Report Prepared by

Introduction

Methodology used to collect the references and the resources.

Outline the case study and why you chose that.

Methodology: I searched on Google Scholar for contemporary papers.

The interesting aspect of this case study selected lies in its comprehensive exploration of interdisciplinary teaching approaches within secondary education. This study not only investigates the implementation of interdisciplinary methods but also employs a mixed-methods approach, incorporating both qualitative and quantitative techniques. By examining the perspectives of various stakeholders, including students, teachers, and parents, the study provides a holistic understanding of the challenges and potential benefits associated with interdisciplinary teaching. Additionally, the study's focus on project-based learning and logical thinking skills assessment adds depth to the research, highlighting the practical implications of interdisciplinary education. Furthermore, the findings suggest a potential gap in students' ability to perceive connections between different subjects, indicating a crucial area for further exploration and instructional intervention. Overall, this case study offers valuable insights into the complexities of interdisciplinary teaching in secondary education and underscores the importance of fostering students' holistic learning experiences and cognitive development.

List of Reference and Resources

1)Roberts, G., Hilliardb, C. and Calixtea, C. (2018). High School Student Reactions to an Interdisciplinary Teaching Method in Agricultural Education. Journal of Research in Technical Careers, v2 n2 p52-60

Utilizing interdisciplinary approaches is increasingly essential for addressing complex issues, necessitating professionals to collaborate across disciplines. Teaching through an interdisciplinary lens can equip students with the skills necessary to tackle these challenges effectively. This study aimed to investigate student responses to interdisciplinary teaching within secondary agricultural education and what should teachers consider when implementing this approach. Overall, students responded positively to this approach, influenced by various student characteristics. Additionally, factors such as facilitation methods and specific features of the interdisciplinary approach also influenced student reactions. Student's reactions reflect participants' degree of positive or negative interest in topics addressed, their acceptance of activity leaders and their attraction to the educational methods. The facilitation implemented throughout the focus groups, the theme of lecturing emerged consistently, with students expressing appreciation for the clarity and understanding gained through these sessions. Terms like "explain," "presentation," and "understand" were commonly used to describe the value of lectures. Students particularly valued the concise nature of the lectures, suggesting that shorter 10-20 minutes sessions were effective and should be utilized more frequently. Observations by the lead researcher supported this sentiment, noting the efficacy of these shorter lectures. Regarding structure Participants in the focus groups also emphasized the importance of structure, which they found in the form of personal attention, overall guidance, and clear directions. They appreciated specific instructions, such as being directed to particular websites, and valued the teacher's individualized support as they circulated among student groups. Additionally, students highlighted the significance of connections between concepts, noting that everything was tied back to the initial topic and that understanding was enhanced through these connections. Regarding Interdisciplinary Approach students were directed to a series of websites to gatherData and finally made many connections with the concepts learned and referenced world history and sciences classes. Research indicate that student characteristics contribute to their reactions to this interdisciplinary teaching approach and teachers should consider the characteristics of their students and the importance is the prior knowledge of students.

2)Ambroz, M., Pernaa, J. Haatainen, O. and Aksela, M. (2023). Promoting STEM Education of Future Chemistry Teachers with an Engineering Approach Involving Single-Board Computers. Appl. Sci. 2023, 13(5), 3278; https://doi.org/10.3390/app13053278

This research to do with a master's level chemistry education course that was designed to support STEM education by strengthening the E component with an engineering and interdisciplinary approach. express the need for at least two types of collaboration: one between teachers from different fields, thus striving for interdisciplinarity, and the other between peers. Both types are important and require careful planning, execution, and support from the instructors. The research express the need for at least two types of collaboration: one between teachers from different fields, thus striving for interdisciplinarity, and the other between peers. Both types are important and require careful planning, execution, and

support from the instructors. Based on the interviews, it was suggested that lecture content should incorporate practical examples using established devices outlined in the literature, as exemplified by references [23,25]. Utilizing a function-and-functionality matrix was deemed beneficial for systematically planning objectives, components, and budget allocation. However, the selection of components should be guided by the requirements identified through measuring the specific chemical phenomenon under consideration, which in turn dictates the necessary device functions, as highlighted in references [31,32]. This consideration is pivotal during the planning phase when evaluating the concept. Furthermore, the procurement phase was noted as an opportunity to acquire new expertise in component purchasing. From both learning and future teaching perspectives, prospective chemistry teachers perceived a Small-Scale Chemistry (SBC) project as conducive to hands-on learning through project-based approaches. It facilitates the retrieval of prior knowledge upon which new knowledge is built, thus enabling the integration of various STEM disciplines into the project, as indicated in reference [35]. Additionally, the SBC project was recognized as a significant learning avenue for scientific instrumentation, benefiting both teachers and learners. The data gathered from interviews and student articles indicates that the primary hurdles in the communication domain involve effectively communicating the instructor's willingness to assist and showcasing the potential applications of technology. Instructors need to adeptly introduce the available communication channels at the course's outset, explicitly encouraging students to utilize them, and consistently remind them to do so throughout the duration of the course. Evidently, students highly value access to diverse avenues for high-quality and timely communication.

3) Lee, Y.F., Lee, F. C. and Nguyen, H. B. (2023). A Comparison of STEM Education Status and Trends in Five Highly Competitive Countries in the Asia-Pacific Region. Journal of Asian Vocational Education and TrainingVol. 16-2

STEM education is gaining significant traction across the five APAC countries, with some viewing it as a primary focus in ongoing educational reforms. While traditional education, emphasizing a mono-disciplinary approach, remains prevalent, an increasing number of educators recognize the importance of embracing an interdisciplinary approach. This approach aims to stimulate students to grasp overarching themes and concepts that transcend individual disciplines, establish connections between diverse fields, and expand their applicability to real-world scenarios, thus enabling them to redefine problems beyond conventional boundaries and devise solutions based on a fresh comprehension of complex situations. While traditional education, emphasizing a mono-disciplinary approach, remains prevalent, an increasing number of educators recognize the significance of embracing interdisciplinary methods. This approach aims to facilitate students' comprehension of overarching themes and concepts spanning multiple disciplines, fostering connections between diverse fields, and enhancing their ability to tackle real-world challenges by transcending conventional boundaries and devising solutions based on a nuanced understanding of complex situations. Undoubtedly, STEM education will continue to be advocated for and progress rapidly in these nations, with collaborative efforts from policymakers, educators, and other stakeholders. Furthermore, Vocational Education and Training (VET) may emerge as a pivotal conduit for delivering STEM education effectively. STEM teacher preparation programs vary widely in their approach to integration, reflecting differing perspectives on STEM as either monodisciplinary or transdisciplinary. In some countries, such as CA and HK, STEM is treated as distinct and separate subjects, with teachers specializing in individual fields without specific STEM qualifications or pre-service programs. Instead, they acquire STEM teaching skills primarily through in-service training or personal experience. In contrast, in other contexts, STEM teachers receive comprehensive training in either intradisciplinary or transdisciplinary approaches, ensuring they are equipped to teach across STEM fields effectively. Initially, the conventional paradigm of segmented S.T.E.M. education predominates within schools, wherein discipline-specific curricula and instructional methods are favored (observed in CA, SG, TW, and the USA). Within this framework, schools may occasionally offer activities and modules that encourage students to merge the four STEM fields, although comprehensive integrative STEM courses are infrequent, particularly at the secondary and tertiary levels. Secondly, due to the entrenched nature of traditional education, which tends to prioritize individual STEM subjects, access to, flexibility in, and adequacy of integrative STEM education and curricula are limited, especially within formal educational settings (notably observed in CA, SG, TW, and the USA). The third challenge pertains to STEM teacher training and professional development. In many countries, teacher education traditionally concentrates on discipline-specific pedagogy, with most programs focusing on preparing educators within particular STEM disciplines, such as science or mathematics education. Consequently, educators often lack comprehensive competency in integrated STEM teaching methods, particularly at the secondary and tertiary levels.

4) Tonnetti, B. & Lentillon-Kaestner, V. (2023). Teaching Interdisciplinarity in secondary school: A systematic review, Cogent Education, 10:1, 2216038, DOI: 10.1080/2331186X.2023.2216038

This review aimed to achieve three objectives: (1) establish the current state of studies focusing on interdisciplinary experiences in schools, (2) highlight the effects identified on both students and teachers, and (3) identify the conditions conducive to the development of interdisciplinary sequences. The findings indicate that there is a scarcity of interdisciplinary practices in secondary schools, with even fewer achieving substantial integration. Many challenges contribute to this, including the limited availability of interdisciplinary training programs for teachers, who often lack the necessary preparation to support interdisciplinary teaching. Additionally, teachers must navigate their roles within

interdisciplinary approaches and manage relationships with colleagues, while facing constraints imposed by institutional choices and opportunities. Despite these obstacles, interdisciplinary approaches demonstrate positive effects on both students and teachers, fostering learning, interest, relational competencies, and professional development. Furthermore, the review underscores the importance of certain conditions for constructing interdisciplinary practices in schools. However, ensuring high-quality integration is often challenging in practice, with projects typically tailored to their specific contexts and rarely categorized according to the level of integration achieved. Future research could explore the classroom effects of projects categorized as multidisciplinary, interdisciplinary, or transdisciplinary, providing valuable insights into their effectiveness.

5) Mansilla V.B. and Lenoir, Y. Interdisciplinarity in United States Schools: Past, Present, and Future. (2010). ISSUES IN INTEGRATIVE STUDIES

No. 28, pp. 1-27

Looking ahead to the future of interdisciplinary education in the American educational system, given its transitional state, making definitive predictions becomes challenging. One potential future scenario involves the continuation of current standards and accountability movements, with concerns about their efficacy in delivering high-quality disciplinary or interdisciplinary education remaining largely unaddressed. Another scenario, characterized by reform, could emerge in response to the growing demand for interdisciplinary competence in the workforce and increasing interest in integrative learning in higher education. This scenario may lead to the development of new standards in emerging interdisciplinary fields such as STEM, humanities, and new media. A third, more transformative scenario might emerge from an open debate about the most critical knowledge needed to thrive in today's global, digital, and environmentally challenged societies. In this scenario, interdisciplinary learning would be viewed not as an end goal but as a means to foster innovation, problem-solving, and the generation of pertinent questions. Historian Patricia Graham's delineation of four "A" eras in American public education over the 20th century offers insight into the purposes assigned to education during different periods. The ongoing debate surrounding the re-authorization of the ESEA and the role of interdisciplinarity in public schools reflects competing visions for the future. Will there be a retreat into an era focused solely on accountability? Will there be a pursuit of advantage through international test comparisons? Alternatively, might we envision an era prioritizing adaptive agency, preparing individuals for participation in increasingly complex social contexts and uncertain knowledge domains? Drawing from past educational transitions, it's evident that the transition ahead will be multifaceted, characterized by competing agendas and overlapping influences. Start and end dates may be indistinct, but underlying orientations and influences will shape the trajectory of change.

6)Fidalgo-Neto, A., Lopes, R. M., Cerqueira Magalhães, J. L,Pierini L., Alves, L.A., (2014) Interdisciplinarity and Teacher Education: The Teacher's Training of the Secondary School in Rio de Janeiro—Brazil

This study investigates teachers' perceptions and understanding of interdisciplinarity in public secondary schools in Rio de Janeiro, Brazil. A total of 101 teachers participated by completing a questionnaire on the subject. The teachers' perceptions were analyzed alongside lesson plans prepared by those who claimed to have strong knowledge of interdisciplinary practices. The findings suggest a lack of institutional support and teacher competence in implementing interdisciplinary approaches in the classroom. To address this gap, the study proposes the adoption of methodologies like Problem-Based Learning in teacher training programs in Brazil and emphasizes the importance of ongoing professional development through postgraduate programs. Upon analysis of the lesson plans, several observations were made. Only a few teachers explicitly outlined learning objectives and assessment procedures in their plans. Additionally, a small number of lesson plans involved collaboration among multiple teachers. Some plans lacked explicit descriptions of teaching strategies, while others relied heavily on traditional lecture formats. However, a few teachers incorporated project-based or problem-based approaches into their lesson plans.

7) Bullock, P., Park, V., Snow, J. et al. Redefining Interdisciplinary Curriculum: A Journey of Collaboration and Change in Secondary Teacher Education. Interchange 33, 159–182 (2002). https://doi.org/10.1023/A:1016500303163

This article describes our collective journey of navigating through changes such as interdisciplinary collaboration, co-teaching segments of courses, exploring the integration of arts, and providing hands-on experiences. We present our experiences in four distinct voices, aiming for the reader to gain insights into both our individual perspectives and our collaborative endeavors. Along the way, we encountered various challenges, but we also discovered opportunities for generating new knowledge among ourselves and our students.

8) Santa olalla, E.,Belén, Urosa, O., MartínORCID, O., VerdeORCID, A., and Díaz, T., (2020). Sustainability, 12(17), 6748; https://doi.org/10.3390/su12176748.

This study which was carried out amongst teacher education students will enable the effects of the aforementioned Interdisciplinary Educational Innovation Project to be evaluated, taking into account the development of the preservice teachers' skills. Interdisciplinary projects are pivotal in shaping students' profiles aligned with 21st-century skills. However, integrating an interdisciplinary approach poses challenges for both teachers and teacher educators. This study aims to devise an interdisciplinary model for teacher education and conduct an empirical investigation to assess its impact on learning. An educational innovation project involved preservice teachers who engaged in Problem-Based Learning with interdisciplinary activities merging Mathematics and Social Sciences, utilizing the National Archaeological Museum as an educational resource. These proposals were then implemented with primary school children to evaluate the project's effectiveness, focusing on two aspects: (a) enhancing teaching skills among preservice teachers (N = 26) and (b) improving learning outcomes in Mathematics and Social Sciences among primary school children (N = 58). Analysis of variance revealed significant empirical evidence of improvement in various dimensions of teaching skills and competences among student teachers. Additionally, primary school students demonstrated significant progress in learning both subjects and perceived museums as valuable places for learning. The primary research variable, Teaching Skills, was analyzed across four dimensions: (a) Knowledge Integration, (b) Teamwork, (c) Interdisciplinary Teacher Education, and (d) Assessment of a teacher's role as a manager of interdisciplinary activities. Descriptive data in Table 5 summarizes the characteristics of different groups and the results for each dimension of the variable. Table 6 presents the results of the variance analysis (ANOVA) for the four dimensions. The descriptive statistics indicate that, for two dimensions of the principal variable (Teamwork and Interdisciplinary Teacher Education), the mean values across all groups surpass the midpoint of their respective scales. This suggests that, overall, preservice teachers perceive themselves as performing well in terms of teamwork (with means ranging between $M = 6.82$ and $M = 8.80$, on a scale of 1 to 30) and believe they have received adequate interdisciplinary teacher education (with means ranging between $M = 22.09$ and $M = 27.00$, on a scale of 3 to 30). Furthermore, the main effect of the intersubject factor was statistically significant in three of the four dimensions of the principal variable: Teamwork ($p < 0.05$), Interdisciplinary teacher education ($p < 0.01$), and Assessment of a teacher's role as a manager of interdisciplinary activities ($p < 0.001$). Similarly, the main effect of the intrasubject factor was statistically significant in three dimensions of the principal variable: Knowledge Integration ($p < 0.01$), Interdisciplinary teacher education ($p < 0.05$), and Assessment of a teacher's role as a manager of interdisciplinary activities ($p < 0.01$). However, no empirical evidence was found for any interaction between both factors across any of the four dimensions of the principal variable.

9)Rodríguez, G., J., and Blasco, C.M., (2010). ISSUES IN INTEGRATIVE STUDIES, No. 28, pp.109-137,

This article explores education policy regarding curricular integration and interdisciplinary practices within primary and secondary education (K-11) in Colombia. Drawing from empirical research conducted in Bogotá, it provides insights into institutional and teachers' discourses and practices on this subject. Additionally, it discusses a collaborative research initiative involving 16 schools and a university aimed at curriculum transformation through interdisciplinary projects focused on local issues. Despite the inherent complexity of such projects, the article suggests that it is feasible to engage stakeholders and leverage knowledge to reshape the school environment, imbuing it with new significance and enhancing its connections to the community and the broader world. Collaborative initiatives between schools and universities yield numerous advantages for individuals involved in both institutions. The integration of interdisciplinary alternatives has opened up new avenues for addressing widespread issues, fostering learning, and empowering individuals to engage as active citizens.

The Experiential Learning Styles Model outlines how individuals determine the most suitable mode of experiential learning. Although situational factors are significant, personal preferences also play a crucial role. Kolb highlights that individuals categorized as "watchers" tend to favor reflective observation, whereas those identified as "doers" are inclined towards active experimentation.

Kolb explains, "Due to our genetic makeup, past life experiences, and environmental demands, we develop a preferred decision-making process." These preferences form the basis of Kolb's learning styles, where each type exhibits dominant learning abilities in two areas.

Diverging (concrete, reflective):Focuses on innovative and imaginative approaches, viewing concrete situations from multiple angles and adapting through observation rather than action. Interested in people and tends to be emotionally

driven. Enjoys activities like collaborative group work and brainstorming.

Assimilating (abstract, reflective): Integrates various observations and thoughts into a cohesive whole, preferring inductive reasoning and the creation of models and theories. Enjoys designing projects and experiments.

Prioritizes the practical application of ideas and problem-solving. Prefers decision-making, problem-solving, and applying ideas in practical scenarios. Shows a preference for technical challenges over interpersonal ones.

Accommodating (concrete, active):Relies on trial and error rather than reflection, excelling at adapting to changing circumstances and solving problems intuitively through discovery learning. Also comfortable with interpersonal interactions.

Kolb's Learning Styles theory suggests that individuals' preferred approaches to perceiving and processing information determine their learning styles. He emphasizes that learning styles are not fixed personality traits but rather stable behavioral patterns influenced by background and experiences. Different people tend to favor specific stages of the learning cycle in group settings, emphasizing or feeling more comfortable with certain stages over others.

The learning styles identified by Kolb include:

Reflector/Diverger

Theorist/Assimilator

Pragmatist/Converger

Activist/Accommodator

For instance, individuals with the Diverging learning style excel in concrete experience and reflective observation. Kolb suggests various factors that can influence preferred learning styles, such as personality type, educational background, career choices, current job roles, and adaptive competencies.

PLBased

10)Kangas, M. & Rasi P. (2021). Phenomenon-Based learning of multiliteracy in a Finnish upper secondary school, Media Practice and Education, 22:4, 342-359, DOI: 10.1080/25741136.2021.1977769

To address the third research question regarding the optimal pedagogical model for supporting phenomenon-based teaching of multiliteracy, the PLM model was developed. Firstly, emphasis was placed on understanding the concept of representation and diversifying the forms of presenting analyzed information beyond traditional written reports. Secondly, the model highlights the importance of co-teaching between school and university educators, as well as fostering cross-curricular activities and subject interactions. The PLM model, serves as a practical tool for teachers to implement phenomenon-based multiliteracy learning. Its steps include teachers' collaborative design, student orientation sessions to establish shared learning visions, planning stages for students to select topics and research questions, checkpoints for joint evaluation of analysis plans, and exploration phases where students gather and critically assess information related to their chosen phenomena. These steps ensure alignment with curriculum objectives and promote students' engagement with multiliteracy through various learning methods. This model include teachers co-design, Kick-off – students' orientation, Planning.: At the beginning of the actual multiliteracy work, students plan their work and choose the phenomenon and their information sources. The aim is to guide the most relevant information sources for their projects, Checkpoint: This is the stage at which teachers and students jointly evaluate analysis plans and how different subjects can be used in analysis and reporting. The purpose is to ensure that the learning objectives, understanding of multiliteracy and exploration of the phenomenon from different subjects are achieved. Exploration – searching for and analyzing information: Students search for and gather information about a selected phenomenon and critically assess.

Phenomenal Learning from Finland presents Finland's path to 21st-century competencies and the exciting concept of phenomenon-based learning as part of the new curriculum. It's a book about Finnish schooling and the education system which is at the top of the world.

11) Counsil for creative education (CCE)- Filand

https://www.ccefinland.org/phenomenon

Following are the skills and chapter titles:

1. Thinking and Learning to learn

2. Cultural Competencies, Interaction, and Self-expression

3. Self-care and Managing Everyday life

4. Multiliteracy

5. Information and Communication Technology (ICT)

6. Working Life Skills and Entrepreneurship

7. Participating, Influencing, and Building a Sustainable Future

12) Grusche, S. (2019). Phenomenon-based learning and model-based teaching: Do they match? J. Phys.: Conf. Ser. 1287 012066

The objective of physics education is to transition students from their everyday understandings and activities to scientific models and practices. This journey typically involves two distinct approaches: Phenomenon-based instruction and model-based instruction. Phenomenon-based instruction is characterized by subjectivity, emotional engagement, mediation, exploration, and limited use of models. Conversely, model-based instruction is defined by objectivity, logical reasoning, direct confrontation, hypothesis testing, and extensive utilization of models. Initially, it may appear that these two methods are incompatible. However, it is possible to integrate them to facilitate a gradual progression from phenomena to models in student learning. Five key criteria, based on expert opinions, delineate phenomenon-based instruction: subjectivity, emotional engagement, mediation, exploration, and restricted use of models. Subjectivity involves students gaining scientific insights through personal experiences, with teachers leveraging everyday experiences as the foundation for instruction. Classroom activities often entail immersive experiments where students actively participate, fostering an understanding of phenomena as interactions between the observer and the observed. Affectivity in physics instruction involves the teacher creating an emotional connection with the subject matter. By highlighting certain aspects of everyday phenomena, the teacher transforms them into engaging experiences resembling artistic presentations, inviting students to immerse themselves emotionally. This approach fosters not only student interest and motivation but also emotional and social competencies by encouraging students to express their feelings openly. Mediation bridges the gap between students' everyday experiences and scientific concepts by using familiar phenomena as a foundation for learning. Through carefully planned steps, the teacher guides students from initial perceptions to deeper understanding, employing exploratory experiments and Socratic dialogue to facilitate learning. Exploration involves hands-on experimentation, allowing students to familiarize themselves with the phenomenon in a lifeworld-oriented manner. By varying parameters and observing changes, students identify necessary conditions and develop empirical laws through inductive reasoning, which serve as the basis for predictions and further exploration. Over time, the teacher can transition students along a continuum, leading them from exploratory experiments to more theory-driven ones, from inductive reasoning to deductive reasoning, from descriptive modeling to explanatory modeling, and from their everyday experiences to the realm of physics. This approach allows for physics instruction to be both phenomenon-based and model-oriented. Certain elements of phenomenon-based instruction overlap with model-based methods, and vice versa. To effectively integrate all aspects, the teacher must adopt a flexible approach towards phenomena, teaching strategies, and models.

Case Study Presentation

How the case study selected implement interdisciplinary approaches?

Why the began to implement this methodology in education?

What challenges do they face?

Lessons Learned?

Results.

Demirel, M. & Coskun, Y. D. (2010). Case Study on Interdisciplinary Teaching Approach Supported by Project Based Learning. ***The International Journal of Research in Teacher Education 2010, 2(3):28-53***

This study aimed to explore the implementation of an interdisciplinary teaching approach, employing a case study design supported by a combination of qualitative and quantitative methods. Thirty-four 10th-grade students from a private school in Ankara were tasked with developing projects aligned with this interdisciplinary approach. To gauge the effectiveness of this approach, a pre-post test using a logical thinking skills test (GALT) was administered in a single-group experimental design format. To gather insights into the perceptions of students, teachers, and parents regarding the application of this approach, two sets of interviews were conducted before and after the implementation. Additionally, a questionnaire focusing on the interdisciplinary teaching approach was distributed to all teachers at the school.

In this research, a nested single case design, a type of case study design, was employed. This design allows for the examination of multiple sublayers or units within a single case, offering the opportunity for multiple units of analysis (Yıldırım and Şimşek, 2000). Data were collected from the school, with various sub-components analyzed. The students, teachers, and parents within the school organization were considered as sub-units, while the school organization itself served as the main unit of analysis. To complement the case study research, a quantitative study was conducted. The effectiveness of the interdisciplinary teaching approach, supported by project-based learning, was assessed using a scale (GALT) administered as both a pre-test and post-test. The study participants included 36 teachers working at a state high school in Ankara, along with 34 students and 29 parents. Among the teachers, there were representatives from various subjects: 1 each from art, music, biology, chemistry, physics, geography, mathematics, computer science, and psychology, and 2 each from history, literature, and English. In terms of parental education, 17 had attained a college degree, 10 held a high school diploma, and 2 had completed primary school.

Prior to the implementation, teachers underwent a comprehensive 6-hour training session on interdisciplinary teaching methods and project-based learning, led by researchers. The training encompassed theoretical concepts of project-based learning and showcased practical examples of interdisciplinary teaching applications, with 1 hour dedicated to approach introduction, 1 hour to studying application examples, and 4 hours to team collaboration. Teams comprising teachers from diverse subject areas were established beforehand, fostering collaboration across disciplines and ensuring close monitoring of the process.

Both the beginning and conclusion of the process involved seeking input from participating teachers to incorporate their perspectives. Meanwhile, students in the research group received a 2-week (12-hour) instruction on scientific research techniques and project preparation based on interdisciplinary teaching. Their proficiency in utilizing internet, computer, and PowerPoint tools for project work was assessed through information forms, with deficiencies addressed accordingly. Additionally, a 4-hour presentation was provided to students on research conduct and project preparation before they selected project topics and formed groups of 2-3 members. Each group was assigned a teacher as an advisor, who reviewed and confirmed project topics for suitability. Teachers from various disciplines allocated working hours according to the projects' requirements and provided guidance tailored to their areas of expertise. “Logical Thinking Group Test” was applied to the students at the beginning and end of the process.

An open-ended interview format was employed to conduct interviews with participants. To gather insights from both students and teachers regarding the process, four teachers and ten students who participated in the application were interviewed using the focus group interview technique before and after the application. Each teacher was presented with six open-ended questions, while the same set of questions was utilized for the student interviews. Parents' perspectives were gathered through a questionnaire consisting of eight open-ended questions. Expert opinions were sought to ensure the content validity of the interview forms.

An in-depth analysis of the overall framework of EU school curricula reveals a foundation rooted in interdisciplinary teaching methods. This approach facilitates students in transferring their knowledge across different subject areas, recognizing connections between diverse topics, and nurturing advanced cognitive abilities. The present study aims to explore interdisciplinary teaching practices across various dimensions within secondary education. Secondary education was selected due to the emphasis on developing students' interdisciplinary project management skills during this stage. Furthermore, the research instrument utilized in this study incorporates concepts, such as logical thinking skills (e.g., preservation, proportional judgment), which are particularly relevant at the secondary education level.

The objective of this research is to investigate the interdisciplinary teaching approach and provide a practical example of its implementation. To achieve this goal, a group of randomly selected 10th-grade students (N=34) were tasked with developing projects aligned with the interdisciplinary teaching approach. The study aims to assess the impact of this approach on the learning process and the enhancement of students' logical thinking skills.

Findings

The teaching-learning process strives to foster students' holistic understanding and interpretative abilities. It aims to equip them with skills to grasp problem statements, interpret data, formulate hypotheses, and engage in experiences that showcase their scientific and analytical reasoning. This process is deemed effective in developing skills such as proportional judgment, variable control, connective judgment, and relational judgment, all of which are assessed by the test of logical thinking skills.

Initially, students expressed that they did not actively utilize their existing knowledge to integrate new information, but they could recognize connections between closely related disciplines. By the end of the process, however, they reported consciously applying knowledge transfer, particularly linking historical topics with contemporary events. One student noted, "Every subject is interconnected, but recognizing those connections is crucial. I was particularly impressed when the teacher bridged math and history, which served as a model for me." Working across various disciplines and with different teachers throughout the process, and delving into specific research topics, empowered students to effectively transfer knowledge across diverse fields. The teaching-learning process endeavors to cultivate students' comprehensive comprehension and interpretive skills. Its goal is to provide them with the capacity to comprehend problem statements, interpret data, devise hypotheses, and partake in activities that demonstrate their scientific and analytical reasoning. This approach is considered efficacious in nurturing abilities such as proportional judgment, variable control, connective judgment, and relational judgment, all of which are evaluated through assessments of logical thinking skills.

At the beginning of the process the teachers pointed out that the level of students' perception was insufficient in establishing associations between topics learnt, and that it would be difficult to instil the skill in students in secondary education. They highlighted the importance of designing effective learning activities and equipping students with the ability to analyze and interpret knowledge proficiently. Regarding the skill of effective language usage (self-expression), teachers initially noted the influence of families and communities on language skills and their efforts to cultivate this skill in students. By the end of the process, they stressed the necessity of closely monitoring students' interests to facilitate the development of these skills, emphasizing the integration of such skills into the objectives of all courses. A considerable portion of teachers were found to lack proficiency in utilizing evaluation methods aligned with the interdisciplinary teaching approach. Approximately 58% of teachers reported not conducting evaluations beyond traditional exams, and 64% admitted to not being able to assess learning processes comprehensively. Additionally, 50% of teachers indicated not facilitating student self-assessment, while 56% reported difficulties evaluating learning outcomes applicable to real-life scenarios.

Conclusion

The primary findings and observations from interdisciplinary and phenomenon-based learning in secondary education references:

- Enhanced Understanding: Introducing interdisciplinary approaches fosters a deeper comprehension of concepts by allowing students to make connections across various subjects.
- Holistic Learning: Phenomenon-based learning encourages holistic learning experiences, enabling students to explore real-world phenomena and develop transferable skills.
- Improved Problem-Solving: Integrating different disciplines facilitates problem-solving skills development as students tackle complex issues from multiple perspectives.
- Engagement and Relevance: Students exhibit increased engagement when learning through interdisciplinary and phenomenon-based approaches, as they see the relevance of their studies to real-life situations.
- Teacher Challenges: Educators may face challenges in implementing evaluation methods aligned with interdisciplinary teaching, indicating a need for professional development in this area.
- Overall, interdisciplinary and phenomenon-based learning in secondary education have the potential to enhance student learning outcomes by promoting deeper understanding, critical thinking, and engagement with real-world issues.
- Lack of institutional support and teacher competence: A study conducted in public secondary schools in Rio de Janeiro, Brazil, revealed a deficiency in institutional support and teacher competency in implementing interdisciplinary approaches. The study recommends incorporating methodologies like Problem-Based Learning into teacher training programs and emphasizing ongoing professional development.
- Evaluation of an interdisciplinary educational innovation project: An interdisciplinary model for teacher education involving Problem-Based Learning activities was evaluated among preservice teachers and primary school children. The study found significant improvements in teaching skills among preservice teachers and enhanced learning outcomes in Mathematics and Social Sciences among primary school students.
- Development of a Pedagogical Learning Model (PLM) for phenomenon-based multiliteracy teaching: The PLM model emphasizes representation diversity, co-teaching between school and university educators, cross-curricular activities, and collaborative student design. The model aims to support teachers in implementing phenomenon-based multiliteracy learning through collaborative design, student orientation, planning, checkpoints, and exploration stages.

- Transformation of everyday phenomena: The teacher effectively transforms everyday phenomena into engaging learning experiences resembling artistic presentations, thereby fostering student interest, motivation, and emotional engagement.
- Development of emotional and social competencies: By encouraging students to express their feelings openly in response to the phenomena presented, the approach not only enhances academic understanding but also cultivates emotional and social competencies.
- Mediation between everyday experiences and scientific concepts: Through mediation, the teacher bridges the gap between students' everyday experiences and scientific concepts, utilizing familiar phenomena as a foundation for learning.
- Guided learning process: The teacher employs carefully planned steps, including exploratory experiments and Socratic dialogue, to guide students from initial perceptions to deeper understanding of the phenomena.
- Hands-on exploration: Exploration involves hands-on experimentation, allowing students to engage with phenomena in a lifeworld-oriented manner, identify necessary conditions, and develop empirical laws through inductive reasoning.
- Transition towards more advanced reasoning: Over time, the teacher transitions students along a continuum from exploratory experiments to theory-driven ones, from inductive to deductive reasoning, and from descriptive to explanatory modeling.
- Integration of phenomenon-based and model-oriented instruction: The approach allows for physics instruction to be both phenomenon-based and model-oriented, emphasizing the importance of flexibility in integrating teaching strategies and models to effectively engage students in learning.

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