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INNOVATIVE STRATEGIES FOR TEACHING VOCATIONAL, SCIENCE, TECHNOLOGY AND MATHEMATICS EDUCATION: CLASSROOM PRACTICES

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PREFACE

The electronic book (e-book) acknowledges that traditional methods in Vocational, Science, Technology and Mathematics Education: Classroom Practices may not be sufficient to equip students with the necessary skills for a rapidly evolving technological landscape.

Therefore, it advocates for the adoption of Innovative teaching approaches that promote a more dynamic and effective learning experience.

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FOREWORD

This book entitled "**Innovative Strategies for Teaching Vocational, Science, Technology and Mathematics Education: Classroom Practices",** is a book of readings on various innovative classroom pedagogies. It is a welcome literature for Education System and a very important resource book for teachers who are functioning in the disciplines of Vocational Education, Science, Mathematics and Technology education and training. It is a compendium of most of the **active learning strategies** aimed at producing graduates who have been prepared for adaptation to the conditions of the 21st century world of fluidity. The 21st century world accommodates soft skills which the individual can edit from time to time as the conditions of socio-cultural, economic and technological environments change constantly and uncontrollably. A century in which cross-border job openings are important means of employment, a century where attitude is more important than subject-based excellence, a century where collaboration, innovation and creativity are irreducible demands by employers of labour, a century where adaptive skills are critical for entrepreneurship, creation of jobs and wealth.

All categories of teachers at all levels of education would find this resource book interesting and professionally helpful for their teaching practice. Because conditions of the modern world are in perpetual flux, teachers have to re-skill in order to produce adaptive graduates and the era of lecture method is literally over. It is these modern innovative instructional strategies that would enable teachers to produce such graduates who would survive and then succeed in the 21st century global economy.

This book would also be very useful to researchers and innovators in the envisioned pedagogic paradigm shift of this era. I therefore, proudly recommend this book, a compendium on innovative pedagogies to all classes of teachers and researchers on pedagogies and curriculum reforms in the modern era.

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DEDICATION

This book is dedicated to educators in the world

CHAPTER 21

INTERDISCIPLINARY APPROACH TO TEACHING BASIC SCIENCE: THE CHALLENGES AND BENEFITS

Melody Otimize Obili
Nneka R. Nnorom

Abstract
This paper explores the application of interdisciplinary approaches in teaching Basic Science, aiming to shed light on both the challenges and benefits associated with this innovative educational strategy. With the ever-evolving landscape of scientific knowledge and the interconnected nature of modern challenges, there is a growing recognition of the importance of integrating multiple disciplines in science education. The research also delves into the challenges inherent in implementing interdisciplinary teaching methods. These challenges may include institutional barriers, such as rigid educational structures and departmental silos. Despite the challenges, this paper highlighted a number of benefits which ranges from promoting creativity and innovation to preparing students for diverse career paths and real-world challenges. Interdisciplinary approaches offer unique opportunities for enriching the educational experience and empowering students to become lifelong learners and problem-solvers. This work provides educators with strategies for effectively integrating interdisciplinary approach into their teaching practice. By embracing interdisciplinary approach, educators can unlock the full potentials of Basic Science education and empower students to thrive in an increasingly complex and interconnected world.

Keywords: Interdisciplinary approach, Challenges, Benefits.

Introduction

Basic Science education in Nigeria encompasses the teaching and learning of fundamental scientific principles across various disciplines, including biology, chemistry, physics and mathematics. It is typically taught at the primary and secondary school levels, laying the groundwork for further study and specialization in science-related fields (Adeniyi & Arowosola, 2017).

Basic Science was known as integrated science, the reform agenda in Nigeria Education brought a change in Integrated Science both in content and name, the content became broad and the name changed from Integrated Science to Basic Science. Basic Science is the first form of science a child comes across at the secondary school level. It is an introductory course to the study of the sciences in the senior secondary school; it is first taught generally as a single subject at basic level (i.e Basic 1 to 9), then split into specialized science subjects (biology, physics and chemistry) in the senior secondary level.

UNESCO cited in Omiko (2016) defined Basic Science as a Science in which concepts and principles are presented, so as to express the fundamental unit of scientific thought and avoid premature or undue stress, on the distinction between various scientific fields. Omiko (2016) defined Basic Science as the Science in undifferentiated form which stresses the fundamental unity of Science. The study of elementary biology, earth/solar system, ecology, genetics, chemistry and physics were all merged to become a single science subject called basic science secondary level.

The aims of Basic Science as stipulated in the National Policy on Education (Federal Republic of Nigeria [FRN], 2013) are to enable students who are exposed in it, to acquire the following skills: observe carefully and thoroughly; report completely and accurately what has been observed; organize information acquired; generalize on the basis of the acquired information; predicting as a result of the generalization; designing experiments (including control

where necessary) to check predictions; using models to explain phenomena where appropriate; and continuing the process of inquiry when new data do not conform to prediction. To achieve these objectives, the teaching and learning of Basic Science should integrate modern pedagogical approaches and involve the use of innovative strategies and methods of teaching.

The delivery of science concepts and principles has been done through the traditional method of teaching, where teaching happens within the four walls of the classroom and the teacher is the sole source of knowledge. It's a teacher-centric method that promotes the supremacy of the teacher within the classroom setup. Also, every aspect of learning proceeds as per their will, Teachers follows the drill and rote method of memorization hence students are made to learn through repetition and memorization. There is little or no scope for critical thinking. Although this method is the mother of all teaching methods but it's definitely outdated. So, today, we have the traditional method of teaching at the core of our education system but with public attention on school reform; school leaders are looking for different approaches to improve curriculum and instruction in order to better prepare students for the rapidly changing world. It is in the light of the foregoing that this paper intends to throw light on the use of interdisciplinary approach for the teaching of Basic Science.

Statement of the Problem

Current teaching of Basic Science often isolates core disciplines, limiting students' ability to connect concepts to real-world applications. While interdisciplinary methods could bridge this gap, implementation faces challenges like rigid curricula, inadequate teacher training, and misaligned assessments. This study examines how an interdisciplinary approach enhances learning of Basic Science, identifies key barriers, evaluates its benefits for student engagement and critical thinking.

Purpose of the Study

This study aims to:

1. evaluate the effectiveness of an interdisciplinary approach in enhancing student learning, engagement, and critical thinking in Basic Science
2. identify the key challenges hindering its implementation.
3. assess the potential benefits of implementing interdisciplinary approach
4. provide recommendations for educators and policymakers to facilitate interdisciplinary BST instruction.

Interdisciplinary Approach

A paradigm change in science education can be seen in the interdisciplinary approach to teaching Basic Science, which places an emphasis on integrating multiple disciplines to improve student learning and comprehension. This approach moves beyond traditional silos of knowledge and fosters connections between different scientific fields, encouraging students to explore complex real-world problems from a holistic perspective.

According to Brown & Smith (2018) interdisciplinary teaching involves "the combination of two or more academic disciplines into one activity or course, in which the boundaries between the disciplines blur and students are challenged to integrate knowledge and methods from different fields." Bowers et al. (2020) noted that this integration of information fosters creativity, critical thinking and problem-solving abilities in addition to deepening students' understanding of scientific concepts

In traditional science education, subjects such as biology, chemistry, physics, and mathematics are often taught in isolation, leading to fragmented learning experiences for students (Fernandez et al., 2019). However, the interdisciplinary approach breaks down these barriers by exploring connections between disciplines and demonstrating the interconnectedness of scientific phenomena. For example, a lesson on environmental science could incorporate elements of biology, chemistry, and geography to study the impact of pollution on ecosystems. By examining the biological effects of pollutants on organisms, the chemical processes involved in pollution, and

the geographical factors influencing pollution distribution, students gain a comprehensive understanding of environmental issues from multiple perspectives. Moreover, interdisciplinary teaching promotes the application of scientific knowledge to real-world problems, preparing students for careers in STEM (science, technology, engineering, and mathematics) fields (Jacobsen et al., 2021).

By engaging with authentic, interdisciplinary challenges, students develop the skills and mindset necessary to tackle complex issues facing society, such as climate change, healthcare disparities, and technological innovation. Many branches of modern science are related closely. Therefore, the school subjects cannot be isolated from each other. Casey (2009) as cited in Korsun (2017) "the interdisciplinary approach has become an important and challenging technique in the modern curriculum". Manolea (2014) said that "learning the Basic Sciences in interdisciplinary spirit ensures the enhanced effectiveness of the school performance, allowing students to understand that physics, chemistry, biology and mathematics are open systems whose structure may be changed and whose borders are pushed increasingly on humanity. Turna and Bolat (2016) proved that interdisciplinary approach provides the didactic conditions and means of deep and comprehensive mastering the basics of science. The possibilities of using the interdisciplinary approach for the formation of learners' interest in sciences have been not investigated enough.

Interdisciplinary teaching refers to an educational approach that integrates knowledge, method and perspectives from multiple disciplines to address complex problems or topics (Jacobs, 1989 as cited in Demirel, 2010). Interdisciplinary teaching is a pedagogical approach that integrates different subject areas and disciplines into a single lesson plan. It is a unique approach to learning which encourages students to examine and explore topics from multiple perspectives. Unlike traditional teaching approaches, interdisciplinary teaching encourages students to apply their knowledge from different disciplines in order to understand the topic better and gain a more holistic understanding. The basic aim in this approach is to use knowledge coming from various disciplines for a certain purpose rather than simply transferring the knowledge of a discipline.

Interdisciplinary teaching encourages connections and synthesis across disciplines. It involves drawing appropriately from several disciplines to redefine problems outside of normal boundaries and reach solutions based on a new understanding of complex situations.

Interdisciplinary approach has a crucial role in science teaching, because it supplies new resources for the process of science and technology. The purpose of interdisciplinary approach is to dissolve the boundaries of various areas of study and encourage learning across the curriculum. The key factors of an interdisciplinary education are the application, association, integration and transfer of knowledge. Learning skills in isolation is not a viable approach in modern education but through interdisciplinary teaching, the students can experience the applicative part of what they are learning and also see the value of it.

Use of Interdisciplinary Approach in other subjects

There is a growing body of literature indicating that the interdisciplinary approach is fruitful and positive results are obtained as a result of the practice of the interdisciplinary approach. In his research, Dogan (2014) investigated the effect of the interdisciplinary teaching process on the geography course, concluding that interdisciplinary teaching significantly contributed to the achievement of the acquisitions in the geography curriculum and permanent learning. In a similar vein, Zimmerman et al., (2011) measured the effectiveness of interdisciplinary, case-based learning on the critical-thinking ability of graduate students enrolled in allied health care programs. They designed a voluntary classroom experience to examine the effectiveness of case studies used in an interdisciplinary setting to increase critical-thinking ability. The research showed that interdisciplinary learning experience improved critical-thinking ability in students with the least proficiency. Noy et al., (2017) in their study inspiration From the Classroom: A Mixed Method Case Study of Interdisciplinary Sustainability Learning in Higher Education found that students,

regardless of discipline background, valued the processes and pedagogy used to promote interdisciplinary collaboration and awareness. The experience left students feeling more skilled and confident of their ability to contribute to future interdisciplinary sustainability collaboration.

Karakus & Aslan (2016) in their work revealed that the current primary school curriculum is insufficient in terms of an interdisciplinary instructional approach. In the study, it was observed that while teachers' views on the interdisciplinary approach differed by the variables of professional seniority and teaching level, they did not differ by the gender variable. In parallel with the findings of this research, However, Celik (2014) argued that male teachers' views on interdisciplinary approach differed significantly compared to female teachers in terms of the gender variable, while their views did not significantly correlate with the seniority variable. In the education process, it is expected that knowledge is created by individuals in a meaningful and holistic way, and the resulting knowledge is transferred to different environments and used in appropriate places. The knowledge that emerges in this way will also contribute to the problem-solving skills of individuals. Thus, holistic education can be achieved with an interdisciplinary approach. Teachers are the agents of the interdisciplinary approach, allowing students to achieve learning gains (İhtiyaroglu, 2018). In addition to that, the fact that teachers do not have sufficient knowledge of the interdisciplinary approach may prevent them from using it effectively, even if they use it in their own lessons. Consequently, it is necessary to provide in-service training to teachers at this point and encourage them to acquire the required knowledge and skills related to the interdisciplinary approach, especially in education faculties.

Strategies for Successful Implementation of Interdisciplinary Approach

Repko & Welch (2005) as cited in Klaassen (2018), leading figures in the movement to promote interdisciplinary education, identify 9-steps to follow to engage students in an interdisciplinary exploration. They encouraged instructors to follow the follow 9-steps to prepare to become an interdisciplinary educator and then to succeed in this endeavor. These 9-steps include:

- DEFINE problems, issues, topics or questions that warrant interdisciplinary examination.
- PRESENT a clear rationale for taking interdisciplinary approach including the advantages to be gained.
- IDENTIFY relevant disciplines.
- CONDUCT a literature review (what is known on the topic from each of the disciplines)
- DEVELOP a command of each relevant discipline set out the analytical structure central to each discipline; identify key underlying assumptions, and methods of evaluation.
- STUDY the problem and generate insights including predictions from each of the relevant disciplines in isolation.
- IDENTIFY conflicts between and/or areas of complementary between the insight offered from each discipline
- CREATE common ground by developing a cohesive framework of analysis that incorporates insights from the relevant disciplines in a systematic manner.
- COMBINE disciplinary insights to construct new more integrated understanding of the problem

Furthermore, the Science and Research Institute at Carleton College, U.S.A. put together the following six steps that can be used to effectively design and implement an interdisciplinary classroom exploration, regardless of the level or type of class:

- **Pre-Instructional Planning** - Prior planning establishes the topics to be examined in an interdisciplinary manner and allows the educator to acquire the requisite knowledge; and to develop an action plan, codified in a set of notes that may include open ended questions to guide the classroom experience.

- **Introduce the Methodology to Students** - Explain to students the nature of interdisciplinary, rather than discipline based learning. Impress upon them the importance of integrating insights and approaches from multiple disciplines to form a framework of analysis that will lead to a rich understanding of complex questions.

- **Take it to the Classroom** - Model how to explore questions from an interdisciplinary perspective.
- **Practice Interdisciplinary Thinking** - Students practicing interdisciplinary thinking by reenacting what they observe in the classroom is an effective way to acquire this higher order cognitive skill. Students can be assigned the task of rethinking an issue discussed in a discipline based manner in class by bringing another discipline to bear and then attempting to synthesize and integrate their analysis. In a small class setting (i.e. freshmen seminars, upper level classes supporting interdisciplinary programs, capstone courses) students can be asked to prepare interdisciplinary position papers for each assigned reading that extends the analysis to reflect the interdisciplinary process; consider other disciplinary perspectives, synthesize and integrate. Collaborative forms of learning can be used to promote development of interdisciplinary analysis skills such as breaking into groups in class to work on ways to approach issues of concern in an interdisciplinary fashion. Student groups can bring their work back to the larger group for refinement.
- **Provide Feedback** - Extension and interdisciplinary position papers should be evaluated regularly using a rubric. The aim should be to provide the students with feedback on their ability to understand and delineate the underlying structure and analytical framework of other relevant disciplines and to produce an integrated analysis. Grading might best take the form of check, check plus and check minus, so as to simply identify the areas in need of additional skill development. The goal is for students to improve their capacity to think in an interdisciplinary manner over the course and come up with lasting knowledge.
- **Assessment** - Students should engage in self-evaluation periodically by rating their ability to: set out the structure of multiple disciplines that are well suited to the problem of interests; synthesize insights from multiple disciplines; and integrate ideas across disciplines. This information will allow them to gauge their progress, identify challenging areas, to seek help and set goals for improvement.

Application of the six key steps in Interdisciplinary Approach – Conservation of Natural Resources

The Conservation of Natural Resources has some effect on the environment. The sources and consequences of conserving natural resources will be covered using these six steps relating it to real life happenings. How to go about this following the six-step procedure for teaching in an interdisciplinary manner is briefly set out below to highlight the ease with which interdisciplinary teaching can become part of a conventional Basic Science course.

1. **Pre-Instructional Planning -** read materials to familiarize yourself with unfamiliar terms that are used to describe concepts (e.g. global warming).
2. **Introduce the Methodology to Students** - engage students in a preliminary conversation about some certain changes in climate and how it affects availability of seasonal crops. Encourage insights from them about this phenomenon.
3. **Take it to the Classroom** - lay out the conventional natural resources explanation; highlighting how the misuse of these resources can lead to negative effect on the ecosystem and climate.
4. **Practice Interdisciplinary Thinking** - give students a related assignment to help them develop their interdisciplinary analytical skills. For instance, the students can be asked to conduct an interdisciplinary analysis on climate change over a period of 10 years to observe the change in climate and state possible reasons for the change. Then make prediction on future happenings based on the current attitude of the society on conservation of natural resources.

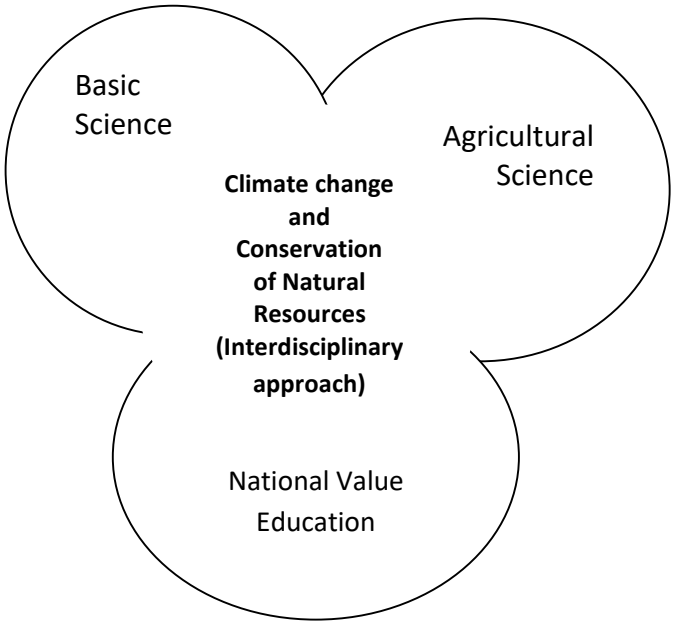

Fig. 1: Schematic diagram of interdisciplinary approach on 3 disciplines.

5. **Provide Feedback** - review students' analysis.
6. **Assessment**- Ask the students to evaluate their ability to examine. If they are uneasy about their ability to do so, arrange a meeting with them to set out a procedure for them to improve this key skill.

Challenges of implementing interdisciplinary approach

Implementing interdisciplinary teaching can present various challenges for educators and institutions which include:

1. Siloed Disciplinary Structures: Traditional educational structures often compartmentalize knowledge into separate disciplines, making it challenging to integrate content across subject areas. This siloed approach can hinder interdisciplinary teaching efforts, as educators may encounter resistance to collaboration and integration from within disciplinary departments. To address this challenge, encourage faculty members to collaborate across departments and disciplines, establish interdisciplinary research centers or institutes to facilitate collaboration and innovation and advocate for institutional support and recognition of interdisciplinary efforts through funding, tenure, and promotion policies.
2. Lack of Faculty Training and Support: Many educators may lack training and support in interdisciplinary teaching methodologies and approaches. Without adequate professional development opportunities and institutional support, educators may struggle to design and implement effective interdisciplinary curricula and instructional strategies. To overcome this challenge, provide opportunities for interdisciplinary training and professional development for both faculty and students, foster open communication and mutual respect among interdisciplinary team members and encourage the use of common language and frame works to facilitate understanding across disciplines.

iii. Administrative and Logistical Challenges: Implementing interdisciplinary teaching may pose administrative and logistical challenges, such as scheduling conflicts, resource allocation issues, and coordination of faculty and resources across departments. These challenges can impede the seamless integration of interdisciplinary content into existing curricular structures.

iv. Assessment and Evaluation Issues: Assessing student learning and achievement in interdisciplinary teaching environments can be challenging, as traditional assessment methods may not adequately capture the interdisciplinary nature of student work and

learning outcomes. Developing meaningful assessment tools and criteria that reflect interdisciplinary competencies and learning objectives is essential but can be complex.

v. Resistance to Change: Resistance to change from students, faculty, and administrators can pose a significant barrier to implementing interdisciplinary teaching. Individuals may be accustomed to traditional disciplinary approaches and may be hesitant to embrace interdisciplinary methods due to perceived challenges or uncertainties.
vi. Time and energy consuming: One of the biggest challenges is the time and efforts required to plan and implement an interdisciplinary approach. This can be time consuming and requires a great deal of preparation.
vii. Unfamiliar to students: Another challenge is that students may not be familiar with the different disciplines and topics that are included in the lesson. This may lead to confusion or frustration, which can lead to students disengaging with the lesson.
viii. Cost/resources implication: Interdisciplinary teaching may require additional resources, such as technology or materials, which can be expensive.

Benefits of Interdisciplinary Approach

Interdisciplinary teaching in Basic Science offers numerous benefits that enhance students' learning experiences and outcomes despite the challenges.

a. Enhances Understanding of Complex Concepts: Interdisciplinary teaching integrates knowledge from various scientific disciplines, providing students with a more comprehensive understanding of complex scientific concepts. By connecting concepts across disciplines students gain insights into the interconnectedness of scientific phenomena.
b. Promotes Critical Thinking and Problem-Solving Skills: Interdisciplinary teaching encourages students to analyze problems from multiple perspectives and apply diverse methodologies to solve them. By engaging in interdisciplinary inquiries and investigations, students develop critical thinking skills and become adept at tackling real-world challenges.
c. Fosters Creativity and Innovation: Interdisciplinary teaching stimulates creativity and innovation by encouraging students to explore connections between different scientific disciplines and to think outside traditional disciplinary boundaries. By integrating knowledge from diverse fields, students are inspired to generate novel ideas and approaches to scientific inquiry.
4. Prepares Students for Interdisciplinary Careers: In today's interconnected world, many scientific careers require individuals to apply knowledge and skills across multiple disciplines. Interdisciplinary teaching equips students with the interdisciplinary competencies needed to succeed in diverse fields such as biotechnology, environmental science, and healthcare.
5. Enhances Engagement and Motivation: Interdisciplinary teaching engages students by making learning relevant and meaningful. By exploring interdisciplinary connections and addressing real-world problems, students become more motivated and enthusiastic about their studies, leading to increased engagement and participation.
6. Real-World Relevance: By integrating real-world examples, case studies, and applications into the curriculum, interdisciplinary teaching makes Basic Science concepts more relevant and meaningful to students. By demonstrating how scientific principles apply to everyday phenomena and societal issues, educators can enhance students' motivation, engagement, and appreciation for the relevance of science in their lives.

Conclusion

Interdisciplinary teaching is a great way to engage students and provide them with a more comprehensive learning experience. It encourages students to explore topics from multiple perspectives and to develop critical thinking skills. It also provides teachers with an opportunity to become more creative in their approach to teaching and to stay up-to-date with the latest developments in different disciplines. Interdisciplinary education holds immense promise for preparing students to tackle the complex challenges of the modern world. By integrating insights

and methods from multiple disciplines, it promotes holistic learning, critical thinking, creativity, and collaboration. Students engaged in interdisciplinary learning gain a deeper understanding of complex issues and develop the skills necessary for success in diverse career paths.

However, the implementation of interdisciplinary education is not without its challenges. Institutional barriers, including traditional structures and departmental boundaries, can impede its integration into educational systems. Developing cohesive interdisciplinary curricula and assessing interdisciplinary learning outcomes require careful planning, coordination, and innovative approaches. Additionally, the need for faculty with expertise in multiple disciplines and the allocation of resources for interdisciplinary programs present further obstacles.

Despite these challenges, interdisciplinary education offers significant benefits that outweigh the difficulties. By addressing these challenges through collaborative efforts among educators, institutions and policymakers could unlock the full potential of interdisciplinary education and better prepare students to thrive in an increasingly interconnected and complex world. Embracing interdisciplinary approaches is not only essential for enhancing the quality of education but also for equipping students with the skills and knowledge needed to address the multifaceted challenges of the 21st century.

Recommendations

Having explored the application of interdisciplinary approaches in teaching Basic Science, the researcher recommends the following;

1. Integration of Subjects: Rather than teaching biology, chemistry, and physics as separate entities, integrate concepts from these disciplines. For example, when teaching about cellular respiration in biology, discuss the chemical reactions involved (chemistry) and the energy transformations (physics).
2. Real-world Applications: Connect basic science concepts to real-world applications across different fields. For instance, when studying the principles of genetics, discuss how these principles are applied in fields such as medicine, agriculture, and forensic science.
3. Project-Based Learning: Implement project-based learning activities that require students to apply knowledge from multiple disciplines to solve real-world problems. For instance, students could work on a project to design a sustainable energy solution, which would involve concepts from physics, chemistry, and environmental science.
4. Collaborative Learning: Encourage collaboration among students from different disciplinary backgrounds. This can foster a deeper understanding of basic science concepts as students learn from each other's perspectives and approaches.
5. Inquiry-Based Learning: Use inquiry-based learning methods to promote critical thinking and problem-solving skills. Allow students to explore scientific phenomena through hands-on experiments and investigations, incorporating multiple disciplines as necessary.
6. Field Trips: organize field trips to scientific institutions, laboratories, or natural habitats to provide students with firsthand experiences of interdisciplinary science in action.
7. Cross-Curricular Connections: Foster connections between basic science and other disciplines such as mathematics, technology, engineering, and the arts. For example, students could explore the mathematical principles underlying biological patterns or use technology to collect and analyze scientific data.
8. Flexible Curriculum: a flexible curriculum should be design that allows for the integration of new developments and emerging fields of interdisciplinary science. This ensures that students are exposed to cutting-edge research and innovation across multiple disciplines.

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