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Exploring the Effectiveness of STEM Interdisciplinary Approach in Teaching Grade 12 Agricultural Sciences Learners

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ABSTRACT

This study explored the effectiveness of the STEM interdisciplinary approach in teaching grade 12 Agricultural Sciences learners. The study applied social constructivism theory and a qualitative approach using Phenomenology design, sampling 24 participants including 12 teachers and 12 learners through purposive in Capricorn South District, Limpopo, South Africa. Data was collected using semi-structured interviews. Results indicated that the interdisciplinary approach in STEM positively influences learner engagement and critical thinking in the retention of agricultural science concepts by relating theory to actual agricultural challenges being experienced in the real world. However, the study also identified key challenges, including resource limitations, time constraints, and teachers' varying levels of STEM integration experience. Based on the findings of this study, modification in the curriculum is recommended to assign more time for activities with an interdisciplinary approach and invest more in resources and training of teachers to implement effectively the practice of STEM interdisciplinary approach in agricultural science education. This study contributes to scholarship by demonstrating how the STEM interdisciplinary approach enhances learner engagement and critical thinking in Agricultural Sciences. It also highlights key challenges, informing curriculum modifications, teacher training, and resource investment for effective STEM integration.

Keywords: *Agricultural Sciences, Resource Constraints, Critical Thinking, Problem-Solving, Learner Engagement, Curriculum Innovation.*

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INTRODUCTION

Traditional teaching approaches fail to provide learners with a holistic understanding of complex agricultural systems, limiting their ability to address real-world challenges effectively.[1] As such, the STEM interdisciplinary approach can be utilized to examine, combine, and harmonize the connections among disciplines to create a well-coordinated and cohesive whole.[2] Since interdisciplinary approaches

[1] David H Jonassen, "Toward a Design Theory of Problem Solving," *Educational Technology Research and Development* 48, no. 4 (2000): 63–85; Lusanda Ncisana et al., "A Comparative Study of Teaching Approaches in Agro-Ecology: An Investigation of 10th-Grade Agricultural Sciences Learners in Selected Schools," *Sustainability* 15, no. 5 (2023): 4048; Frans Lesiba Khubayi, Lusanda Ncisana, and Thokozani Isaac Mtshali, "Investigating the Effectiveness of Using YouTube Videos as an Alternative Learning Media for Grade 11 Life Sciences Learners," *E-Journal of Humanities, Arts and Social Sciences* 5,no.6(2024):1001–14.
[2] Bernard C K Choi and Anita W P Pak, "Multidisciplinarity, Interdisciplinarity and Transdisciplinarity in Health Research, Services, Education and Policy: 1. Definitions, Objectives, and Evidence of Effectiveness.," *Clinical & Investigative Medicine* 29, no. 6 (2006). 351.

integrate knowledge and methodologies from multiple disciplines, they can provide a promising alternative to close the gap. Wu et al., in their meta-analysis, suggest that secondary school science teachers should adapt their instructional approaches to foster the development of learners' problem-solving skills.[3] To effectively handle many issues facing the agriculture sector, including climate change and sustainable resource management, interdisciplinary approaches promote critical thinking, creativity, and problem-solving abilities.[4] These issues, which are sometimes not related to the system, call for complex and creative solutions, advanced problem-solving abilities, and the involvement of several different parties.[5] Sophisticated problem-solving abilities are necessary in today's quickly changing world since many problems have several facets and complex solutions.

Capabilities to evaluate intricate situations, pinpoint underlying causes, and come up with original solutions that tackle the core problems as opposed to just treating the symptoms are necessary for effective problem-solving. Making links between subject areas is a major goal of teachers in interdisciplinary teaching.[6] Capraro and Jones assert that rather than causing curriculum fragmentation, these links enhance natural learning and promote profound conceptual understanding.[7] To increase the variety of learning options available to learners, teachers must collaborate. Al Salami et al., state that since most teachers lose autonomy when devoting time to decision-making and may encounter conflicts with one another on the team, they cultivate cooperation, communication skills, and a positive mindset toward interdisciplinary approaches.[8] A study by DiBenedetto et al. has examined the application of interdisciplinary approaches in agriculture at the undergraduate education level.[9]

However, research on the efficacy of interdisciplinary approaches in secondary schools is scarce.[10] Since it helps learners to think more critically and allows them to apply knowledge from several science disciplines to grasp a concept or issue in its entirety, investigating the effectiveness of interdisciplinary approaches in teaching Agricultural Sciences in secondary schools is crucial.[11] Furthermore, it prioritizes the application and synthesis of knowledge and abilities.[12]

The purpose of this study is to therefore explore the effectiveness of the STEM interdisciplinary approach in teaching grade 12 Agricultural Sciences learners. The study is guided by the following objectives:

1. To identify the perceived benefits and challenges associated with implementing a STEM interdisciplinary approach in teaching Agricultural Sciences
2. To evaluate the impact of interdisciplinary teaching methods on learner-learning outcomes, including academic achievement and knowledge retention.

LITERATURE REVIEW

Effectiveness of Interdisciplinary Approach in Education

Interdisciplinary approaches in education incorporate methodologies and knowledge from numerous disciplines to resolve complex problems and foster holistic learning. Županec et al., conducted research,

[3] Xinning Wu et al., "A Meta-Analysis of Interdisciplinary Teaching Abilities among Elementary and Secondary School STEM Teachers," *International Journal of STEM Education* 11, no. 1 (2024): 38.

[4] Ncisana et al., "A Comparative Study of Teaching Approaches in Agro-Ecology: An Investigation of 10th-Grade Agricultural Sciences Learners in Selected Schools."

[5] Steven Levy, *Artificial Life: A Report from the Frontier Where Computers Meet Biology* (Random House Inc., 1993); Kurt A Richardson, Paul Cilliers, and Michael Lissack, "Complexity Science: A" Gray" Science for the" Stuff in between"," 2001; Praygod Bonginkosi Nkosi and Thokozani Isaac Mtshali, "Enacting Creative Thinking Skills Using Design Process in Technology Classrooms," 2024.

[6] Annika Sdunekv and Thomas Waitz, "Algae: The Green All-Rounder–An Interdisciplinary Teaching Unit for Middle School Students," in *International Conference on the New Perspectives in Science Education, 6th Edition, Florence*, 2017, 23–27.

[7] Mary Margaret Capraro and Meredith Jones, "Interdisciplinary STEM Project-Based Learning," *STEM Project-Based Learning*, 2013, 51–58.

[8] Mubarak K. Al Salami, Carole J. Makela, and Michael A. de Miranda, "Assessing Changes in Teachers' Attitudes toward Interdisciplinary STEM Teaching," *International Journal of Technology and Design Education* 27, no. 1 (March 3, 2017): 63–88, https://doi.org/10.1007/s10798-015-9341-0.

[9] Catherine A DiBenedetto et al., "Examining Undergraduate Student Attitude towards Interdisciplinary Education," *Journal of Agricultural Education* 57, no. 1 (2016): 167–78.

[10] Aaron J McKim et al., "Interdisciplinary Learning Opportunities in Agriculture, Food, Natural Resources, and Science: The Role of the Teacher.," *Journal of Agricultural Education* 59, no. 2 (2018): 179–96.

[11] W. H. Newell, " Integrating the College Curriculum," in *Interdisciplinary Education in K-12 & College*, ed. J. T. Klein (New York: College Board Publications, 2002), 119–37; W. H. Newell, *Interdisciplinary: Essays from the Literature* (New York: College Board, 1998).

[12] Sdunekv and Waitz, "Algae: The Green All-Rounder–An Interdisciplinary Teaching Unit for Middle School Students."

and the findings revealed that an interdisciplinary approach enhanced the quality and recollection of student knowledge.[13] Dong and Ran assert that the interdisciplinary teaching approach effectively enhances students' understanding of courses and stimulates the improvement of their vocational skills and literacy and offers an innovative teaching method at colleges and universities.[14] Through interdisciplinary learning, learners cultivate more advanced epistemological beliefs, their critical thinking skills and metacognitive abilities improve and they obtain a deeper comprehension of how different disciplines are interrelated.[15] Hubert alludes that interdisciplinary lessons promote student engagement, academic achievement, high order thinking skills, and problem-solving skills, co-taught interdisciplinary lessons create context and relationships for the lessons and projects that students work on.[16]

Additionally, an interdisciplinary approach can enhance students' comprehension of different subjects, empowering them to become more creative and proficient students.[17] In a study by Levintova and Mueller, research demonstrated that the most successful way to teach core concepts is to use traditional methods and supplement them with active learning ways (interdisciplinary approach) that allow learners to apply the knowledge.[18] They discovered that interdisciplinary approaches to education foster deductive reasoning, and produce more meaningful learning experiences, which raise students' academic achievement.[19] This means the interdisciplinary approach is responding positively in education. Interdisciplinary approaches provide students with a comprehensive understanding of agricultural concepts and practices by integrating knowledge from other disciplines, including biology, chemistry, environmental sciences, and economics.[20]

Challenges and Limitations of Implementing Interdisciplinary in Schools

According to several studies, teachers' inability to successfully incorporate interdisciplinary teaching approaches is a result of their lack of pedagogical knowledge and topic understanding.[21] Similarly, Weinberg and McMeekin found that teachers' knowledge, skills, talents, assessment fit, degree of control, and collaboration were among the obstacles to interdisciplinary collaboration.[22] Rafiq et al., discovered that challenges such as limited institutional support and resistance from traditional structures create obstacles to the successful implementation of the interdisciplinary approach.[23] Kanmaz conducted research with primary and secondary teachers and the results of the study showed that teachers do not effectively implement an interdisciplinary approach during in-class activities, as this approach is not adequately integrated into the curriculum.[24] Karakuş and Aslan found that teachers put effort into associating concepts, subjects, or themes with various disciplines but encounter challenges with time constraints when implementing the interdisciplinary teaching approach.[25] This is because schools lack

[13] Vera Županec et al., "The Effectiveness of an Interdisciplinary Approach in Biology Teaching in Primary School: A Comparison with Monodisciplinary Approach.," *International Journal of Educational Methodology* 9, no. 1 (2023): 169–82.
[14] Jian Dong and Meng Ran, "The Application and Effectiveness of Interdisciplinary Integration Education in Teaching Interior Design and Environmental Design," *Applied Mathematics and Nonlinear Sciences* 9, no. 1 (2024).
[15] Lana Ivanitskaya et al., "Interdisciplinary Learning: Process and Outcomes," *Innovative Higher Education* 27 (2002): 95–111.
[16] Carrie Hubert, "Interdisciplinary Learning and the Effects on Students," 2021.
[17] Selma Deneme and Selen Ada, "On Applying the Interdisciplinary Approach in Primary Schools," *Procedia-Social and Behavioral Sciences* 46 (2012): 885–89.
[18] Ekaterina M Levintova and Daniel W Mueller, "Sustainability: Teaching an Interdisciplinary Threshold Concept through Traditional Lecture and Active Learning," *The Canadian Journal for the Scholarship of Teaching and Learning* 6, no. 1 (March 31, 2015), https://doi.org/10.5206/cjsotl-rcacea.2015.1.3.
[19] Newell, " Integrating the College Curriculum"; Newell, *Interdisciplinary: Essays from the Literature*; P. Horton, *Integrated Science, an Introduction, & A Bibliography* (Melbourne, FL: Florida Institute of Technology, 1981).
[20] Hye Sun You, "Why Teach Science with an Interdisciplinary Approach: History, Trends, and Conceptual Frameworks.," *Journal of Education and Learning* 6, no. 4 (2017): 66–77.
[21] Marshall A Baker, J C Bunch, and Kathleen D Kelsey, "An Instrumental Case Study of Effective Science Integration in a Traditional Agricultural Education Program.," *Journal of Agricultural Education* 56, no. 1 (2015): 221–36; Leila A Graves, Harrison Hughes, and Meena M Balgopal, "Teaching STEM through Horticulture: Implementing an Edible Plant Curriculum at a STEM-Centric Elementary School," *Journal of Agricultural Education* 57, no. 3 (2016): 192–207.
[22] Andrea Elizabeth Weinberg and Laura Beth Sample McMeeking, "Toward Meaningful Interdisciplinary Education: High School Teachers' Views of Mathematics and Science Integration," *School Science and Mathematics* 117, no. 5 (2017): 204–13.
[23] Shahid Rafiq, Farrukh Kamran, and Ayesha Afzal, "Investigating the Benefits and Challenges of Interdisciplinary Education in Higher Education Settings," *Journal of Social Research Development* 5, no. 1 (2024): 87–100.
[24] Ahmet Kanmaz, "A Study on Interdisciplinary Teaching Practices: Primary and Secondary Education Curricula.," *African Educational Research Journal* 10, no. 2 (2022): 200–210.
[25] M Karakuş and S Aslan, "Examination of the Current Situation Regarding Interdisciplinary Teaching in Primary Schools [İlkokulda Disiplinlerarası Öğretime Yönelik Mevcut Durumun Incelenmesi]," 2016.

support and teachers are incompetent to develop interdisciplinary approaches in the classroom.[26] Nurturing interdisciplinary learning in this educational context presents challenges because the separation between subjects is often seen by both teachers and learners as a natural characteristic of the topics themselves rather than because of how the curriculum is organized.[27] According to Wang et al., secondary teachers lack experience in utilizing multidisciplinary STEM techniques during their pre-service teaching assignments.[28] As a result, teachers might fail to integrate multiple subjects in meaningful ways.[29]

THEORETICAL FRAMEWORK

This study is guided by the theory of social constructivism. According to social constructivism, learning is an active process in which learners create new knowledge and understanding through their experiences and interactions with others.[30] Akpan et al., believe that social constructivism shifts the learner from a passive listener to an active participant and a co-constructor of knowledge alongside his or her peers.[31] According to Amineh and Asl, the learner's background enhances the knowledge and understanding they develop and achieve throughout the learning process.[32] As such, the interdisciplinary nature of STEM helps learners to create new knowledge by linking concepts across different disciplines. According to the Department of Basic Education, Agricultural Sciences encompass a variety of disciplines, including biology, chemistry, economics, and environmental sciences.[33] Through the combination of these several disciplines, social constructivism offers a framework for comprehending how learners learn.

Amineh and Asl highlight that a learner plays a passive role when the teacher simply delivers information, but the learner takes an active role when the teacher facilitates the learning process and helps learners to learn.[34] Thus, the teacher serves as a guide and co-constructor of knowledge, ensuring that learners actively participate in their learning process. Therefore, this study explored the effectiveness of the STEM interdisciplinary approach in teaching grade 12 Agricultural Sciences learners.

METHODOLOGY

This study adopted the qualitative research approach to explore the effectiveness of the STEM interdisciplinary approach in teaching grade 12 Agricultural Sciences learners. The qualitative approach was suitable for this study since it captures a wide range of responses, which entails observed situations, and ideas of respondents.[35] This phenomenological research design was employed because it places a strong emphasis on examining and comprehending the lived experiences of individuals.[36] The study deployed purposive sampling. Purposive sampling is a non-probability technique in which specific groups of individuals are selected because they meet the characteristics needed in a sample.[37] Purposive sampling in this study was deployed to select grade 12 Agricultural Sciences teachers and learners from Capricorn South District in Limpopo province, South Africa to participate in the study.

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[26] Antonio Augusto Fidalgo-Neto et al., "Interdisciplinarity and Teacher Education: The Teacher's Training of the Secondary School in Rio de Janeiro—Brazil," *Creative Education* 5, no. 4 (2014): 262–72.
[27] E Barelli et al., "Disciplinary Identities in Interdisciplinary Topics: Challenges and Opportunities for Teacher Education," *ESERA 2021: Fostering Scientific Citizenship in an Uncertain World*, 2022, 934–43.
[28] Hui-Hui Wang et al., "Defining Interdisciplinary Collaboration Based on High School Teachers' Beliefs and Practices of STEM Integration Using a Complex Designed System," *International Journal of STEM Education* 7 (2020): 1–17.
[29] Yves Lenoir, François Larose, and Yvon Geoffroy, "Interdisciplinary Practices in Primary Education in Quebec: Results from Ten Years of Research," *Issues in Interdisciplinary Studies*, 2000.
[30] L.S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes* (Harvard University Press, 1978).
[31] Vera Idaresit Akpan et al., "Social Constructivism: Implications on Teaching and Learning," *British Journal of Education* 8, no. 8 (2020): 49–56.
[32] Roya Jafari Amineh and Hanieh Davatgari Asl, "Review of Constructivism and Social Constructivism," *Journal of Social Sciences, Literature and Languages* 1, no. 1 (2015): 9–16.
[33] Department of Education, *Curriculum and Assessment Policy Statement Grades 10-12 Agricultural Science* (Pretoria, South Africa, 2011).
[34] Amineh and Asl, "Review of Constructivism and Social Constructivism."
[35] Frank Ohemeng-Appiah, "Teaching the Design Process in the Grade 9 Technology Class" (University of KwaZulu-Natal, 2014).
[36] Dan Zahavi and Shaun Gallagher, "Phenomenological Approaches to Self-Consciousness," *The Stanford Encyclopedia of Philosophy*, 2005, 207–22.
[37] K. Nikolopoulou, " What Is Purposive Sampling?| Definition & Eexamples," 2022, https://www.scribbr.com/methodology/purposive-sampling/.

Furthermore, Coffelt highlights that confidentiality and anonymity are ethical principles designed to protect the privacy of individuals while collecting, reporting and analysing data.[38] As a result, in this study, the names of the schools and participants were not mentioned to ensure the confidentiality and privacy of participants following the requirements of ethical conduct proposed by the institution to which researchers are affiliated. Tables 1 and 2 below show the profile of the participants.

Table 1: Participant's profile information (Teachers)

Teacher	District	Qualification	Teaching experience	Grade
A1	Capricorn South	BEd (Life sciences)	6 years	12
A2	Capricorn South	BSc Agriculture (Soil Science and PGCE)	2 years	12
A3	Capricorn South	BEd (Life Sciences)	4 years	12
A4	Capricorn South	BSc Agriculture (Animal Production and PGCE)	3 years	12
A5	Capricorn South	BSc Agriculture (Animal production and PGCE)	2 years	12
A6	Capricorn South	BSc Agriculture (Soil Science and PGCE)	5 years	12
A7	Capricorn South	BSc Agriculture (Soil Science and PGCE)	4 years	12
A8	Capricorn South	BEd (Life Sciences)	7 years	12
A9	Capricorn South	BEd (Agricultural Sciences)	9 years	12
A10	Capricorn South	BEd (Life Sciences)	4 years	12
A11	Capricorn South	BSc Agriculture (Plant Production and PGCE)	3 years	12
A12	Capricorn South	BSc Agriculture (Plant Production and PGCE)	3 years	12

Table 2: Participant' profile information (Learners)

Learner	District	Discipline/Stream	Age	Grade
A	Capricorn South	mathematics	18	12
B	Capricorn South	Mathematics and science	16	12
C	Capricorn South	Mathematics and science	17	12
D	Capricorn South	Mathematics and science	18	12
E	Capricorn South	Mathematics and science	18	12
F	Capricorn South	Mathematics and science	17	12
G	Capricorn South	Mathematics and science	18	12
H	Capricorn South	Mathematics and science	17	12
I	Capricorn South	Mathematics and science	19	12
J	Capricorn South	Mathematics and science	16	12
K	Capricorn South	Mathematics and science	16	12
L	Capricorn South	Mathematics and science	17	12

Data Collection

Data was collected through semi-structured interviews administered to learners and teachers involved in Agricultural Sciences programs to gather information about their experiences, challenges, and perspectives on interdisciplinary approaches. Semi-structured interviews are the most applicable tool for obtaining a comprehensive understanding of participants' opinions and experiences.[39] A total of 24

[38] Tina Coffelt, "Confidentiality and Anonymity of Participants," 2017.
[39] Paul Gill et al., "Methods of Data Collection in Qualitative Research: Interviews and Focus Groups," *British Dental Journal* 204, no. 6 (2008): 291–95.

participants including 12 teachers and 12 learners were interviewed at different schools. An hour of semi-structured interview allowed for a thorough examination of the subject matter while preserving participant interest and preventing weariness.

Data Analysis

The effectiveness of the STEM interdisciplinary approach in Agricultural Sciences education was examined through the lens of recurrent patterns and themes found in the qualitative data through thematic analysis.[40] Firstly, Detailed notes and recordings were taken during the interviews for viewing and listening. Secondly, codes were analysed, and similar codes were grouped to form one theme. Some of the interview questions were coded and grouped to form one theme because they were similar. Braun and Clarke stress the importance of combining codes that have similar characteristics to find significant trends in the data.[41] Lastly, the themes were clearly defined and named for better understanding.

PRESENTATION OF RESULTS

The information gathered for this study is presented as themes and subthemes which are supported by the findings of existing literature and current research. To represent the findings, verbatim quotes were translated from Sepedi into English for the aim of this study. Meaningful codes were created using the data obtained from interviews and verbatim quotes from a few transcripts that had similar properties were coded and grouped into the same groups. Five main themes (learners) and 2 main themes (teachers) were identified. The first main theme which is presented in the form of a graph (figure 1) indicates learners' understanding of the STEM interdisciplinary approach. Table 3 indicates the qualitative analysis of the learner's results where 4 themes were generated from the interviews. Also, table 4 indicates the analysis of the teachers' results where 2 main themes were generated from the interviews.

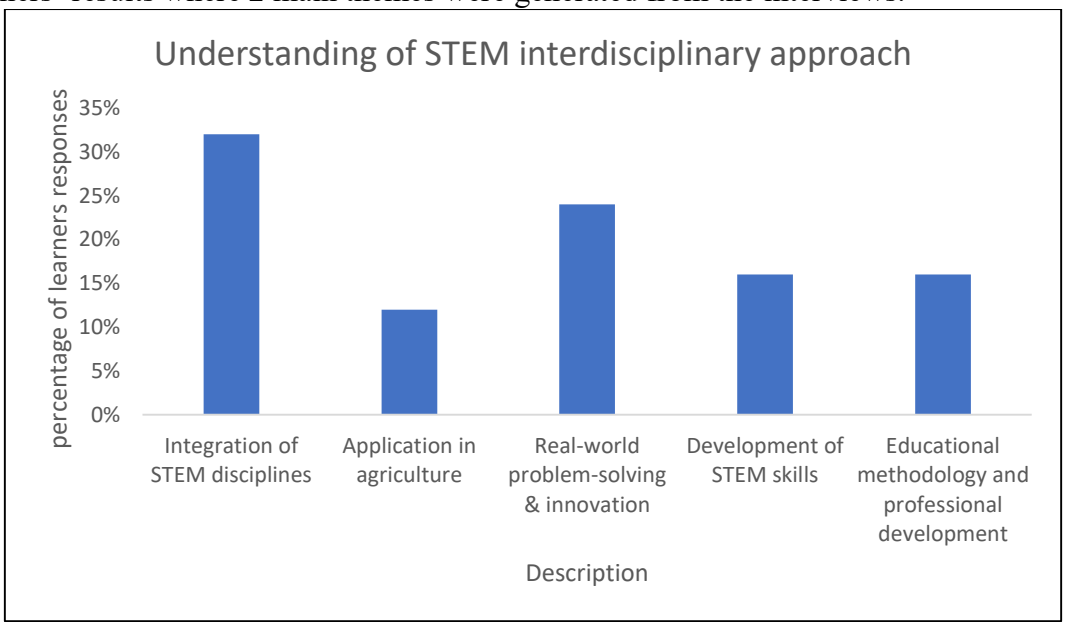

Figure 1: Learners' understanding of STEM interdisciplinary approach

Table 3: Analysis of the learner's results

Generated themes from the interview	Summary of the themes
Understanding of STEM interdisciplinary approach	Learners understanding of STEM interdisciplinary approach
Advantages and benefits of STEM interdisciplinary approach	Benefits of learning Agricultural Sciences using the STEM interdisciplinary approach

[40] Virginia Braun and Victoria Clarke, "Using Thematic Analysis in Psychology" 3, no. 2 (January 1, 2006): 77–101, https://doi.org/10.1191/1478088706qp063oa.
[41] Virginia Braun and Victoria Clarke, "What Can 'Thematic Analysis' Offer Health and Wellbeing Researchers?," *International Journal of Qualitative Studies on Health and Well-Being* (Taylor & Francis, 2014).

Engagement of learners, perceptions and experience with STEM activities	Learners' engagement and the activities taught using the STEM interdisciplinary approach
Memory retention and alternative teaching methods	Common teaching methods employed in grade 12 for learners to understand Agricultural Sciences better
Challenges and areas for improvement in STEM interdisciplinary approach	Challenges faced by learners when agriculture is taught using STEM interdisciplinary approach and recommendations needed for applying this method

Table 4: Analysis of the teachers' results

Generated themes from the interview	Summary of the themes
Teachers understanding of STEM interdisciplinary approach	Description of STEM interdisciplinary approach by teachers
Challenges in implementing STEM interdisciplinary approach	The main challenges that teachers encounter when implementing a STEM interdisciplinary approach

Analysis of Learners' Results

Learners' Understanding of STEM Interdisciplinary Approach

During the interviews, it became apparent that all participants shared a common understanding that the STEM interdisciplinary approach is an integration of science, technology, engineering, and mathematics. Below are responses from Participants A and D.

Participant A: *The STEM interdisciplinary approach is an approach where different strategies are used from different disciplines such as science, engineering, and mathematics. Also, instead of teaching these subjects separately, it combines them to solve real-world problems and promote deeper understanding.*

Participant D: *The STEM interdisciplinary approach is an approach where different methods are being used from various disciplines like technology, mathematics, engineering, and science. Also, instead of teaching these subjects individually, it encourages them to solve real-world situations and encourages deeper understanding.*

The STEM interdisciplinary approach is defined by Roehrig et al. and Rennie et al. as a method of teaching the material of two or more of the four STEM topics utilizing real-world situations to integrate the material and improve student learning.[42]

Figure 1 illustrates that 32% of the learners believe that a STEM multidisciplinary approach incorporates several STEM disciplines. That is, in learners' minds, the multidisciplinary approach of STEM is mainly related to the integration of several STEM subjects within agricultural education. Whereas 24% of the learners are concerned with the practical application, specifically offering innovation in agriculture and solving current actual problems. According to 16% of learners, STEM multidisciplinary education focuses on professional growth, educational technique, and the development of STEM abilities. Lastly, the lowest percentage (10%) for the STEM multidisciplinary approach as an application in agriculture indicates that few learners make the direct connection between STEM interdisciplinary learning and particular agricultural applications. According to the comments above, learners are aware of what an interdisciplinary STEM approach entails.

Advantages and Benefits of STEM Interdisciplinary Approach

The participants were asked about the advantages and benefits of the STEM interdisciplinary approach in Agricultural Sciences. The identified advantages and benefits of the STEM interdisciplinary approach mentioned by the learners included the role of enhancing critical thinking, problem-solving skills, and

[42] Gillian H Roehrig et al., "Beyond the Basics: A Detailed Conceptual Framework of Integrated STEM," *Disciplinary and Interdisciplinary Science Education Research* 3 (2021): 1–18; Leonie Rennie, Grady Venville, and John Wallace, "Making STEM Curriculum Useful, Relevant, and Motivating for Students," in *STEM Education in the Junior Secondary: The State of Play* (Springer, 2017), 91–109.

engagement during the classes of Agricultural Sciences. The following are the responses from some of the participants.

Participant B: *The STEM interdisciplinary approach in Agricultural Sciences offers real-world relevance, enhances problem-solving skills, provides hands-on learning experiences, encourages collaboration, and fosters adaptability to changes in the sector.*

Participant F: *STEM interdisciplinary approach fosters creative problem-solving and innovation, prepares students for practical applications, and promotes a broader understanding of STEM concepts.*

Participant J: *Even though I don't have much knowledge about the STEM interdisciplinary approach, I can say that through the approach, there is encouragement of engagement among learners and critical thinking skills.*

The supporting comments from some of the participants on the benefits of STEM interdisciplinary for future studies or careers in agriculture are presented as follows:

Participant D: *It will assist me in problem-solving whereby I will be able to tackle complex challenges in agricultural production and the ability to work in many agricultural sectors.*

Participant H: *A STEM interdisciplinary approach in agriculture will help me develop problem-solving skills. I'll learn to use technology to improve farming methods.*

The comments suggest that the STEM interdisciplinary approach is beneficial for teaching Agricultural Sciences since it promotes critical thinking, teamwork, and involvement of learners. According to Lynch et al., a STEM interdisciplinary approach aids in experiential learning enhances learners' performance and fosters critical thinking abilities.[43]

Learners' Engagement, Perceptions, and Experience with STEM Activities

Learners were also questioned regarding their opinions and experiences with STEM-related activities, as well as how involved they were in class when the STEM multidisciplinary approach was used. This was done to better understand different STEM activities they had previously engaged in and to determine the effectiveness of the STEM interdisciplinary approach. Most of the learners stated that they like participating in STEM-related activities, and they broadly had favourable opinions of the STEM interdisciplinary approach, including the fact that it made Agricultural Sciences more interesting and approachable. The supporting comments from some of the participants are presented as follows:

Participant E: *I feel incredibly blessed that I had the opportunity to grow up on a farm where I learned critical thinking and problem solving along with maths, biology, and physics.*

Participant I: *It feels so good to learn Agricultural Sciences using a STEM interdisciplinary approach because it helps in developing problem-solving skills.*

Participant A: *I feel happy because it makes the Agricultural Sciences lessons more interesting.*

The above responses show that learners find STEM activities more enjoyable and very helpful as they encourage collaboration where learners can exchange ideas with their peers during the class. Engagement in STEM activities encourages learners to connect academic concepts to their everyday lives, making the content more meaningful.[44] These insights reveal that the interdisciplinary approach not only fosters academic understanding but also connects learners to Agricultural Sciences in ways they find personally relevant.

Memory Retention and Alternative Teaching Methods

Learners were also questioned about other approaches they are familiar with outside of the STEM multidisciplinary approach, as well as how well they retain the information when taught this way as opposed to more conventional ways. In contrast to traditional approaches, most of the participants stated that the STEM multidisciplinary approach improved their ability to recall information since it was practical and hands-on. The following responses reflect the views of the participants.

[43] Sharon J Lynch et al., "Understanding Inclusive STEM High Schools as Opportunity Structures for Underrepresented Students: Critical Components," *Journal of Research in Science Teaching* 55, no. 5 (2018): 712–48.

[44] Robert M Capraro and Scott W Slough, "Why PBL? Why STEM? Why Now? An Introduction to STEM Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach," in *STEM Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach* (SensePublishers Rotterdam, 2013), 1–5.

Participant A: *I retain the information very well because this method uses technology in some way, which helps me understand everything being taught*.
Participant D: *I still remember a lot of things that I was taught using the stem approach because it encourages a learner-centered approach.*
Participant B: *In contrast to conventional techniques, the STEM interdisciplinary approach usually improves knowledge retention. It emphasizes experiential, active learning, and real-world applications to strengthen concepts and increase their memorability.* The responses are consistent with the findings of Thomas et al., who discovered that combining many disciplines through practical approaches improves recall and comprehension of difficult subjects.[45]
Participant K: *I remember the little information that I was taught because we take a lot of time learning and I am struggling when it comes to applying what we did during the class. The STEM interdisciplinary approach is time-consuming, and a lot of things must be covered in a short period.*

According to studies, STEM's interactive approach improves memory retention more than conventional techniques because hands-on activities increase learner engagement and create cognitive links that facilitate recall.[46] Participant K mentioned that the method can be time-consuming, which occasionally makes memory recall difficult because of the short class period. In contrast to the disjointed approach of traditional approaches, several participants felt that the STEM interdisciplinary approach helped them retain knowledge.

Challenges in Learning Agricultural Sciences using STEM Interdisciplinary Approach

Grade 12 learners were asked about the challenges they have encountered in learning Agricultural Sciences using the STEM interdisciplinary approach. Even though many students commended the advantages of the STEM interdisciplinary approach, several of them also mentioned difficulties, especially about time and resource limitations. The responses of some of the participants are as follows:
Participant B: *There are challenges in learning Agricultural Sciences using the STEM interdisciplinary approach because at school there are not enough resources when we want to do some of the STEM activities, and it is time-consuming.*
Participant G: *Using STEM interdisciplinary in Agricultural Sciences classes is a challenge because it is time-consuming and at school, there are not enough resources that we can use to learn some of the topics that require us to do it practically.*
Participant H: *Applying the STEM interdisciplinary approach needs a lot of time and ATP is being followed so that we don't spend 1 week doing the same topic.*

These issues are like those noted by Honey, who noted that curricular limitations and a lack of resources can make STEM less effective in given learning environments.[47] Furthermore, the literature on STEM integration frequently draws attention to these difficulties, especially in environments with limited resources, where a shortage of resources may prevent the full application of interdisciplinary techniques.[48] Conversely, other participants responses are as follows:
Participant D: *Learning Agricultural Sciences using a STEM interdisciplinary approach is not a challenge because it is modern and interesting. Any learner can adapt smoothly.*
Participant I: *I have never encountered any challenges during the class, and I enjoy STEM activities a lot because it's better to learn something practical that is going to help you not to forget easily.*
Participant J: *I have never faced any difficulties when the STEM interdisciplinary approach is used during Agricultural Sciences classes. I enjoy classes that apply the STEM interdisciplinary approach.*

According to these results, the STEM multidisciplinary approach is widely accepted, but to maximize its efficacy, its implementation calls for careful resource allocation and scheduling flexibility.

[45] Devon Thacker Thomas et al., "Incorporating High-Impact Practices for Retention: A Learning Community Model for Transfer Students," *Journal of College Student Retention: Research, Theory & Practice* 23, no. 2 (2021): 243–63.
[46] Rodger W Bybee, "The Case for STEM Education: Challenges and Opportunities," 2013.
[47] Margaret Honey, *Design, Make, Play: Growing the next Generation of STEM Innovators* (Routledge, 2013).
[48] Margaret Honey, Greg Pearson, and Heidi A Schweingruber, *STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research*, vol. 500 (National Academies Press Washington, DC, 2014).

Analysis of Teachers' Results

Teachers understanding of STEM interdisciplinary approach

During the interview, teachers were asked about their understanding of the STEM interdisciplinary approach. Most teachers demonstrated a shared understanding that the approach integrates science, technology, engineering, and mathematics to address practical agricultural issues.

Participant A3 explained:

When teaching Agricultural Sciences, the STEM multidisciplinary method integrates science, technology, engineering, and mathematics to address practical agricultural issues. This approach fosters the development of critical thinking skills and creative solutions to agricultural problems.

This statement aligns with research by Roehrig et al., and Rennie et al., which highlights that incorporating STEM subjects into real-world contexts helps learners develop critical thinking and problem-solving abilities.[49]

Similarly, Participant A5 shared:

Teaching Agricultural Sciences using the STEM multidisciplinary method combines ideas from science, technology, engineering, and mathematics to improve students' learning and problem-solving abilities. It focuses on real-world applications and practical, hands-on exercises to help learners better grasp agricultural concerns and procedures.

This perspective is supported by Bybee, who emphasizes that STEM interdisciplinary education promotes experiential learning and enhances problem-solving capabilities.[50]

Additional responses from participants include:

Participant A2: The *STEM interdisciplinary approach is an approach to learning and development that integrates the areas of science, technology, engineering, and mathematics*.

Participant A4: *An educational strategy that integrates biology, technology, chemistry, and engineering to prepare learners for challenges related to sustainability, food security, and careers.*

These viewpoints are consistent with Moore et al., who argue that multidisciplinary STEM education not only enhances academic understanding but also prepares learners to tackle real-world challenges across various fields, including agriculture.[51] Overall, the participants' comments indicate their awareness of the potential of the STEM interdisciplinary approach to improve agricultural education and their willingness to adopt multidisciplinary strategies that encourage contextual and hands on learning.

Challenges of Implementing the STEM Interdisciplinary Approach in Agricultural Sciences

During the interviews, all teachers identified a lack of resources as the primary challenge in implementing the STEM interdisciplinary approach. Some participants elaborated on this issue:

Participant A3: *One of the challenges I faced was a lack of resources at school. My learners are many, and we don't have enough materials for experiments. I try to use videos from YouTube to show them how things are done, for example, the procedure for artificial insemination.*

Participant A8: *The efficiency of the STEM interdisciplinary method may be impacted by limited access to the materials, equipment, and technology required for practical projects*.

This aligns with the findings by Dare et al., and Roehrig et al., who note that resource constraints often hinder the adoption of multidisciplinary approaches, particularly in underfunded schools.[52]

Another challenge mentioned was the diversity of learners' backgrounds:

Participant A4: *It was challenging to engage all learners equally in the STEM interdisciplinary approach due to the diversity of learners and their differing levels of prior knowledge and skills*.

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[49] Roehrig et al., "Beyond the Basics: A Detailed Conceptual Framework of Integrated STEM"; Rennie, Venville, and Wallace, "Making STEM Curriculum Useful, Relevant, and Motivating for Students."

[50] Rodger W Bybee, *STEM Education Now More than Ever* (National Science Teachers Association Arlington, VA, 2018).

[51] Tamara J Moore et al., "The Status of Engineering in the Current K-12 State Science Standards (Research to Practice)," in *2013 ASEE Annual Conference & Exposition*, 2013, 23–1234.

[52] Emily A Dare, Elizabeth A Ring-Whalen, and Gillian H Roehrig, "Creating a Continuum of STEM Models: Exploring How K-12 Science Teachers Conceptualize STEM Education," *International Journal of Science Education* 41, no. 12 (2019): 1701–20; Roehrig et al., "Beyond the Basics: A Detailed Conceptual Framework of Integrated STEM."

Valiandes highlights the influence of diverse learner backgrounds on the effectiveness of STEM activities, emphasizing that differentiated instructional strategies may be essential to ensure equitable participation.[53]

Some teachers expressed a lack of experience with the approach:

Participant A1: *Since I have never used it before, it's difficult for me to identify the challenges of implementing this approach. But I will research it*.

DISCUSSION

These results provide valuable insight into the perceived understanding, benefits, challenges, and impacts of the multidisciplinary approach to teaching Agricultural Sciences to Grade 12 learners. Despite facing practical limitations, both teachers and learners recognized the unique value and benefits of this approach. Through the inductive thematic analysis of qualitative data from interviews, it became clear that learners generally demonstrated a sound understanding of STEM multidisciplinary education. Many highlighted the integration of science, technology, engineering, and mathematics as a means to solve complex, real-world agricultural problems.

Most participant responses aligned with recent studies emphasizing that integrated STEM approaches enhance both the relevance and understanding of the subject matter. This perspective is supported by Roehrig et al., and Rennie et al., who assert that interdisciplinary thinking and problem-solving foster learners' ability to engage with complex issues.[54] Additionally, the mixed nature of learners' interests, spanning professional aspirations and practical life applications, suggests that learners view STEM as a pathway to personal and professional growth within the agricultural industry.

Learners embraced the benefits of STEM, particularly its positive impact on engagement, critical thinking, and problem-solving. By actively participating in STEM-based activities, learners were able to connect classroom knowledge to real-life scenarios, promoting deeper understanding and retention.[55] This point was emphasized by Participant B, who highlighted the flexibility and experiential nature of STEM as key advantages. Participant D noted that the collaborative aspect of STEM projects enhanced learners' teamwork skills, effectively preparing them for future collaboration in agricultural contexts. Lynch et al., similarly argue that multidisciplinary approaches enhance engagement and foster critical competencies, such as creativity and resilience, that are essential for both academic and practical success.[56]

Teachers, despite their limited exposure to the interdisciplinary approach in STEM, demonstrated an understanding of its value and expressed enthusiasm for its implementation. Moore et al., emphasizing the role of STEM in equipping learners with the tools needed to address sustainability and food security challenges.[57] However, teachers also emphasized the importance of professional development and support to ensure the effective integration of STEM methodologies in the classroom. This aligns with the view of Ncisana et al., who also recommended professional development for Agricultural Sciences secondary teachers.[58]

RECOMMENDATIONS

Funding for schools should be strategically allocated to essential resources such as laboratory supplies, agricultural tools, and technology-based learning aids that support the implementation of the interdisciplinary approach in STEM education. This will always ensure that learners have materials at their disposal to make this approach more practical and effective. This study further recommends Department of Basic Education engage in the provision of workshops and training sessions that are aimed

[53] Stavroula Valiandes, "Evaluating the Impact of Differentiated Instruction on Literacy and Reading in Mixed Ability Classrooms: Quality and Equity Dimensions of Education Effectiveness," *Studies in Educational Evaluation* 45 (2015): 17–26.

[54] Roehrig et al., "Beyond the Basics: A Detailed Conceptual Framework of Integrated STEM"; Rennie, Venville, and Wallace, "Making STEM Curriculum Useful, Relevant, and Motivating for Students."

[55] Capraro and Slough, "Why PBL? Why STEM? Why Now? An Introduction to STEM Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach."

[56] Lynch et al., "Understanding Inclusive STEM High Schools as Opportunity Structures for Underrepresented Students: Critical Components."

[57] Moore et al., "The Status of Engineering in the Current K-12 State Science Standards (Research to Practice)."

[58] Lusanda Ncisana et al., "From Theory to Practice: Teachers' Pedagogical Experiences in Animal Studies," *International Journal of Learning, Teaching and Educational Research* 23, no. 1 (2024): 207–30.

at developing methods with an orientation towards interdisciplinary teaching related to Agricultural Sciences. This will enhance pedagogical skills within teachers for the effective integration of STEM into their classrooms. The curriculum needs to be revised and allow more time instead for interdisciplinary hands-on learning activities. Giving teachers flexibility in scheduling will help overcome these strict curriculum pacing challenges that pose a problem for STEM projects.

CONCLUSION

The findings of this study confirm that an interdisciplinary approach to teaching STEM disciplines effectively enhances learners' engagement while fostering critical thinking and problem-solving skills to address real-life agricultural challenges. This approach is particularly relevant for application-based learning in Agricultural Sciences, offering a significant improvement over traditional methods that often overlook practical perspectives. While both teachers and learners appreciate the benefits of this approach, its success is hindered by constraints such as inadequate resources, insufficient teacher preparation, and limited time allocation for STEM-based activities within the curriculum. Addressing these challenges could pave the way for a more holistic understanding of Agricultural Sciences, equipping learners with the skills and knowledge needed for employment opportunities in the Agricultural sector through a robust interdisciplinary STEM framework.

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