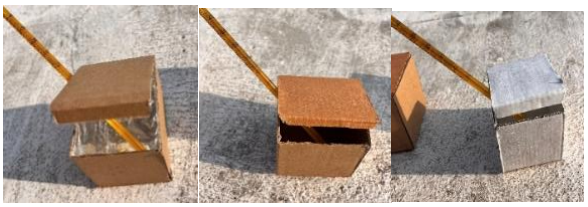


Figure (c) Aluminum foil lined box measured as 39°C, Control box measured as 40°C and white surface box measured as 38°C

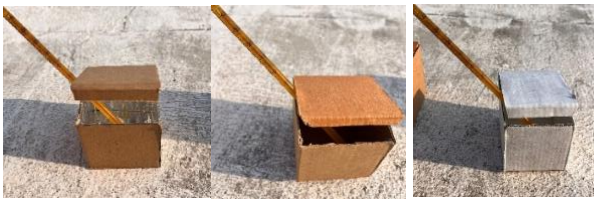
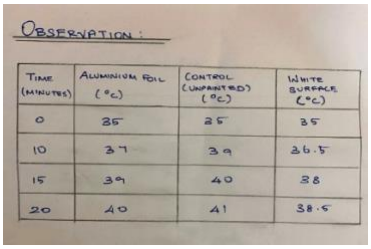


Figure 14 (d) Aluminum foil lined box measured as 40°C, Control box measured as 41°C and white surface box measured as 38.5°C



OBSERVATION :

TIME (MINUTES)	ALUMINIUM FOIL (°C)	CONTROL (UNPAINTED) (°C)	WHITE SURFACE (°C)
0	35	35	35
10	37	39	36.5
15	39	40	38
20	40	41	38.5

Figure 14 (e) Observation table

3. Thermal Insulation Challenge: Keeping Ice from melting

Concept:

- Heat transfer
- Energy efficiency in building ➲ Sustainable home design

Objectives:

- ✓ Compare insulation materials' heat transfer resistance, relating efficient designs to SDG 13 reduced building emissions worldwide.
- ✓ Evaluate ice melt rates, empowering sustainable home retrofits that minimize energy consumption and climate impact.

Materials needed:

- Ice cubes
- Different insulation materials (cotton, aluminum foil, cardboard)
- Stopwatch

Steps:

1. Warp the ice cubes in different insulation materials.
2. Observe which materials are best for energy efficient homes.
3. Discuss which materials best for energy efficient homes.

Expected result:

Cotton insulates best, preventing heat transfer.

Figure 15 (a) Ice cube is being placed in the insulation material at the initial time

Figure 15 (b) Condition of the ice cube after 7 minutes

Figure 15 (c) After 30 mins the condition of the ice cube in different insulation materials

Figure 15 (d) Ice cube is slighly melted in cotton, partially melted in cardboard and completely meltaed in aluminium foil